CALIFORNIA COASTAL COMMISSION
455 MARKET STREET, SUITE 228
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F7

9-23-0874-W (Equinor Wind US LLC)

May 10, 2024

CORRESPONDENCE

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9-23-0874-W (Equinor Wind US LLC)

CORRESPONDENCE: Form Letter

Emails

This item is a form letter received from **83** separate contacts:

Dear Commissioners:

The California Coastal Commission is responsible for protecting California resources. Fish and Fishing rights are highly protected in California. Fish habitat is highly protected in California waters.

Equinor seeks a de minimis waiver for high resolution geographic (HRG) site survey work through critical habitat that affects fish, fishing rights, and habitat. How can Equinor qualify for a de minimis waiver?

SB 286 legislation and the California Coastal Commission's 7th Condition of its Consistency Determination requires a working group made up of fishermen, wind developers, and State agency representatives to develop a Statewide template for "best practices for site surveys." No surveys should be allowed until the 7c working group is finished and until comprehensive biological and independent acoustic monitoring, and comprehensive mitigation for impacted fishermen are established.

Equinor must know all of this and appears to be going around CA law. Do not cooperate with them. Vote NO at this time to support our marine resources.

Sincerely,

9-23-0874-W (Equinor Wind US LLC

CORRESPONDENCE: Letters of Support

FW: Support for 9-23-0874-W, Equinor Wind US LLC (San Luis Obispo County) waiver

McNair, Heather@Coastal <Heather.McNair@coastal.ca.gov>
Fri 5/3/2024 3:14 AM
To:Energy@Coastal <EORFC@coastal.ca.gov>

From: Street, Joseph@Coastal <Joseph.Street@coastal.ca.gov>
Sent: Thursday, May 2, 2024 5:03 PM
To: McNair, Heather@Coastal <Heather.McNair@coastal.ca.gov>
Cc: Teufel, Cassidy@Coastal <Cassidy.Teufel@coastal.ca.gov>
Subject: Fw: Support for 9-23-0874-W, Equinor Wind US LLC (San Luis Obispo County) waiver

Comment received by Central Coast

From: Kahn, Kevin@Coastal <kevin.kahn@coastal.ca.gov>
Sent: Thursday, May 2, 2024 4:08 PM
To: Susan Callery <susancallery@gmail.com>; Carl, Dan@Coastal <Dan.Carl@coastal.ca.gov>
Cc: Teufel, Cassidy@Coastal <Cassidy.Teufel@coastal.ca.gov>; Street, Joseph@Coastal <Joseph.Street@coastal.ca.gov>
Subject: RE: Support for 9-23-0874-W, Equinor Wind US LLC (San Luis Obispo County) waiver

Good afternoon Ms. Callery, thanks for your note. I'm forwarding to our Energy and Ocean Resources Unit managers.

Kevin Kahn
District Manager
Central Coast District Office
California Coastal Commission
725 Front Street, Suite 300
Santa Cruz, CA 95060

From: Susan Callery <susancallery@gmail.com>
Sent: Thursday, May 2, 2024 4:06 PM
To: Carl, Dan@Coastal <Dan.Carl@coastal.ca.gov>; Kahn, Kevin@Coastal <kevin.kahn@coastal.ca.gov>
Subject: Support for 9-23-0874-W, Equinor Wind US LLC (San Luis Obispo County) waiver

Dear Mr. Carl and Mr. Kahn,

I would like to voice my support for the waiver for Equinor Wind to conduct their site surveys in nearshore waters in the Morro Bay Wind Energy Area.

I led NASA's Jet Propulsion Laboratory's Earth Public Engagement Office for many years and also served as the Managing Editor of NASA's Climate website, climate.nasa.gov. I believe in scientific evidence and am disturbed by the large amount of misinformation in opposition of offshore wind being promulgated by a well-organized group in the area.

I have read a large amount of scientific research related to wind energy, including information about the types of sonar used in site surveys. This kind of mapping has been done by aquariums, universities, and other research institutions around the world, including the Monterey Bay Aquarium. The Nippon Foundation and the General Bathymetric Chart of the Oceans (GEBCO) are working globally to map the whole seafloor topography by the end of 2030. NOAA and the Army Corps of Engineers have also used this technology for seafloor mapping. These surveys help scientists understand undersea erosion, shoreline change, faults, and movement of sediment and pollutants and are carefully regulated. Sonar is also used in stock assessment surveys and fish behavior tracking.

I'm sure you know that the largest threat to marine species, by far, is warming oceans due to fossil fuel combustion.

I urge you to support the finding in support of a de minimis waiver for this effort.

Thank you.

Sincerely,

Susan Callery
Arroyo Grande, CA

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources

Dean Thomas <dthomas134@gmail.com>
Fri 5/3/2024 10:27 PM
To:Energy@Coastal <EORFC@coastal.ca.gov>

Dear Board Members,
I am responding in support of the Commission's decision to allow ocean surveys for offshore wind feasibility studies to proceed without further deliberation because their impacts to the environment are less than significant. This is supported by Mackenzie Shuman's excellent investigative piece in a March Tribune article. Experts were interviewed that said impacts from surveys are temporary and insignificant.
Thank you,
Dean Thomas
Dthomas134@gmail.com
Sent from my iPad

9-23-0874-W (Equinor Wind US LLC)

May 10 2024

CORRESPONDENCE: Individual

Emails

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources

pkoteen@aol.com <pkoteen@aol.com>

Thu 5/2/2024 4:05 PM

To:Energy@Coastal <EORFC@coastal.ca.gov>

Dear Commissioners:

I am opposed to agenda item 7 where Equinor Wind US LLC is seeking a waiver.

The site survey work will surely deleteriously effect marine habitat. At this time of declining fish life, we must work to support marine habitat instead of destroying any of it.

The California Coastal Commission is responsible for protecting California resources. Fish and Fishing rights are highly protected in California. Fish habitat is highly protected in California waters.

Please vote non this item.

Sincerely,
Peggy Koteen
San Luis Obispo, CA

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources

Phillip Baggett <pbaggett1@charter.net>
Thu 5/2/2024 10:20 PM
To:Energy@Coastal <EORFC@coastal.ca.gov>

My name is Vickie Baggett. I live in Morro Bay and enjoy the fresh fish we get from our local fishermen.

I understand the Equinor wants a waiver to do the invasive removal studies prior to the studies that needs to be done for the permitting process.

Please hold the line and help protect the ocean and our fish from procedures that Equinor wants to complete prior to the permitted time.

Please let the process run as it should without Equinor getting special waivers from the Coastal Commission.

You are there to protect our ever unstable environment due to climate change and other matters.

Respectfully submitted
Vickie Baggett
Morro Bay, CA 93442

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources

Linde Owen <lindeaowen@gmail.com>
Fri 5/3/2024 6:11 AM
To:Energy@Coastal <EORFC@coastal.ca.gov>

Dear Commissioners,

I'm writing with my concern over the request for a de minimus waiver from Norwegian Equinor oil and gas group to begin HRG (high resolution geographic) site survey work on the proposed ocean wind farm off the Central Coast.

While HRG survey techniques are not as damaging to marine wildlife as ocean seismic air guns, they inevitably still produce anthropogenic noise disturbance that affects and harms marine life. HRG sources considered to be de minimus will still have a negative effect on a multitude of species, especially if strict mitigation protocols aren't followed.

SB 286 legislation, as well as the CCC's Consistency Determination, Condition 7, requires that a working group of representatives from the local fishing industry, wind developers, and involved State agencies work together to develop a template for Best Practices for Site Surveys.

Until that time, please do not grant Equinor Wind a waiver. Establishing de minimus for California Coastal resources is yet to be determined and they are attempting a go-around.

There's much to be determined about the ultimate financial feasibility of this multi-corporate large project and it is too early to start 'charting' the multitude of disturbance areas this project will ultimately unleash on our marine areas and fishing community.

Thankyou for delaying the site survey work until more details are worked out and best practices are determined from the 7c working group. Please vote no at this time.

Respectively,

Linde Owen
Los Osos
805 528-6403

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources

betty winholtz <winholtz@sbcglobal.net>
Fri 5/3/2024 6:36 AM
To:Energy@Coastal <EORFC@coastal.ca.gov>

Dear Commissioners:

I am concerned about the misuse of a de minimis waiver in the case of Equinor's one-year high resolution geographic (HRG) site survey work within State waters. Surely your scientists are aware of the findings on the East Coast as they are ahead of the West Coast allowing Offshore Wind development.

The California Coastal Commission is responsible for protecting California resources. Fish and fishing rights as well as fish habitat are highly protected in California by our Constitution and laws.

Equinor's map implies they are staying outside of sensitive, protected areas. However, sound does not observe lines drawn on a map. Sound carries into the protected areas. A true public hearing is necessary and rightfully so. Sound experts and vibration experts must be interviewed, so you can decide what level of destruction is acceptable, just as the CCC do so a decade ago.

In addition, SB 286 legislation and the California Coastal Commission’s 7th Condition of its Consistency Determination requires a working group made up of fishermen, wind developers, and State agency representatives to develop a Statewide template for “best practices for site surveys.” **No surveys should be allowed until the 7c working group is finished and until comprehensive biological and independent acoustic monitoring, and comprehensive mitigation for impacted fishermen are established.**

Use the law to protect marine resources for all of us, as the law was designed to do. Object to the de minimis at this time, and call for a regular hearing.

Sincerely,
Betty Winholtz

Public Comment Agenda Item May 2024: Energy, Ocean Resources

Dalila For Assembly D30 <Sunflowers67@protonmail.com>
Fri 5/3/2024 4:45 PM
To:Energy@Coastal <EORFC@coastal.ca.gov>

California Coastal Commissioners,

With respect, are you not responsible for protecting California resources i.e. Fish and Fishing rights which have been highly protected in California? And fish habitat also highly protected in California waters?

It is already a fact that high resolution geographic survey work directly affects fish and habitat which in turn directly affects commercial fishing.

So explain how you are even considering giving a de minimis waiver to Equinor for survey work with HRG? This should not even be on the agenda. Plus there's SB 286 and the 7th Condition of its Consistency Determination clause to consider. So no surveys at all, ever, should be considered until that is fulfilled and established.

We completely understand that Equinor is aware of this but they are obviously trying to take a short cut that is breaking the law, by going through you.

Do not allow this. Vote NO.

From a concerned citizen actively watching what you will allow, knowing it will continue down the California coast in a horribly destructive sequence,

Dalila Epperson
Monterey

Public Comment on May Agenda-- Ocean resources

Laurie Gibson <thesuperioreditor@gmail.com>

Fri 5/3/2024 5:45 PM

To:Energy@Coastal <EORFC@coastal.ca.gov>

Dear Commission,

Today I'm writing to ask that you please consider my perspective regarding the development of wind farms off the California coast.

I am not in favor of this idea, as wind farms off the East Coast shores have resulted in unprecedented disruption to the ocean floor and to the habitats of all marine species in the region.

Please do not approve the development of wind farms off the coast of California; the health of the ocean and all its life forms is vitally important to the planet and should not be additionally imperiled by industrial energy development.

Thank you for your time and attention ~ I sincerely appreciate it.

Laurie Gibson
La Mesa, CA
858-635-1233

Equinor Site Survey: Tell them no

Richard von Stein <anchornow1@gmail.com>

Fri 5/3/2024 6:14 PM

To:Energy@Coastal <EORFC@coastal.ca.gov>

Hello:
The California Coastal Commission is responsible for protecting California resources. Fish and Fishing rights are highly protected in California. Fish habitat is highly protected in California waters. Equinor seeks a de minimus waiver for high-resolution geographic (HRG) site survey work throughout critical habitat that affects fish, fishing rights, and habitat. How can Equinor qualify for a de minimus waiver?
Do not cooperate with them. Vote no at this time to support our marine resources.

Dr Richard von Stein

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources - Permit No. 9-23-0874-W

Richard Hubbard <richhubbard7@hotmail.com>
Fri 5/3/2024 8:26 PM
To:Energy@Coastal <EORFC@coastal.ca.gov>

May 3, 2024

Dear Coastal Commissioners,

This letter is in reference to Permit No. 9-23-0874-W, for Equinor Wind LLC (now Atlas Wind).

I have lived on the Central Coast of California for 39 years and the proposed Offshore Wind projects are by far the biggest industrial projects I have seen during that time. It would be my expectation the California Coastal Commission would take the utmost care and precaution when reviewing each stage of these projects, allowing the maximum public participation (as stated in your mission statement), ensuring adequate notification of the hearing and provision of all related documents.

I use the term "lack of transparency" carefully in referring to the Coastal Development Permit (CDP) *de minimis waiver* staff document for the Equinor site surveys. For the average public member not familiar with the Coastal Commission, it would be almost impossible to find the document written by staff and signed by the executive director. Furthermore, the plans submitted by the applicant are not findable at all. And finally, the timeline of the posting the staff document and submission deadline for written comments is extremely tight. This begs the question as to whether the Coastal Commission has acted in good faith with the residents of California on this large industrial project, or just trying to move this project forward as fast as possible.

The idea this project will be approved as a *de minimis waiver* is inconceivable. Many friends and acquaintances have struggled to work through a full Coastal Development Permit process on projects that are in no comparison to this size and scope of this project. As I read the *de minimis waiver* explanation **the executive director has determined that this project and site surveys specifically will have no potential for any adverse effect on coastal resources, either individually or cumulatively**. I won't even go into the absurdity of the conclusion that your executive director has made. Surveys extending from the coastline to the three-mile state boundary are going to occur adjacent to marine protected areas, state marine reserves, essential fish habitat and near to the Morro Bay National Estuary – many of these areas are reserved for very few activities. The equipment being used operates at high decibels, with no onboard monitoring required. Again, the assertion that there is no potential for any adverse effect to coastal resources is ludicrous.

In closing, I ask you do not approve the *de minimum waiver* and require a CDP for this project.

Sincerely,

Richard Hubbard

Fwd: Agenda Item 7. Waiver 9-23-0874-W

Saro Rizzo <saro@reactalliance.org>
Fri 5/3/2024 9:14 PM
To:Energy@Coastal <EORFC@coastal.ca.gov>

RE: Notice Of Errata

Dear California Coastal Commission:

In the below email I sent to you this morning I made a small typographical mistake. The 6th sentence in the 2nd paragraph should read:

"The sound frequencies produced by the multibeam sonar and sidescan sonar (>200 kHz) are very high and there are no guarantees their use will not result in injury or behavioral changes in marine mammals, sea turtles, and fish."

Regards,

Saro Rizzo

---------- Forwarded message ---------
From: **Saro Rizzo** <saro@reactalliance.org>
Date: Fri, May 3, 2024 at 11:03 AM
Subject: Agenda Item 7. Waiver 9-23-0874-W
To: <EORFC@coastal.ca.gov>

Waiver: 9-23-0874-W
Applicant: Equinor Wind US LLC
Location: Offshore of Morro Bay and Diablo Canyon Nuclear Power Plant, San Luis Obispo County

Dear California Coastal Commission:

My name is Saro Rizzo and I live in Avila Beach, California. I am a public interest attorney and also Vice-President of REACT Alliance whose mission is to protect California's Central Coasts (https://www.reactalliance.org/). I am writing to you regarding the Energy, Ocean Resources, and Coastal Development Permit de minimis waiver No. 9-23-0874-W requested by Equinor Wind US LLC, now Atlas Wind US LLC (Atlas Wind). The application is for state water geophysical, geotechnical sampling, and benthic habitat surveys in state waters off of San Luis Obispo County and directly adjacent to the Point Buchon State Marine Reserve (SMR) and Point Buchon State Marine Conservation Area (SMCA). The matter will be before you at your May 10, 2024, hearing. As you are aware, pursuant to Coastal Act, section 30624.7, a de minimis waiver is not effective until it is reported to the Commission at a scheduled hearing. At this hearing, if four (4) or more Commissioners object to the waiver, then the application must be processed as a regular Coastal Development Permit (CDP) application. I am asking that you object to the waiver at this upcoming hearing and ask that Atlas Wind's proposed project be processed as a regular CDP application so that many very real and legitimate environmental concerns surrounding it are given the proper and close attention they deserve by your staff.

The Executive Director of the Coastal Commission is waiving the requirement for a CDP pursuant to Section 13238.1, Title 14, California Code of Regulations by finding that the proposed development is de minimis. Section 30624.7 of the Coastal Act provides that "proposed development is de minimis if the executive director determines that it involves **no potential for any adverse effect**, either individually or cumulatively, on coastal resources and that it will be consistent with the policies of Chapter 3 of the Coastal Act (commencing with Section 30200)". The project at issue involves Atlas Wind conducting geophysical, geotechnical, and benthic habitat sampling surveys off San Luis Obispo County from the coast to the three-mile state water boundary. The applicant proposes using a combination of offshore vessels (250 – 360 feet in length), nearshore vessels (30 feet in length, and autonomous underwater vehicles (AUVs) to deploy the equipment that will perform their geophysical, geotechnical, and benthic surveys. The nearshore vessel would operate for 12 hours a day and the offshore vessel would operate for 24 hours a day. Geophysical equipment proposed for use in this project includes multibeam sonar, sidescan sonar, and sub-bottom profiler which can generate elevated sound levels (i.e., high decibel). The sound frequencies produced by the multibeam sonar and sidescan sonar (>200 kHz) are very high and there are no guarantees their use will result in injury or behavioral changes in marine mammals, sea turtles, and fish. Further, the sub-bottom profiler also produces sound with frequencies (2-16 kHz) in the hearing range of marine mammals. The April 26, 2024, staff report minimizes these environmental concerns, but given that the use of this equipment will also be taking place directly adjacent to the highly protected Point Buchon SMR and Point Buchon SMCA, **it is impossible to confidently state that there is no potential for any adverse effect.**

The Point Buchon SMR and the Point Buchon SMCA are located eight miles south of Morro Bay in San Luis Obispo County. The onshore-offshore pair of adjoining marine protected areas (MPAs) covers almost 19 square miles of rocky reefs, sandy seafloor and beaches, kelp forests, rocky intertidal areas, and offshore pinnacles. These MPAs also contain some of the shallowest cold-water corals in California. Point Buchon SMR encompasses more than 6½ square miles of ocean waters and spans 2½ miles of coastline between Coon Creek and the Diablo Canyon nuclear power plant. Point Buchon SMCA sits offshore of the SMR and encompasses more than 12 square miles of waters that range from about 200 to 400 feet deep. This area of the ocean is highly productive due to local upwelling of nutrients that support plankton and the marine food web. Kelp forests are filled with rockfish, sea stars, gumboot chitons, and abalone, as well as larger visitors like southern sea otters and migrating whales. (These areas in the marine and estuarine environments were established under California Public Resources Code Section 36710 and are listed in California Code of Regulations Title 14 (CCR T14), Section 632.) These areas are heavily regulated for very important environmental reasons. For example, in a SMR, it is unlawful to injure, damage, take, or possess any living, geological, or cultural marine resource, except under a scientific collecting permit issued by the California Department of Fish and Wildlife (CDFW) pursuant to Section 650 or specific authorization from the California Fish and Game Commission (CFG Commission) for research, restoration, or monitoring purposes. (CCR T14, Section 632 (a)(1)(A)). Similarly, in a SMCA it is unlawful to injure, damage, take, or possess any living, geological, or cultural marine resource for commercial or recreational purposes, or a combination of commercial and recreational purposes except as specified in subsection 632(b), areas and special regulations for use. The CDFW may issue scientific collecting permits pursuant to Section 650. Also, the CFG Commission may authorize research, education, and recreational activities, and certain commercial and recreational harvest of marine resources, provided that these uses do not compromise protection of the species of interest, natural community, habitat, or geological features. (CCR T14, Section 632 (a)(1)(C)). Further, pursuant to Fish & Game Code section 2862, the CDFW in evaluating proposed projects with potential adverse impacts on marine life and habitat in MPAs, must highlight those impacts in its analysis and comments related to the project and must recommend measures to avoid or fully mitigate any impacts that are inconsistent with the goals and guidelines of the chapter or the objectives of the MPA.

The staff report does not even address, let alone mention or analyze, any possible potential adverse impacts the project may have on marine life and habitat in these MPAs even though there is a very good chance they can and will be affected given that the project will be taking place directly adjacent to these areas and the fact sound travels extremely fast and efficiently under water. Given this, there is no doubt that high sound frequencies produced by the multibeam sonar and sidescan sonar, and sub-bottom profiler will enter into these highly sensitive and protected areas and potentially adversely affect them. Given this, a proper analysis must be done by way of a CDP to make sure the area’s unique and protected marine environment remains unharmed. Also, there is no mention in the report of any staff outreach to the CDFW concerning this application and how it could potentially impact the Point Buchon SMR and the Point Buchon SMCA. Further, the report is also silent as to whether the applicant has even sought or obtained a permit from the CDFW for this project.

This is not the time to throw caution to the wind and hope for the best. Such an approach has never been the practice of the California Coastal Commission in performing it’s very important duties under the California Coastal Act. Accordingly, I ask that you object to the waiver and ask that a CDP be required for the project.

Sincerely,

Saro Rizzo

Public Comment on May 2024 Agenda Item Friday 7 - Energy, Ocean Resources

Andrea Lueker <alueker@sbcglobal.net>
Fri 5/3/2024 10:00 PM
To:Energy@Coastal <EORFC@coastal.ca.gov>

May 3, 2024

Dear Coastal Commissioners,

RE: Permit No. 9-23-0874-W, for Equinor Wind LLC

I strongly request that you do not move forward with the de minimis waiver for the proposed Equinor Wind/Atlas Wind project and require the project go through a full Coastal Development Permit hearing process.

After 35+ years of municipal government experience and understanding the importance of clear and transparent communication to the public. I have reviewed the de minimis wavier agenda item for Equinor Wind and am trying to understand how one might believe the process used provides the general public with any idea about the agenda item. This project is likely the biggest industrial project coming to the Central Coast and as such, it would be prudent to make sure that the information is readily available and easily found – it is not. It is also concerning the "staff report" was not available when the agenda was published, the plans/permit submitted by Equinor do not appear to be included at all and the Item 7 agenda title does not describe what is contained within – the de minimis item seems hidden in this section and only those "in the know" would be successful in finding the item.

While the process for this item is concerning and does not yield to the public's education/participation, the more important issue is the recommendation from the executive director to the item moving forward as a de minimis waiver. In reviewing Coastal Act - Section 30624.7 **"A proposed development is de minimis if the executive director determines that it involves no potential for any adverse effect, either individually or cumulatively, on coastal resources…."** It is unfathomable how the executive director determined that conducting geophysical, geotechnical, and benthic habitat sampling surveys off San Luis Obispo County from the coastline to the three-mile state water boundary, 12 to 24 hours each day, using high decibel sound, up to 217 decibels as well as taking core samples by penetrating up to 65 feet into the ocean floor would have no potential of any adverse effect.

Even the most layperson would read the description of the proposed site surveys and conclude that would be some adverse effects to something. And while there continues to be adamant denial by some of any correlation to the horrific whale stranding/death on the east coast, over 470 have died (that are known and that number does not include whale fall) since 2016 near areas of offshore wind activity. Also, since January 2024, there have been 21+ large whale deaths (Right Whales, Humpbacks, etc.) near offshore wind sites on the east coast.

Finally, the decision/statement from the executive director there will be no adverse effects from this project on the west coast due to site surveying is interesting as on the east coast in the Ocean Wind 1 Offshore Wind Farm – Final Environmental Impact Statement, Appendix L, Table L.1 entitled - Potential Unavoidable Adverse Impacts of the Proposed Action https://tethys.pnnl.gov/sites/default/files/publications/OW1_FEIS_AppL.pdf), under the Marine Mammal Column the potential unavoidable adverse impact to marine mammals states "disturbance (behavior effects) and acoustic marking due to underwater noise from pile driving, shipping and other vessel traffic, aircraft, **geophysical surveys (HRG surveys and geotechnical drilling surveys)**…..".

In closing, I strongly request that you do not move forward with the de minimis waiver for the proposed Equinor Wind/Atlas Wind project and require the project go through a full Coastal Development Permit

Hearing.

Sincerely,

Andrea K. Lueker

Former City Manager/City of Morro Bay

Harbor Manager-Retired/Port San Luis Harbor District

Andrea K. Lueker
805.550.3909

Public Comment on 5/24 Agenda, Item Friday 7 - Energy, Ocean Resources

Nina Beety <nbeety@netzero.net>
Fri 5/3/2024 11:54 PM

To:Energy@Coastal <EORFC@coastal.ca.gov>
Cc:nbeety@netzero.net <nbeety@netzero.net>

Dear Commissioners:

I strenuously object to the Equinor proposal and permit waiver. It is the responsibility of the Coastal Commission to protect the ocean and its inhabitants, and to ensure that the public's due process and that of our relatives in the ocean are not blocked or violated. You must avoid harmful impacts to the ocean and its inhabitants, so as to reduce climate change.

However, it appears that both Equinor and Commission staff are skirting public accountability, due process, and state laws, to the detriment of the ocean and its inhabitants and of science.

You are being asked to grant a rushed, secretive waiver. That thwarts a reasoned, science-based assessment of impacts. Assessments of sonar impacts from NOAA or CDFG are not credible given the known biological damage from so-called “inaudible” frequencies. “Audibility” is no guarantee of safety. For instance, very low frequency sound – infrasound – was studied by the U.S. Air Force Institute for National Security Studies which found that transmission of long wavelength sound creates biophysical effects; nausea, loss of bowels, disorientation, vomiting, potential organ damage or death may occur. NOAA's webpage itself states clearly the harm to marine life from sonar – https://www.fisheries.noaa.gov/insight/understanding-sound-ocean Marine Life in Distress

Further, NOAA has a direct conflict of interest due to its partnership with the company SailDrone to sonar-profile the ocean floor for commercial interests. NOAA cannot be depended on for neutral assessment of this project, especially given the heightened political and financial forces driving these policies. No independent assessment has been allowed or even requested from stakeholders or the public. This agenda item has, in fact, been hidden from the public and is intended for a “quickie” approval.

State law (Government Code § 11125(b)) requires that items are listed and described on the agenda. However, Coastal Commission staff unlawfully hid this agenda item in a staff report. This leaves the Commission and Equinor and any decision granting this waiver open to legal challenge overturning it.

Equinor seeks a de minimis waiver for high resolution geographic (HRG) site survey work through critical habitat that affects fish, fishing rights, and habitat. How can Equinor qualify for a de minimis waiver?

SB 286 legislation and the California Coastal Commission's 7th Condition of its Consistency Determination requires a working group made up of fishermen, wind developers, and State agency representatives to develop a Statewide template for “best practices for site surveys.” No surveys should be allowed until the 7c working group is finished with drafts that gather input from the public via public noticing, and until comprehensive biological and independent acoustic monitoring rules, and comprehensive mitigation for impacted fishermen are established. Equinor knows state law but is avoiding compliance. Do not cooperate with them.

The ocean cannot afford more damage or reckless decision-making. Haste makes waste. We cannot afford to get this wrong, or blindly support “green” PR without detailed and public evaluation, and without probing realities. Wind energy, done wrong, risks becoming another costly internal combustion gasoline engine scenario that exacerbates climate change. Safeguarding the ocean environment protects against climate change.

What will your legacy be? Vote NO and support the ocean, marine resources and habitat, and all its life.

Sincerely,

Nina Beety
Monterey

MORRO BAY COMMERCIAL FISHERMEN'S ORGANIZATION, INC.

P.O. Box 450 Morro Bay, CA. 93443
Website: mbcfo.org

May 1, 2024

Dear California Coastal Commission,

Regarding:
Energy, Ocean Resources, and Coastal Development Permit de minimis waiver No. 9-23-0874-W, Equinor Wind US LLC, for state water geophysical, geotechnical sampling, and benthic habitat surveys in state waters off San Luis Obispo County from the coast to the three-mile state water boundary.

I am Tom Hafer, President of Morro Bay Commercial Fishermen's Organization which consists of approximately 90 members. The Morro Bay commercial fishing fleet have grave concerns regarding the proposed site survey work by Equinor in Federal and State waters and **oppose allowing a de minimus waiver**. The Commission should not issue a de minimis waiver because of the conflicts with Coastal Act policies, the Public Trust Doctrine, and the documentation and substantial evidence that the impacts of the surveys are significant and should be subject to the full and complete Coastal Development Permit with a full public hearing and opportunity to be heard and carefully considered; not rushed through without the required permit and hearings via the short-cut of a de minimus waiver. The potential impacts are not de minimus. Further, this waiver or a coastal development permit for site surveys should not be issued until completion of the 7c Working Group and SB 286 mitigations for commercial and recreational fishing.

Historically, high resolution geographic (HRG) site survey work in our area has resulted in lower catch rates (some nearly 70% of their normal average) during the surveys and sometimes for several months to years afterwards. We have experienced this not only with oil exploration but in more recent years with fiberoptic cable surveys and USGS EXPRESS mapping. See attached Declarations of Impacts from recent Equinor's research vessel Island Pride survey work April 19-26 to regional commercial fishermen.

A 2017 study published in Ecology and Evolution titled "Widely used marine seismic survey air gun operations negatively impact zooplankton" demonstrated a decrease in zooplankton and dead larvae and krill after seismic surveys. I know you are saying "but that is with air guns" but the study used an avg of 120kHz and 156 dB to 183 dB peak for the study, similar to what is allowed in the SLC site survey permit. Also, high frequency sound may not cause sound particle movement impacts, but it does cause sound pressure impacts depending on how close it is to the species. (Per acoustic specialist Arthur Popper). The study on impacts to zooplankton is attached as Addendum A.

The State Lands Commission (SLC) rubber stamps General permits to do site surveys from an old 2014 CEQA. **The SLC provides minimal or zero enforcement of the survey work**. **There is no independent acoustic monitoring, biological assessment of impacts and no mitigation for impacted fishermen provided.** There is never even a Notice to Mariners, so fishermen are unaware of the survey taking place. As a result, we attribute wild fluctuations in our catches to something else, not knowing that high decibel pounding had been going on near our fishing grounds.

Surveys last for hundreds of hours, months, and sometimes, years at a time and cover thousands of acres of ocean. This scares away, damages and or kills fish and can kill krill, zooplankton, eggs, and larvae, the base of the food chain, resulting in several years of impacts.

There have been **mass mortality events during the time and location of HRG surveys**, that were never analyzed and/or attributed to the fact high decibels can deafen whales and kill krill, their food source. Coincidentally, in 2019, 600 Gray whales died along the Pacific Coast. The USGS EXPRESS mapping program went from 2018-2020, with most of the HRG mapping in 2019. The East Coast has had over 475 whales die and 1000s of other cetaceans since site surveys for offshore wind began in 2016.

There are **problems of enforcement of the HRG surveys.** The President of the Humboldt commercial fishermen's organization, Ken Bates, wrote a letter to you in 2020 describing the issues the Humboldt fishermen had with a survey vessel working during Dungeness crab season destroying several traps. When the incident was reported to the SLC, they had no idea the survey vessel was even there. See the attached letter under Addendum B.

CSA Ocean Sciences did a study titled "Low Energy Offshore Permit Program" in 2013. In the study, they found several issues with the SLC permit program. One important problem sited was the lack of enforcement:

"**Summary:** *There is currently* ***no mechanism in the Public Resources Code relating to the CSLC's geophysical permit authorities to establish or implement enforcement or penalties for non-compliance.*** *As a result, there is an obvious financial advantage, in terms of compliance costs, to a contractor if they are working without a permit. For permittee contractors who violate the* *terms and conditions of a geophysical permit, the Commission's only clear remedial action is to revoke the permit."*

We have asked the State Lands Commission what has been done to improve enforcement of the HRG surveys and we have gotten no answer. The CSA study is attached under Addendum C.

Robert Rand is an acoustic specialist. Much of his work is studying the sounds of whales all over the world. He was concerned when he saw a mass mortality event of whales on the East Coast, so he began using his hydrophone in the waters near the HRG survey vessels. **He found that the noise emitted from the survey vessels were much higher than what they were permitted**. He believes that the noise from the thrusters and positioning systems (126dB at 9.5Hz) were not calculated into the total noise. This allowed a smaller safety zone for endangered species. This may be what contributed to the mass mortality of several hundred whales and cetaceans and the reason **independent acoustic monitoring of survey work should be required.** The Rand Acoustic report is attached as Addendum D.

There has never been a biological study in the Pacific Ocean, or really anywhere, of the impacts from HRG surveys. The BOEM EA references old 2014 irrelevant studies. Arthur Popper is a renowned fish bioacoustics specialist. He did studies in labs with artificially simulated noise. He documents the results in his 2018 paper "An overview of fish bioacoustics and the impacts of anthropogenic noise on fish". He found that fish, particularly those with swim bladders are susceptible to high decibel pressure expanding their swim bladder, damaging organs, hair cells, and causing gas emboli. He noted small bait fish to be highly susceptible since their hearing is near their swim bladder. He found fish and larvae died at 207 db. Mr. Popper says he assumes there will be minimal impact from high frequency surveys but admits it has not been studied in real life situations and is unwilling to confirm either way. This is the reason **biological monitoring studies before, during, and after in a control and impacted area should be required**. When there is any possibility of significant impacts, there needs to be checks and balances. Mr. Popper's paper is attached as Addendum E.

Fish and Fishing rights are highly protected in California. There are multiple protections in the Constitution, Public Trust doctrine, the Coastal Act, the Endangered Species Act, the Marine Mammal Protection Act, the Marine Life Protection Act, and multiple regulations enforced by the Dept. of Fish and Wildlife and Pacific Fisheries Management Council. **The wind energy area and cable routes are in designated Essential Fish Habitat, Habitats of Particular Concern, and near or inside Marine Protected Areas, a National Marine Sanctuary and Environmentally Sensitive Habitat Areas. They are in the habitat of Endangered sea otters, leatherback turtles, and 6 listed whales**. How could they possibly qualify for a de minimis waiver?

If the Commission erroneously issues the de minimus waiver, or a coastal development permit after public hearings, **it must include the following conditions required by the California Constitution and the Coastal Act:**

"1. This de minimis waiver is subject to the provisions of the California Constitution, Article I, Declaration of Rights Section 25, that:

"**The people shall have the right to fish upon and from the public lands of the State and in the waters** thereof, excepting upon lands set aside for fish hatcheries," and this waiver expressly reserves "in the people the absolute right to fish thereupon."

"2. This de minimis waiver is subject to the limitations in California Constitution, Article X, Water, Section 4, providing that **the permitted is not allowed to "destroy or obstruct the free navigation"** of "navigable water in this State of such water".

3. This de minimis waiver is subject to the limitations of Public Resources Code Section 30234: "**Facilities serving the commercial fishing and recreational boating industries shall be protected, and where feasible, upgraded**. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists, or adequate substitute space has been provided."

"4. This waiver is subject to the limitations of Public Resources Code Section 30230: "**Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance.** Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreation, scientific, and educational purposes."

"5. This de minimis waiver is subject to the provisions of Public Resources Code that: "**The economic, commercial and recreational importance of fishing shall be recognized and protected**."

SB 286 legislation and the California Coastal Commission's 7th Condition of its Consistency Determination requires a working group made up of fishermen, wind developers, and State agency representatives to develop a Statewide template for monitoring and mitigation of offshore wind which includes "**best practices for site surveys**". Equinor or any other wind energy developer should not be allowed to do anything until the 7c working group is finished and until comprehensive biological and independent acoustic monitoring, and comprehensive mitigation for impacted fishermen are established. The working group isn't expected to be finished for several months. **Equinor realizes all of this but insists on pushing forward in trying to skirt around our laws.** American fishermen that do follow the laws and have a huge, vested interest in their livelihoods; paying for expensive permits, vessels, gear, licenses, and taxes should get your vote over a foreign company coming into our waters with no evidence they are concerned about protecting our fisheries or the rights of our fishermen more than their bottom line.

Finally, Despite significant efforts from the commercial fishermen of Morro Bay and Port San Luis to negotiate a monitoring and mitigation plan with the Wind developers prior to the beginning of their project activities, they refused. This forced us to take the legal route. We filed a Writ of Mandamus Feb. 29, 2024, complaining they are not following California's legal process before proceeding. Equinor ignored our complaint and pursued survey work in Federal waters enabled by the staff of the Coastal Commission. So, now the fishermen are forced to file for Injunction relief against Equinor. We filed an order to show cause why preliminary injunction should not be issued and the order was signed by a judge April 22, 2024. The first hearing is May 15, 2024. **Should surveys in State waters be allowed to go forward when completion of SB286 mitigations and monitoring is pending judicial decision in San Luis Obispo Superior Court?**
I have attached the lawsuit titled: "Errata exhibit package in support of reply to opposition to exparte application for order to show cause why preliminary injunction should not issue."

Sincerely,

Tom Hafer, President MBCFO

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SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SAN LUIS OBISPO

MORRO BAY COMMERCIAL FISHERMEN'S ORGANIZATION, PORT SAN LUIS COMMERCIAL FISHERMAN ASSOCIATION, Petitioners/Plaintiffs v. **CALIFORNIA STATE LANDS COMMISSION, CALIFORNIA COASTAL COMMISSION, CALIFORNIA WATER RESOURCES CONTROL BOARD, DOES 1** through **20;** Respondents/Defendants. **ALTAS WIND I, LLC, aka EQUINOR; CSA OCEAN SCIENCES INCORPORATED; GOLDEN STATE WIND, LLC, aka CENTRAL CALIFORNIA OFFSHORE WIND, LLC; EVEN KEEL WIND, LLC, aka INVENERGY CALIFORNIA OFFSHORE LLC,** Real Parties In Interest	Case No.: 24CV-0152 **DECLARATION OF BILL BLUE IN SUPPORT OF REPLY TO OPPOSITION TO SHOW CAUSE** **TIME: 9:00 AM** **HEARING DATE: MAY 15, 2024** **DEPT: 2** **ACTION FILED: FEBRUARY 29, 2024** **JUDGE: HON. CRAIG VAN ROOYEN**

I, BILL BLUE, DO DECLARE AND STATE THAT:

1. I have been fishing out of Morro Bay since the winter of 1974-75 and owned and operated four (4) boats over my 49-year career as a commercial fisherman. Morro Bay has always been my home port. I have participated in all but a few fisheries over that time. In 2007, I started to focus on long-lining for Black Code and Thornyheads. In 2010 I purchased my current Vessel, the forty-five-foot Breita Michelle, from Cape Brenton Island in Nova Scotia.

2. My current fishing operation uses both long-lines with hooks and long-lines with traps. My fishing operation uses up to two crew and takes place between Point Conception and Point Sur in 200 to 600 fathoms of water, targeting Black Cod, Thornyheads and other deep water and slope complexes.

3. Traditionally, April, May and June are very productive months for our fishery. This past April, 2024, we made four trips in these fishing areas. The first three trip were prior to the Island Pride beginning its survey work in areas I would traditionally and often fish. I am very familiar with that the survey area as well as other areas where I have fished. Here is a summary of my first three trips:

Trip # 1: Departure 4-1-24 at 22:00 hours, returned 4-3-24 at 02:30 a.m.

TOTAL POUNDS OF FISH DELIVERED: 7,680

Trip # 2: Departure 4-9-24 at 16:00 hours; returned 4-10-24 at 19:15 hours.

TOTAL POUNDS OF FISH DELIVERED: 6,927

Trip# 3: Departure 4-16-24 at ll:30 hours, returned 4-17-24 at 20:15 hours.

TOTAL POUNDS OF FISH DELIVERED: 8,4084

4. On April 19, 2024, the Island Pride, research vessel, began its survey work in the vicinity just to the north of where I was fishing and the same areas I fished in Trips #1, #2, and #3. The

Island Pride was in the vicinity (BOEM lease area) from April 19 to April 28, 2024. My fourth trip occurred while the Island Pride was in the vicinity conducting its survey work while I completed my normal fishing operations where we had fished on Trips #1, #2 and #3. The conditions in terms of weather and tides were similar to the other trips and generally were favorable for commercial fishing. The Island Pride was approximately ten (10) miles from my locations, varying over time. The similarity of conditions occurs because we intentionally choose the best weather conditions for our trips to maximize the returns, since operating a commercial fishing vessel is very costly in terms of fuel, ice, bate and government fees (IFQ Fishery has associated costs and charges ("fees").) This is the information for Trip #4 (Island Pride):

Trip# 4: Departure 04-24-24, at 01:25 hours, returned 04-24-24, at 22:15 hours
TOTAL POUNDS OF FISH DELIVERED: 2,335

Trip #4 represented a sixty-seven percent (67%) reduction from the average of Trips 1, 2, and 3 prior to the Island Pride being in the general vicinity.

5. Due to the regulations of the IFQ fishery (Individual Fishing Quota, NOAA) which I participate in, I am one hundred percent accountable for every fish that comes over the rail of my boat. These figures are generally accepted as accurate and verifiable. I am required to have videos of each fishing trip of each time the boat leaves the dock until the last fish is unloaded on return to the dock; I keep a log book which has to coincide with the review of the video recording; there is an additional individual who I pay to verify what comes off my boat during the unload for which there are also records.

6. Over the length of my 49-year career, I have experienced many situations where there are surveys occurring in and around our preferred fishing areas. The past surveys have included oil

exploration, fiber optic cable pre-site installation surveys, and bottom surveys. There is always a behavioral change in the fish when surveys occur. It has been an accepted industry methodology in determining the impacts of surveys to rely upon "fish ticket" records in comparison to non-survey conditions which are otherwise similar. Until the Island Pride arrived, the fiber optic, trans-Pacific cable installation surveys were the most frequent site surveys before installation took place. We have informed the representatives of the three offshore wind lessees that site surveys will have impacts on commercial fishing and potentially on the viability of the fisheries.

7. Along with other fishermen, I will not be able to engage in my fishing activities in the approximately 360 +/- square miles of the wind energy projects, which is referred to as a preclusion impact on commercial fishing. We will no longer be able to fish in those areas, including transmission cables, substations, and underwater facilities required to "land" the energy onshore. The fishing methods we use involve deploying long-lines with hooks and traps from one mile in length to five miles in length, and we typically deploy a maximum of eight such lines and a minimum of two such lines during the same trip. These lines drift due to tidal, wind and ocean conditions which makes avoiding the wind facilities increase the areas of preclusion. There are currently no mitigation requirements for impacts from site surveys and ultimately, construction, operation, maintenance and de-commissioning related to commercial fishing or sustaining the productivity of fishery habitats. At this time the wind companies are not responsible for damage, known or unknown, from the site survey work, in part because of the 7c Working Group has not completed the site survey best practice protocols or the SB-286 commercial fishing mitigation requirements.

8. For fifteen years, I have been a member of the Dungeness Crab Task Force (DCTF) funded by the Ocean Protection Council to help regulate the Dungeness crab fishery. I was selected by

the Coastal Commission to be a member of the Working Group as one of six to eight commercial fishing representatives. I resigned as a member of the Working Group because I learned that Statewide Strategy under SB-286 and Condition 7c, including the site survey best practice protocols and other project components, would not be completed before the start of site surveys. It is my opinion that it would be a futile exercise to continue working on the Statewide Strategy including site survey protocols if the Strategy would not be adopted and implemented before the first phases of the projects commenced. My opinion of "futility" has been confirmed by the start of the site surveys before the 7c Working Group and Statewide Strategy, including best practice site survey protocols, has been adopted under SB-286 or the Coastal Commission Consistency Determination Condition 7c.

9. Based upon my experience with commercial fishing and with fishing mitigation, our industry is subject to extensive regulation and many sources of uncertainty. While some uncertainty is inherent in being a fisherman, other aspects of uncertainty are created by the future risks of impacts from ocean developments and especially the wind energy projects, because of their preclusion impacts and the vast scale of the projects planning, construction, operation and decommissioning. The Coastal Commission Consistency Determination (CD-0004-22 (BOEM) for the Morro Bay Lease Areas the uncertainties impacting commercial fishing and that the lease activities *before* any site surveys for offshore wind energy adds to those uncertainties (p. 24.):

> "However, issuance of leases will have immediate effects on fishing communities even before any lease development activities occur, as the leases and overall BOEM process injects uncertainty into an occupation that is heavily regulated and uncertain."

The uncertainties are further exacerbated by the commencement of site surveys without best practice protocols being adopted, widely understood, enforceable, monitored, potential impacts mitigated, and in place. Because of these uncertainties, there is a general loss of interest in participating, starting, buying into existing fishing operations, or learning the commercial fishing business, because the risks of offshore wind energy are currently not mitigated and the site surveys not subject to clear, adopted and enforceable best practice protocols and monitoring. There is a widespread belief that site survey impacts on fisheries are uncertain and the lack of publicly adopted protocols fosters that uncertainty. I know of individuals trying to sell their commercial fishing permits and businesses which have significantly decreased in value due to the uncertainty of the industry in the face of offshore wind energy project commencing, and without best practice protocols. The uncertainty discourages investment in existing commercial fishing businesses. Based upon my years of experience and general knowledge of the commercial fishing industry, it is my opinion that only with well understood, enforceable and comprehensive mitigation and monitoring programs, such as SB-286, and a viable Statewide Strategy adopted after public hearings before the site surveys commence, can the current decline of the industry be meaningfully addressed and mitigated.

10. I also fish rock crab and Dungeness crab in the inshore waters within the jurisdiction of the State of California. If site surveys are allowed in those areas, there are no mitigations or protocols for conducting any site surveys around that type of gear. This is because the gear stays in the ocean between servicing. Under the CFR's for that type of fishing gear, that gear has the right of way and the gear is not supposed to be tampered with, disturbed, moved, or damaged by anyone other than the owner of the gear. Currently, since there are no site survey best practice protocols, there would be a direct conflict between my fishing gear and the conduct of the site surveys. My gear has buoys on the surface to identify the locations and retrieve the catch, and those buoys are connected by ropes to the traps and could likely become entangled with the

survey equipment/devices. This is another reason why site survey protocols must be completed before site surveys commence.

I declare under penalty of perjury that the foregoing is true and correct and based upon my personal knowledge and professional experience, represents my truthful professional opinions, and that if called to testify concerning the same, I could and would do so truthfully and competently.

Executed at Templeton, California, this 2nd day of May, 2024.

/S/ Bill Blue

BILL BLUE

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SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SAN LUIS OBISPO

MORRO BAY COMMERCIAL FISHERMEN'S ORGANIZATION, PORT SAN LUIS COMMERCIAL FISHERMAN ASSOCIATION, Petitioners/Plaintiffs v. **CALIFORNIA STATE LANDS COMMISSION, CALIFORNIA COASTAL COMMISSION, CALIFORNIA WATER RESOURCES CONTROL BOARD, DOES 1** through **20;** Respondents/Defendants. **ALTAS WIND I, LLC, aka EQUINOR; CSA OCEAN SCIENCES INCORPORATED; GOLDEN STATE WIND, LLC, aka CENTRAL CALIFORNIA OFFSHORE WIND, LLC; EVEN KEEL WIND, LLC, aka INVENERGY CALIFORNIA OFFSHORE LLC,** Real Parties In Interest	Case No.: 24CV-0152 **DECLARATION OF OWENHACKLEMAN IN SUPPORT OF REPLY TO OPPOSITION TO SHOW CAUSE;** **TIME: 9:00 AM** **HEARING DATE: MAY 15, 2024** **DEPT: 2** **ACTION FILED: FEBRUARY 29, 2024** **JUDGE: HON. CRAIG VAN ROOYEN**

I, OWEN HACKELMAN, DO DECLARE AND STATE THAT:

1. I have been a commercial fisherman for fourteen years and have fished out of Morro Bay Harbor during that time period. I have a Bachelor of Science Degree in Biology from California Polytechnic University, San Luis Obispo. My fishing business and practices involve fishing for Sablefish and Thornyheads, which are deep water ground fish mostly located in water depths from 300 to 550 fathoms. These are specialty fish markets located mostly in California. My vessel, the Provision, is forty feet long, fiberglass, with one crewman. I usually go out for between 20 hours and two days at a time. I fish anywhere in those water depths between Point Lopez in Monterey County and Point Conception in Santa Barbara County, unusually from fifteen to forty miles from shore, depending on the water depth.

2. We left Morro Bay Harbor on the early morning of April 23, 2024 and returned on the morning of April 24, 2024. We fished approximately 40 miles west of Morro Bay and could observe at night the lights from a Vessel and on my AIS software could identify the Vessel, the Island Pride. I intentionally stayed to the south of the Island Pride, which was in an area I have often fished, and also I have often fished.

3. We returned to Port to unload our catch at Morro Bay. We have had consistently good fishing in those areas in the past few years. On April 24, we landed 2,028 pounds, and the previous trip with similar conditions (except the Island Pride) we landed 3,048 total pounds, or which represents a 34% reduction from the prior trip. We unloaded about 1900 pounds of Black Cod. We are allowed to catch an upper limit of 2500 pounds per week for Black Cod; we almost always reach that limit. The disappointing catch of 2028 total pounds, has

serious economic impacts on us because of fixed costs to fish (fuel, bate, crews). We were unable to catch more than two pounds (one fish) of Grenadiers which is unusual in that area; and the week before when the Island Pride was not in the vicinity, we landed 440 pounds. We try to fish on a tide that changes significantly because it creates more currents and generally is better for fishing. This time period had greater tide changes which usually is beneficial for the size of the catch, so the reduced results of the size of the catch was not to be expected.

4. Typically, variations in quantities of catch will be relatively small when the general conditions are similar. We try to fish when the other conditions, such as wind and tides, are favorable. Our catch rates tend to be predictable and stable unless there are unusual conditions. The only unusual condition which is different from our typical conditions on this last trip was the presence of the Island Pride, which crisscrossed large areas of our preferred fishing grounds areas twenty-four hours a day for several days immediately before and immediately after our last trip.

5. If the area where the Island Pride was conducting site surveys is developed with large wind energy developments, we will be permanently displaced from fishing in those areas. This is because we set long-lines with buoys between two and six miles long with anchors at each end; the buoys are attached to lines that go from the surface to anchors on the bottom at each end of the lines. The whole length of the lines needs to rest on the bottom in order to catch the fish. By the time when we set the line and it reaches the bottom, the location of the lines can shift and move over a mile due to the currents. There is no way that we can have any viable commercial fishing in the wind farm areas because of these conditions.

6. The food web for our fishing areas is dependent on phytoplankton at the base of the food chain, then zooplankton, krill, then various fishes, squids, etc. Whales depend upon krill and small fish; so that whale mortality in significant or unusual numbers is an indicator that the food web affecting many fish species is being disrupted. This is why reported whale mortalities along the East Coast occurring during and after site surveys for offshore wind proposals, in addition to the sad loss of the species, is concerning for commercial fishermen who depend upon the viability and sustainability of the food web on which the fish also depend.

I declare under penalty of perjury that the foregoing is true and correct and based upon my personal and professional experience, and that if called to testify concerning the same I could and would do so truthfully and competently.

Executed at Atascadero, California, this 2 day of May, 2024.

/S/ Owen Hackleman

OWEN HACKLEMAN

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ARTICLES
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Widely used marine seismic survey air gun operations negatively impact zooplankton

Robert D. McCauley[1]*, Ryan D. Day[2], Kerrie M. Swadling[3], Quinn P. Fitzgibbon[2], Reg A. Watson[2] and Jayson M. Semmens[2]*

Zooplankton underpin the health and productivity of global marine ecosystems. Here we present evidence that suggests seismic surveys cause significant mortality to zooplankton populations. Seismic surveys are used extensively to explore for petroleum resources using intense, low-frequency, acoustic impulse signals. Experimental air gun signal exposure decreased zooplankton abundance when compared with controls, as measured by sonar (~3–4 dB drop within 15–30 min) and net tows (median 64% decrease within 1 h), and caused a two- to threefold increase in dead adult and larval zooplankton. Impacts were observed out to the maximum 1.2 km range sampled, which was more than two orders of magnitude greater than the previously assumed impact range of 10 m. Although no adult krill were present, all larval krill were killed after air gun passage. There is a significant and unacknowledged potential for ocean ecosystem function and productivity to be negatively impacted by present seismic technology.

Phytoplankton and their grazers—zooplankton—underpin ocean productivity[1,2], therefore significant impacts on plankton by anthropogenic sources have enormous implications for ocean ecosystem structure and health. In addition, a significant component of zooplankton communities comprises the larval stages of many commercial fisheries species. Healthy populations of fish, top predators and marine mammals are not possible without viable planktonic productivity[1–3].

Man's dependence on fossil fuels requires continual exploration for new resources. Deposits of undiscovered oil and gas reserves in the world's oceans[4] are estimated to be substantial (Fig. 1), with exploration occurring in most petroleum provinces. In the marine environment, exploration is achieved via an acoustic imaging technique that uses intense, low-frequency impulse signals generated near the sea surface and directed into the seabed ('seismic surveys')[5]. Spatially distributed arrays of air guns simultaneously release high-pressure air (13.8 MPa or 2,000 psi) into the water to produce the impulse signal. Reflections from sub-sea density discontinuities received by strings of hydrophones enable sub-sea image generation. Commonly, a series of closely spaced parallel tracks are followed to systematically survey large swathes of ocean, each track with a series of acoustic signal locations (Fig. 1b,c)[5].

Published details of global seismic survey activity are scarce. As an example of effort, in Australian waters alone during 2014 and early 2015, an average of 15,848 km of petroleum-related marine seismic surveys were completed every three months[6]. Along with petroleum exploration, seismic surveys are also used: (1) to image sub-sea formations likely to be used as 'traps' for sequestering CO_2 (ref. [7]); (2) in scientific surveys of the Earth's geology; 3) (for shallow, engineering-related 'site' surveys; or (4) for monitoring petroleum recovery from producing fields[5].

Our understanding of the impact of seismic surveys on the environment is still developing. Considerable effort has been put into understanding the impacts on whales, with evidence of affected behaviour and hearing physiology[8]. Although fish have received less attention[9], behavioural and pathological impacts have been reported for adults[10–13] and eggs[14,15]. Comparatively little effort has been focussed on impacts on invertebrates[16,17]. One study on larval invertebrates showed significant malformations to scallop veliger larvae from simulated air gun exposure in the laboratory[18], whereas a second found no meaningful impacts on larval hatching success or viability immediately post-hatching for lobster eggs exposed to an air gun *in situ* while on the adult female[19]. No published studies have been conducted on seismic impacts on plankton. On small scales zooplankton can be surprisingly mobile, capable of moving several body lengths per second[20–23]; however, they cannot escape an approaching air gun array. We cannot fully understand impacts of seismic surveys on higher order fauna or on an ecosystem level without knowledge of how organisms at the base of the food chain respond. Our experiments were designed to assess how operation of a single air gun (2.46 l or 150 inch^3) of similar mean volume to those used commercially in an array (2.57 l or 157 inch^3 from 25 arrays[24]), operating in a field environment, would impact the local zooplankton field. To investigate potential impacts, sonar surveys, net tows for zooplankton abundance and measurements of dead to total zooplankton counts were assessed before and after air gun operations.

Results

Replicated experiments were conducted on the 2 and 3 March 2015 (Day 1 and Day 2; operations shown in Fig. 2 for Day 1). The conductivity–temperature–depth (CTD) casts (Supplementary Fig. 1) suggested that the upper 25 m of the water column was well mixed, so drifter measurements applied to the entire upper water column. At the time of air gun runs, drift rates were 0.19 m s^{-1} at 171° on Day 1 and 0.12 m s^{-1} at 56° on Day 2. Thirty-four plankton taxa were

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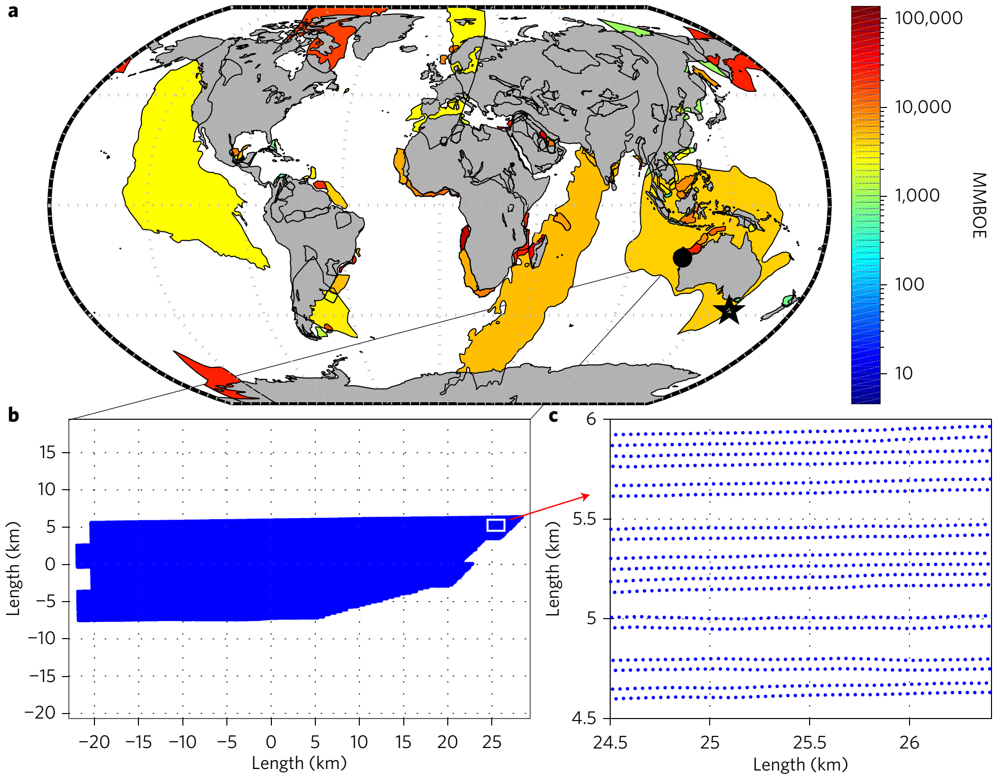

Figure 1 | Potential undiscovered oil deposits worldwide and seismic survey scales. a, Estimated undiscovered marine oil deposits shown by geological province using a logarithmic colour scale in millions of barrels of oil equivalent (MMBOE; source: USGS data[6] for 2012), location of experiment shown by a star symbol. **b**, A typical 3D seismic survey area, located by the black circle in **a**. **c**, Close-up of seismic lines with individual air gun firing locations, from the area indicated by the white rectangle in **b**.

counted in net tows (abundance as individuals (ind.) m^{-3}, listed in Supplementary Table 1). After excluding tows with zero values, 189 taxa/tow combinations ('taxa/tow') were available for comparison of abundance. The taxonomic composition of control tows was similar on Days 1 and 2, with copepods comprising 71% of total taxa counted, cladocerans 15%, euphausiid larvae 4%, appendicularians 5% and the remainder comprising meroplanktonic groups such as larvae of decapods, polychaetes and molluscs. Of the Euphausiidae (krill, *Nyctiphanes australis*), only larval forms were present in samples, possibly due to low net tow speeds. One shark was sighted immediately after the air gun transect on Day 2 and no marine mammal sightings were made.

The site characteristics differed between Days 1 and 2 based on control sonar backscatter observations, zooplankton net tow abundance and locations of fish in the water column. On Day 2, control sonar results showed a significant decrease in zooplankton backscatter (Sv, dB re m^{-3}) from Day 1 ($P << 0.001$, two-tailed *t*-test when comparing mean values within 6–15 m depth range and 10 m range increments, mean ± s.d. of −81 ± 0.1 and −85 ± 0.1, Days 1 and 2, respectively). On Days 1 and 2, the numbers of individual fish targets per 100 m in the control sonar transects were similar (6.8 and 6.1 fish, respectively), but on Day 2 significantly more of these fish were in the water column rather than close to the seabed (comparing mean fish depth below sea surface Days 1 and 2 in 5–25 m depth range, $P < 0.05$, two-tailed *t*-test). Sonar-derived fish schools were similar in number and area on Days 1 and 2 (5 and 7 schools of 82 and 106 m^2, respectively). The mean and median zooplankton abundance decreased by 89% and 96%, respectively (Fig. 3d), when comparing ratios of control zooplankton abundance (Day 2/Day 1) using all taxa/tows with non-zero data ($N = 78$), with data highly skewed to lower abundances in any tow made on Day 2. Mean control abundance had decreased by 91% on Day 2 with all taxa combined each day ($N = 30$).

When comparing exposed with control zooplankton abundance for Days 1 and 2 (Supplementary Table 1), 58% of taxa abundance (ind. m^{-3}) were reduced by ≥50% after air gun exposure when using all taxa pooled for all range categories (so excluding range effects) and only taxa with >10 counts in exposed or control groups ($N = 48$). Furthermore, there was a statistically significant lower zooplankton abundance after air gun exposure ($P < 0.001$, two-tailed *t*-test) when comparing ratios of control abundance with exposed divided by mean control ratios (exposed/control), using all taxa combined or using all crustacean taxa. The distribution of exposed/control abundance for all taxa was skewed to low values with a median abundance reduction of 64%, and 37% with an abundance decrease of ≥95%. For exposed/control ratios ≥1, or no impact, 89% of these occurred on Day 2 when total zooplankton abundance was lower, and 50% of these occurred on Day 2 at the greatest range from the air gun signal (1,200–1,300 m). Exposed abundance reductions of no-change (0%), 25% and 50% compared with control values occurred at ranges of 808, 639 and 409 m, respectively (s.d. 390, 312, 270 m, respectively), as calculated from means of fitted power curves of abundance reduction with range from the drift translated air gun signal location (DTASL; see Supplementary Table 2 for plankton tow ranges, Methods for DTASL definition) for ten independent taxa with r^2 value of >0.8 where only tows with $N > 10$ (control or exposed) were used to generate the curves. Copepods and cladocerans comprised 86% of total zooplankton present, so their pooled abundance reduction with range after air gun passage is important (Fig. 3e). The ranges at which, respectively, no change, and abundance reductions of 25% and 50% occurred for copepods and cladocerans, were

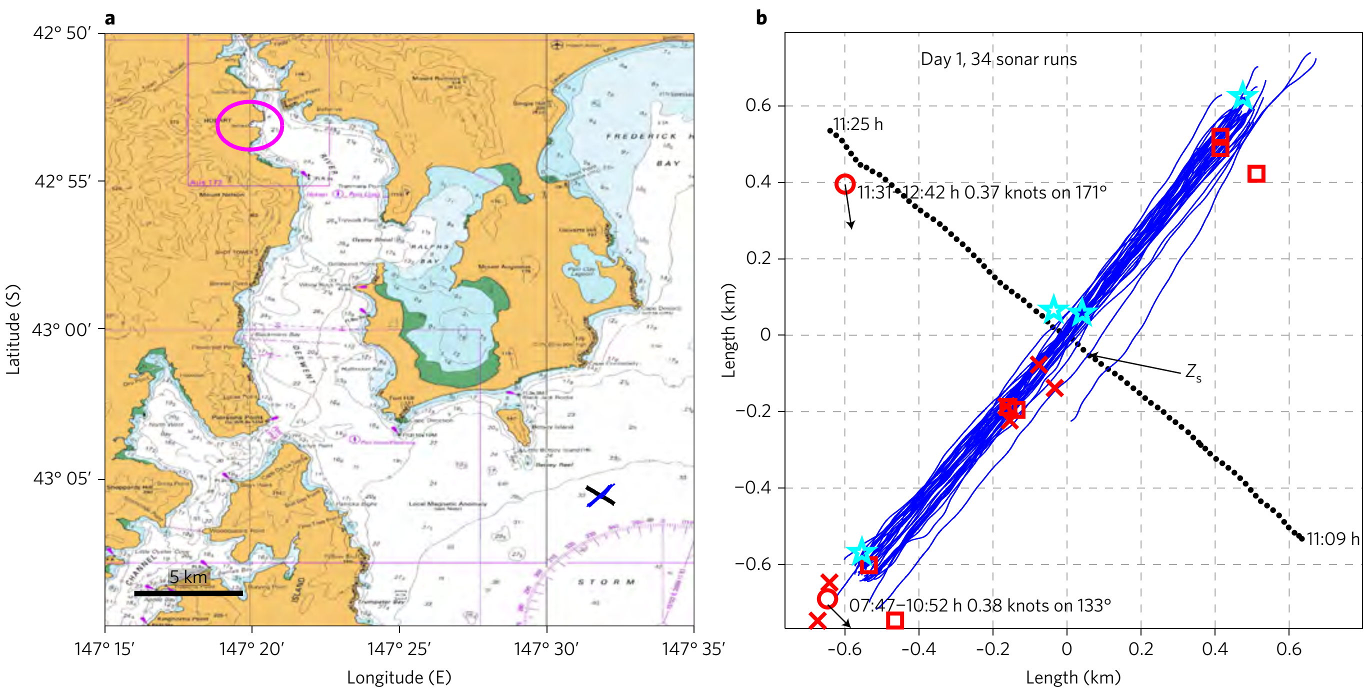

Figure 2 | Location of experimental site in southern Tasmania. a, General area showing air gun (black) and sonar transects (blue) overlaid on Australian chart AUS00796. The magenta circle is Hobart city (from Australian Hydrographic Service chart under Seafarer GeoTIFF Curtin University licence no. 2618SG). **b**, Close-up of experimental set-up for Day 1. Black dots, air gun signal locations; blue lines, sonar transects; red circles with arrows, drifters; red squares, control plankton tow locations; red crosses, plankton tow locations made after air gun exposure; cyan pentagrams, sea noise logger locations. One air gun sonar transect crossing point (Z_s) is shown. Axis scales are zeroed to the Z_e point. The world-wide location of the site was shown by the star in southern Tasmania in Fig. 1.

at 973–1,119 m, 795–932 m and 509–658 m (mean to median values using fitted power curves, $r^2 > 0.92$).

In addition to zooplankton abundance, mortality was assessed using vital stain counts and dead/total ratios (total being dead + live animals) as derived for taxonomic groups of copepods, nauplii and all other taxa (impact ranges and raw counts in Supplementary Tables 2 and 3, respectively). Vital stain control counts were pooled for each taxa per day. To look for range impact effects of air gun exposure in the vital stain results, exposed plankton tows were pooled into range groups of: (1) 79 m Day 1 + 71 m Day 1 + 149 m Day 2; (2) 451 m Day 1 + 547 m Day 2; and (3) 1,248–1,300 m Day 2 (Supplementary Table 3). There were significantly more dead animals in all taxa (copepods, nauplii and other taxa) for all range groups when comparing dead/total ratios of exposed with their respective controls (Fig. 3f for mean values, Supplementary Table 4 for statistics). In general, there were two to three times more dead zooplankton after air gun exposure compared with controls at all range groups for all taxa. All krill larvae found in all exposed samples were dead at all range groups following the air gun pass. The 'copepods dead' category was dominated by the smaller copepod species (*Acartia tranteri*, *Oithona* spp.). Although there were decreasing trends apparent in the ratio of dead to total counted with distance from impact for copepods and nauplii, these were not significant given the variance.

On Day 1, a 'hole' developed in the non-fish sonar backscatter (S_v) extending to ~20–30 m depth, which became noticeable 15 min after air gun passage and continued to expand and move coincident and symmetrically with the DTASL through time. When S_v in the upper 20 m of the water column was significantly reduced on Day 2, this 'hole' was not evident. Examples of the development of this 'hole' are shown in Fig. 4a–d, where consecutive sonar transects made every 15 min from the first air gun, sonar transect crossing time (T_{s1}), are shown.

To elaborate 'hole' definition, S_v on Day 1 was averaged over 6–16 m depth in 10 m range bins and is shown stacked in time zeroed to T_{s1} as a plan view in Fig. 4e along with the DTASL (noting the x axis here is time of full experiment, not distance). A noticeable drop in depth-averaged S_v can be seen in Fig. 4e 30 min post T_{s1} in the 6–16 m depth bin. In Fig. 4f, the average S_v over 6–16 m depth and for 100 m each side of the sonar and air gun line crossing point (Z_s) is shown, along with the average S_v for the same depth and range dimensions but following the DTASL for sonar transects after T_{s1}. A significant, 6 dB drop in depth-averaged S_v occurred 30 min post T_{s1} when following the DTASL track. A depth slice through the water column is shown in Fig. 4g, which averages S_v for five sonar pings either side of the Z_s point prior to air gun operations and which follows the DTASL trajectory for times after the start of air gun operations. The 'hole' in the plankton was clear down to 15 m depth appearing to extend as deep as 30 m, began to be noticeable in the 10–15 m depth range at 15 min post T_{s1}, was most persistent in the 10–13 m depth range and increased in radius through time.

The smoothed, depth- and range-averaged S_v curves for sonar transects after air gun crossing on Day 1 are shown in Fig. 5a, and the resulting 'hole' radius is shown increasing through time in Fig. 5b (see Methods). The development of the plankton backscatter 'hole' is clearly seen (sonar transects 27 onwards) in Fig. 5a, while the 'hole' radius increasing linearly with time is evident in Fig. 5b. The increase of the 'hole' radius through time gave a significant linear fit ($r^2 = 0.91$) with maximum radius based on the 3 dB drop (half power) below the least-impacted northeastern transect end, at 1,161 m, 78 min post T_{s1} during the last sonar transect, 34.

Passage of the operating air gun (Day 1) caused a 'hole' to open in sonar backscatter, a decrease in zooplankton abundance and increased dead/total zooplankton ratios in net tow observations. On Day 1, the sonar backscatter 'hole' followed the prevailing track of the air gun firing locations when these were corrected for water drift, was symmetrical about this track and showed a time-dependency, as evidenced by the 'hole' radius increasing for 78 min after the air

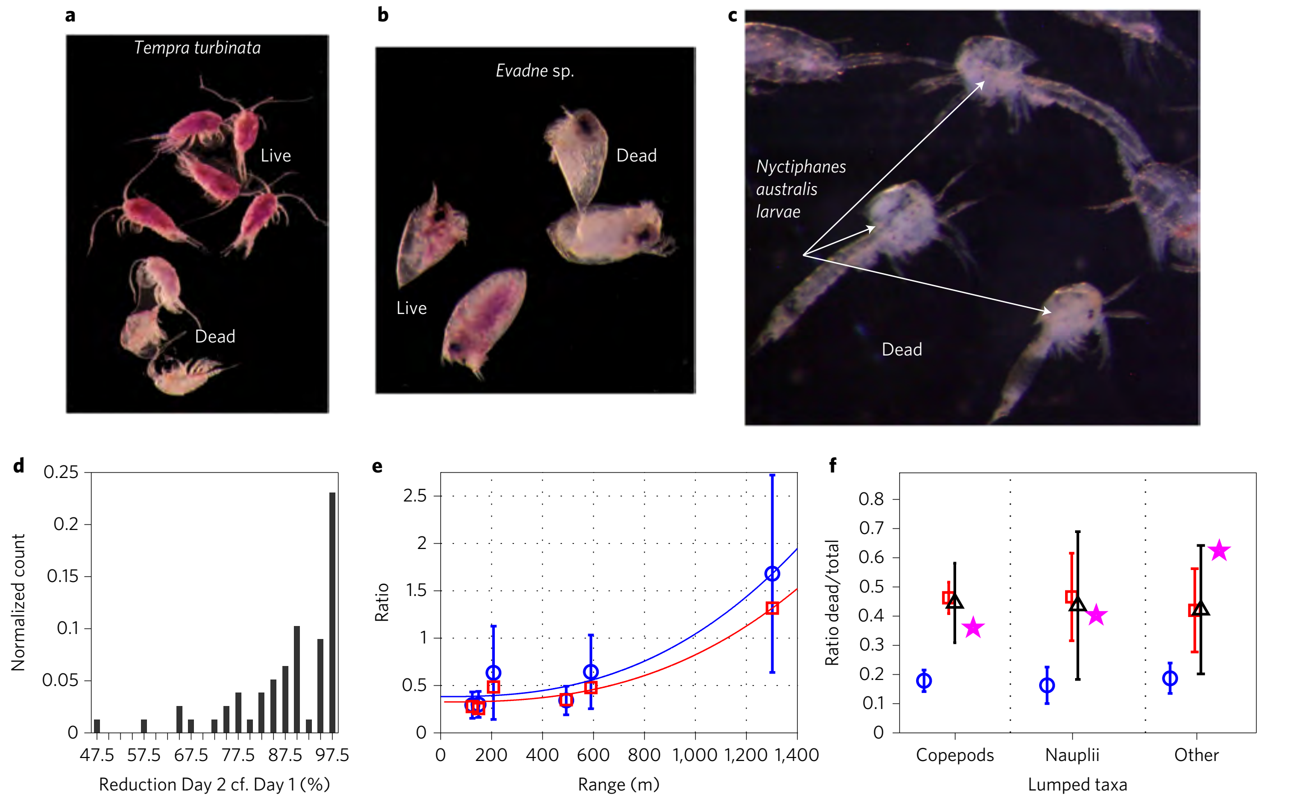

Figure 3 | Zooplankton vital staining images, and ratios of zooplankton abundance and dead to total plankton counted. a–c, Image of copepod (*Temora turbinata*, Temoridae; **a**), cladoceran (*Evadane* sp., Podanidae; **b**) and krill larvae (*Nyctiphanes australis*, Euphausiidae; **c**). **d**, Distribution for control samples of the percentage reduction in abundance of all net tows on Day 2 compared with Day 1. **e**, Ratio of exposed/control abundance for copepods and cladocerans with range from DTASL showing mean (circles), median (squares), and power fit to mean (blue) and median (red) values (r^2 = 0.92 and 0.96, respectively). **f**, Ratio of dead/total animals counted for copepods, nauplii and other zooplankton, with means of controls (blue circles), and 71–150 m (red squares), 451–547 m (black triangles) and 1,248 m (magenta stars) from DTASL. Error bars are 95% confidence limits. Live and dead animals are shown in the vital staining images.

gun crossed the sonar line. The maximum range for a reduction in sonar backscatter associated with the air gun impact track corresponded with the maximum sampling range for sonar (1.2 km). The lower zooplankton abundance on Day 2 meant the sonar backscatter 'hole' could not be visualized after air gun exposure, but like Day 1, on Day 2 statistically significant zooplankton mortality and decreased abundance were found after air gun passage. The zooplankton dead/total ratios were significantly reduced compared with controls at the maximum sampling range of ~ 1.2 km, although the abundance measures suggested a range for a detectable drop in abundance at approximately 1 km. Copepods and cladocerans had the greatest sample size for detecting range effects. Their abundance measures (ind. m^{-3}) after exposure had dropped to 50% of control abundance at 509–658 m from air gun passage, with no impact at 973–1,119 m (Fig. 3e). The received air gun level at 509–658 m range was 156 dB re 1 $\mu Pa^2\ s^{-1}$ sound exposure levels and 183 dB re 1 μPa peak-to-peak, and at 1.1–1.2 km range was 153 dB re 1 $\mu Pa^2\ s^{-1}$ and 178 dB re 1 μPa for the same units (Supplementary Fig. 2).

Discussion

On Day 2, even before the use of the air gun, the zooplankton net tow abundance counts were significantly lower than Day 1, and although individual fish sonar targets were of similar abundance, there was a significant increase in fish presence higher in the water column. The drop of zooplankton abundance on Day 2 compared with Day 1 and increase of fish in the water column on Day 2 raises the question of whether the scale of air gun impact on Day 1 carried over into Day 2. The tidal regime was oscillatory (diurnal tide; Supplementary Fig. 3) and sampling was approximately 24 h apart, but the impact range measured (1.2 km) was unlikely to have been large enough to overcome mixing or advection. Without detailed information on mixing, advection and current set above tidal flow (not known), it is not possible to draw any conclusions on the difference of zooplankton abundance and fish depth observed between Days 1 and 2.

Previous attempts to quantify ecological scale impacts on planktonic larvae from seismic surveys used modelling scenarios with impact ranges of <10 m (refs [14,15]) and suggested insignificant impacts compared with the naturally high turnover of plankton[25]. The impact range observed here, at the maximum range sampled of 1–1.2 km, is more than two orders of magnitude higher than what was assumed in these modelling studies. The impacts seen here were taxon-, range- and time-dependant, with outside bounds for time (1.2 h) and range impacts on the maximum scale of sampling.

Although we did not study the impact mechanism of the impulsive air gun signal, we can present a hypothesis on what may have occurred. Many marine invertebrates, late stage larval fauna and the zooplankton Mysidae use mechanoreceptors of a small, dense mass to 'drive' sensory hairs ('statocyst' systems[26]) partly for vibration perception. Most zooplankton do not have mass loaded mechanosensory systems but have external sensory hairs on the distal antenna ends, attached to 'rigid and stiff' sections of cuticle[27,28], with the cuticle potentially acting as a mechanical impedance for the sensory hairs to move against when driven by hydrodynamic stimuli. The zooplankton mechanosensory systems may by extremely sensitive[29] and either system will respond to an impulsive air gun signal by

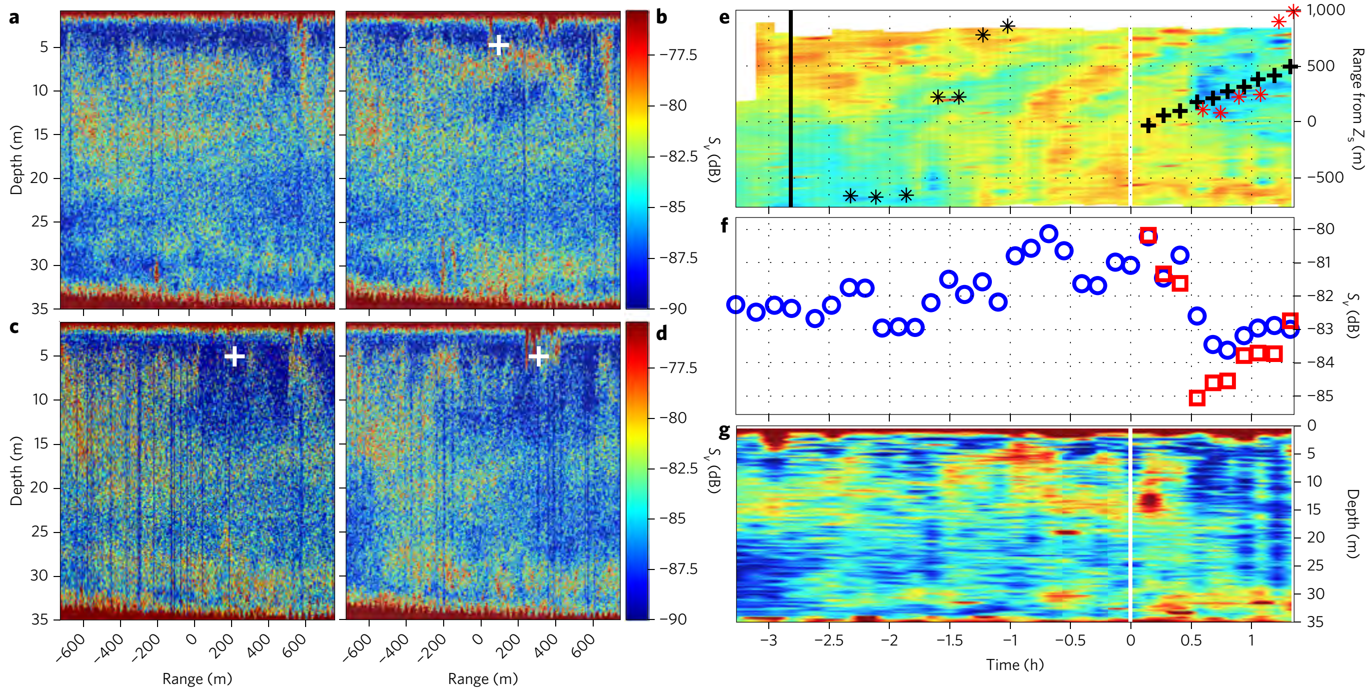

Figure 4 | S_v after Day 1 air gun exposure. a, Immediately before air gun crossing sonar line (run 25). **b**, 15 min after air gun crossed sonar line (run 27). **c**, 32 min after air gun crossed sonar line (run 29). **d**, 47 min after air gun crossed sonar line (run 31). **e**, Plan view of Day 1 range and depth-averaged S_v with range from Z_s (air gun/sonar crossing point) as *y* axis and time from T_{s1} (white line) as *x* axis. **f**, Averaged S_v from 100 m each side of Z_s over 6–16 m depth (circles) with red squares centred on DTASL (drifted location of air gun signal that most impacted sonar line). **g**, A vertical slice through the water column averaged five pings either side of Z_s before air gun crossing then DTASL after air gun starts. The white crosses in **b–d** represent DTASLs, as do black crosses in **e**; the vertical black line in **e** is time of control air gun pass, black asterisks show control plankton tow locations and red asterisks show exposed plankton tow locations. The axes and colour scales are matched in **a–d**, and **e** and **f**. Range in **a–d** is from Z_s.

'shaking', hypothetically, to the point where damage could accrue to sensory hairs or tissue. A subsequent loss or degradation of sensory ability would explain differing results among zooplankton taxa, as there are vast differences in presence, morphology and sensitivity of such systems. Impacted animals might not die immediately after air gun exposure, but rather may be disabled in their sensory capacity with an accompanying loss of fitness and so increased predation risk through time. An orientation disability would alter observed sonar reflectivity as swimming orientations changed from the upright position. The 120 kHz sonar frequency used in experiments will not observe individual zooplankton directly but will measure reflectivity from aggregated zooplankton, thus the observed 'hole' may have been due to a statistical change in zooplankton orientation or to dispersal of aggregations.

Plankton lie well on the *r* side of the *r*/*K* continuum in life strategies[1]. *r*-selected species typically have a short life span, large numbers of offspring and little if any offspring care, whereas *K*-selected species have the reverse. For anthropogenic sources to have significant impacts on an ecological scale on plankton, then the spatial or temporal scale of impact must be large in comparison with the ecosystem concerned. More than 90% of seismic surveys are conducted in a three-dimensional (3D) mode, where the density of sampling points allows 3D imaging of sub-sea geology[5]. These 3D surveys are focussed from a few hundred to thousands of square kilometres, taking weeks to months to complete, and importantly have repetitive signal locations well within the impact ranges observed here (15–25 m along line, 400–800 m across line[5]). Given the extensive spatial scale for serious impacts on plankton observed here, combined with the repeat and sustained nature of many seismic surveys in a comparatively small spatial area, it is highly probable that significant depletion or modification of plankton community structure is occurring on the scale of 3D seismic surveys undertaken.

The significance and implications of potential large-scale modification of plankton community structure and abundance due to seismic survey operations has enormous ramifications for larval recruitment processes, all higher order predators and ocean health in general. There is an urgent need to conduct further study to mitigate, model and understand potential impacts on plankton and the marine environment, and to prioritize development and testing of alternative seismic sources.

Methods

Summary. Two replicated experiments were carried out in Storm Bay at the southeastern end of Tasmania, Australia, at the same location across a uniform 34–36 m depth seabed (Figs 1 and 2) on 2 and 3 March 2015 (Days 1 and 2). Each experiment involved: (1) deployment of acoustic noise loggers with surface buoys at the extremities (1.6 km apart) and centre of a planned line of sonar transects (planned zero point for experiment, or Z_e) to measure air gun signals; (2) deployment of a drifter with drogue at 5 m depth to track surface water drift; (3) CTD measures (Day 2); (4) a control air gun transect, with the air gun (2.461 or 150 inch^3 volume) deployed, the source vessel run on a heading perpendicular to and starting 800 m from the sonar transect, through the Z_e out to 800 m past, but the air gun not operated (1.6 km air gun line); (5) replicate control vertical plankton tows at nominally 0, 250 and 800 m southwest of the Z_e from the seabed to surface using a bongo net with two 0.75 m mouth diameter, 200 μm nets with flow meter and samples split into formalin and a vital stain (so two plankton tows at each nominal range, two cod-ends per tow, to give 12 cod-ends each day at a mean net ascent rate of 0.25 m s^{-1}); (6) active air gun transect (location and headings identical to control); (7) replicate vertical plankton tows after completion of the air gun transect (sampling same as controls); and (8) continual sonar observations between the buoys marking the sonar transect end points. Sonar transects were made for ~3 and 1.5 h pre- and post- the active air gun passage, respectively. Weather was calm on Day 1 (<12 knots) and calm to moderate on Day 2 (12–18 knots). Details of control and active air gun transects and sonar transects are listed in Supplementary Table 5. Note that the actual air gun and sonar transects did not exactly cross through the planned experimental zero point (Z_e), thus the crossing location of each sonar and air gun transect for that day is termed the point Z_s, which is unique for each sonar transect. The measured water

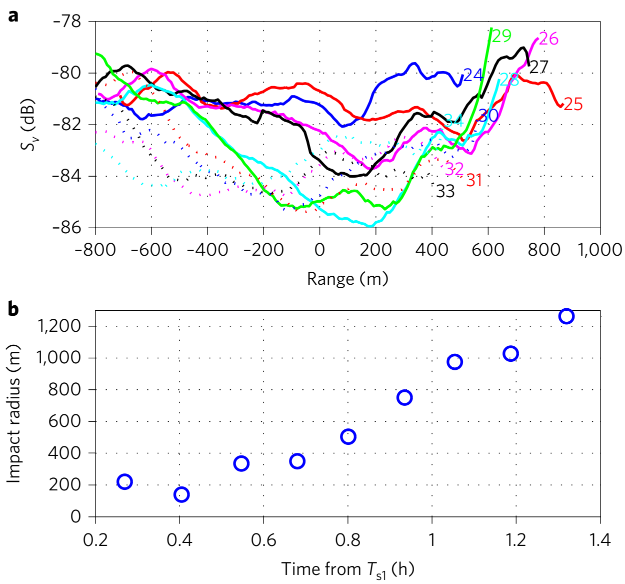

Figure 5 | Quantification of S_v hole averaged within 10–12.5 m depth range. a, Smoothed, averaged S_v on Day 1 for sonar transects 24–34 after the air gun had crossed the sonar transect (that is, from and inclusive of T_{s1}, which occurred during sonar transect 24). The sonar transect numbers are shown for each curve (transects 24-29 solid lines, 30-34 dotted lines) and the and the zero range point is the DTASL (drifted location of air gun signal that most impacted that sonar line). **b**, The measured radius of impact for the zooplankton 'hole', symmetric about the DTASL as given by 3 dB down points below the mean of the first 90 m from the northeast (−ve), plotted with time from T_{s1}, is shown. Note that many sonar transects extended beyond the −800 m shown.

body drift direction and rate was used to account for water impacted by the air gun signals, which when it was sampled by plankton tow or sonar, had drifted (termed DTASL, see below).

Air gun operations. A Sercel G. Gun II with a 2.46 l (150 cubic inch) chamber was used as the air gun source, towed at 5.1 m depth 17 m astern the 11 m vessel FV *Shelle Ton* (10 t gross, 400 hp single propeller). Two GPS units logging every 1 s were mounted side-by-side inboard with the aerial and tow offsets used to calculate air gun location. A near-field hydrophone (HTIU-90) was located 0.5 m off the gun ports and all near-field air gun signals logged to a Sound Devices (SD) 722 or 744 digital recorder, using a −20 dB pre-amplifier, −5 dB gain on the recorder and 24 bit, 48 kHz sampling. The time of the first shot was logged manually and the SD logged near-field hydrophone, air gun signal times used to define all shot fired times. These fired shot times were used to interpolate into the source vessel navigation data to derive the fired signal location. The air gun was operated from a bank of four G-size high-pressure air bottles (35 MPa or 350 bar). Twin SCUBA compressors were operated in parallel to pump the bottles. Approximately 110 shots at full pressure (13.8 MPa or 2,000 psi) were available with full gas bottles and the compressors running. All air gun signals were at 13.8 MPa (2,000 psi). Four vessel crew were used, a skipper, marine mammal observer and two air gun operators.

CTD casts. A Seabird SBE19plus CTD profiler was used on Day 2, with one cast pre-exposure and one post-exposure, each within 100 m of the Z_e point. Data were read and plotted (Supplementary Fig. 1) to ascertain if the water column was well mixed or stratified.

Drifter deployments. Two deployments of a drifter were made on Day 1 and one on Day 2. The drifter comprised a sea anchor (drogue) of 1 m diameter attached to a weighted line at 5 m depth. A surface buoy and a buoy with pole and flag were attached at the surface. The universal time and GPS position of deployment, during deployment and recovery locations were logged.

Water body drift allowance. All plankton net tows and sonar transects were made along approximately the same line perpendicular to the centre of the air gun transect (Z_e point). Many of the sonar transects and plankton tows were made after air gun operations commenced or ceased. The water body was drifting. Thus for sonar transects or plankton tows after air gun operations commenced, allowance had to be made for water drift moving the air-gun-impacted water body, to ascertain the nearest location of the water body impacted by a fired air gun signal for that sampling time point (plankton tows) or time period (sonar transect). To account for drift of the air-gun-impacted water body during sonar transects sampled after air gun operations commenced, several steps were required. First, the location of all air gun signals fired before a sonar ping time point were displaced in the water body drift direction for the distance given by the water body drift rate and elapsed time between that sonar ping and air gun firing. The air-gun-signal-displaced location that had the minimum range difference to the sonar ping location gave the displaced air gun signal location for that sonar ping. This was iterated for all sonar pings in a sonar transect, and the minimum range of the displaced air gun signal locations to all sonar pings in the transect gave the air gun signal location that most impacted that sonar transect. This location has been termed the drift translated air gun signal location (DTASL) and applies to a sonar transect. An example of the air gun signal displacement accounting for drift for the ping at which the DTASL occurred on sonar transect 30, Day 1, is shown in Supplementary Fig. 4. The similarly derived air-gun-displaced location, accounting for drift and time (sampling time minus air gun fire time), that best matched the plankton net tow location, gave the range of plankton net tow to air gun shot firing point, with these ranges listed in Supplementary Table 2.

Sonar. Sonar transects were made using a Simrad EK60 echosounder mounted on a pole bolted athwartships a 6 m vessel. A single beam, 120 kHz transducer was mounted at 0.5 m depth, using a 156 ms ping rate, maximum power, pulse length of 0.06–1.02 ms (depth resolution of 0.048 m) with a mean vessel speed of $3.2 \pm 0.10\ \mathrm{m\ s^{-1}}$ (or 6.4 ± 0.21 knots) and median time for a line 8.2 min. On Day 1, 34 sonar transects were completed, 23 before the active air gun transect, 3 during and 8 after. On Day 2, 28 sonar transects were completed, 19 before the active air gun line, 4 during and 5 after. Details of sonar transects are listed in Supplementary Table 5.

The sonar data raw files were read into MATLAB (Mathworks) and converted to grids of calibrated volume backscattering strength (S_v in units of $\mathrm{dB\ m^{-3}}$) with associated navigation and time data. The sonar navigation data were used to align each sonar transect, deemed to be from one end of its line to the other before or after turns, to the crossing point of the active air gun track for that day. The air gun crossing point was set as the zero range location for that transect (the air gun track was interpolated at a 1 m resolution and the closest sonar ping location to the air gun track found and deemed to be the zero point for that sonar transect, Z_s). Each ping along a sonar line was assigned a range perpendicular to the Z_s point and its sign set so that the northeastern portion of the line was −ve and the southwestern portion +ve. Each sonar transect had a start time, end time and air-gun-line crossing time (T_s). The difference between T_s and the first sonar transect crossing time, T_{s1}, gave the time the sonar transect preceded (−ve) or followed (+ve) the time the air gun crossed the first sonar transect.

The 120 kHz S_v values have been averaged in different range and depth bins. All S_v averaging was carried out in the linear domain ($L = 10^{(S_v/10)}$, where L is the linear value of S_v), summed as appropriate then divided by the number of depth bins and pings, and the result converted back to decibels ($10 \times \log_{10}(L)$). All zooplankton S_v averaging had the surface bubble layer, fish schools, individual fish targets and bad pings removed before averaging. The surface bubble layer was found by following a ping down from the surface in consecutive 3 m bins and finding the first bin with no S_v values exceeding −68 dB. The start of the next bin + 1 m was taken as the surface depth free of surface bubble contamination. Individual fish targets were found by locating the characteristic chevron shape of a fish backscatter return as it moved through the sonar beam. The dimensions of these targets, plus surrounding pings out to 0.25 m, were removed from all analysis of mean S_v values. There were several fish schools on each day; these could not be resolved as individual targets so the boundary of each school was established manually and the schools removed from all analysis of mean S_v values. Several sonar pings were artificially low, usually due to high attenuation of the signal in the surface bubble layer. These pings were found by deriving the median value from below the surface bubble layer to just above the seabed for each ping, and removing any pings where the median value was <−95 dB. These 'bad pings' were excluded from all analyses.

The development and dimensions of the sonar backscatter 'hole' that developed post air gun passage on Day 1 were quantified by averaging S_v in the depth of maximum impact over 10–12.5 m in 10 m range bins along a sonar line, smoothing the resulting curve using a running linear fit (8 points either side), calculating the range at which the curve fell 3 dB (half power) below the mean S_v calculated over 90 m from the northeastern line end (least impacted end of sonar due to prevailing drift), and where possible finding the 3 dB down-crossing points symmetric about the DTASL. On Day 1, when moving from −ve to +ve ranges (northeast to southwest), the curve always fell below the threshold leading towards the DTASL as the drift was taking the water mass in the +ve direction, but the curve did not necessarily climb back up to this value on the southwestern side of the DTASL, as the sonar transects were too short at the longer time periods post T_{s1}. Where the curve did cross the threshold on the northeast and southeast side of the DTASL, the difference in range values at each threshold was divided by two to give the radius of the 'hole', where the curve did not reach the threshold on the southeastern side (transects 31–34), the radius was derived as the distance of range at the

DTASL minus distance of where the curve reached the 3 dB down-threshold on the northeastern side.

Air gun signal measures. Three sea noise loggers were set on the seabed during each day's experiment, one in the centre of the air gun transect (a) and two at the ends of the sonar transects (b and c). A fourth sea noise logger (d), with hydrophone located 9.4 m below the sea surface, was suspended from surface floats above receiver (a). All sea noise loggers recorded pressure while (b) and (c) also recorded ground-borne vibration via geophones. The sea noise loggers were Curtin University designed, CMST-DSTO sea noise recorders (see www.cmst.curtin.edu.au/products). The two noise loggers at the centre of the air gun line (a and d) sampled 2 channels at 0 and 20 dB gain (50 min of every hour at 4 kHz sample rate) with the low gain channel not overloading for air gun signals at short range. The noise loggers at the sonar line ends used 20 dB gain and 4 kHz sample rate (2,600 s every hour) with no overloading of air gun signals. All noise loggers had a High Tek HTI U90 hydrophone, individually calibrated with sensitivities ranging from −197.6 to −197 dB re 1 V μPa^{-1}. All air gun lines were carried out during the 'on' times of all receivers. All sea noise recorders were calibrated for the pressure response by inputting white noise of known level into the instrument with the white noise and hydrophone in series. Analysis of the logged signal gave the system gain with frequency, accounting correctly for the impedance match of the hydrophone, pre-amplifier and system electronics. This system gain curve was used with the known hydrophone sensitivity to convert the logged volts to pascals in the time domain with the system response calibrated over 1 Hz to the anti-aliasing filter frequency. The on-board noise logger clocks were set to GPS, universal time transmitted before deployments and the drift read after recovery to give absolute timing accuracies of <0.1 s.

Air gun signals were analysed as described in ref. [24], briefly by: (1) extracting the signals from the sea noise logger files; (2) converting volts to sound pressure (Pa) using the system calibration curve (system gain with frequency) and hydrophone sensitivity in the time domain; (3) characterizing the air gun signal for 16 signal parameters as defined in ref. [30]; and (4) aligning the shot received time with source navigation data to give source–receiver slant range (direct path source to receiver). The signal parameters of sound exposure levels and peak-to-peak have been used here to describe air gun signal levels. Sound exposure levels were calculated as in ref. [30].

Plankton tows and analysis. At each site, the first tow cod-ends (two of) were placed into the vital stain neutral red, the second tow had one cod-end into neutral red and the second into 4% buffered formaldehyde. The GPS time and co-ordinates of each drop (1: start lowering; 2: reach bottom and start raising; and 3: at surface) were made by a dedicated observer, as were the flow meter readings (model GeoEnvironmental, serial no. 23227) before and at the end of each tow. The summary vertical ascent times, rates, the horizontal distance moved during ascent and the volume sampled by each cod-end using the GPS distance traversed, water depth and net radius are listed in Supplementary Table 6. The water volume sampled during each tow was calculated using the GPS data from the horizontal drift (GPS) and water depth (sonar) to give distance of the net tow, which combined with the area of the net mouth opening gave volume of water sampled for each cod-end and therefore net. The flow meter readings were calibrated to cubic metres of water sampled, but while many agreed with the GPS calculations, some were less than as derived from the net radius and water depth. The flow meter used was capable of spinning backwards, possibly during descent, thus in abundance analysis the GPS-derived water volume sampled by each tow was used.

Samples of zooplankton that had been preserved in formaldehyde were identified and counted using a Leica M165C stereomicroscope. Where necessary, samples were split with a Folsom plankton splitter[31], until there were between 500 and 1,000 individuals in a subsample. All zooplankton in each subsample were identified to the lowest taxonomic level possible; genus or species level for copepods, cladocerans, chaetognaths and euphausiids, and higher levels for other groups.

The methods used for assessing plankton survival followed that of ref. [32]. Vital stained samples were frozen after collection in the field, thawed individually in cold, filtered (0.2 μm) seawater, acidified with a small volume (~1 ml) of 1 M HCl, rinsed with small amounts of filtered seawater, subsampled so that >400 individuals were counted (three replicates each sample) and backwashed into a sorting tray. The samples were examined under a Leica M165C stereomicroscope, fitted with a Canon 5D Mark II camera. Samples were examined using dark field microscopy, which maximized the contrast between live (bright pink after having taken up the vital stain internally) and dead (pale pink, having not taken up the stain internally) specimens. Processing of each sample was completed within 60 min, as after that time the sample became visibly degraded. The ratio of dead zooplankton to total numbers of that taxa counted were derived for each tow.

In assessing change in abundance of zooplankton between pre-air-gun periods on Day 1 compared with Day 2 or control versus exposed periods on Day 1 and Day 2, counts of ind. m^{-3} have been compared as ratios and two-tailed *t*-tests used to determine if the sets of ratios differ. Comparisons were made for control tows of Day 2 divided by control tows of Day 1 abundance to determine how the site differed between days, or of exposed divided by mean control abundance (exposed/control), including data from both days, to compare how air gun exposure impacted measured abundance. As there is normally naturally high spatial variability in plankton abundance, and as there was a time offset between control and exposed plankton tows, then for calculation of exposed divided by mean control abundance, daily control abundance was averaged within a taxa (that is, the mean of the control abundance values at the three nominal ranges that day was used). Control abundance variability ratios were calculated for all combinations of non-zero plankton tows within a taxa and day, and combined for appropriate taxa to compare with exposed divided by mean control ratios. Any taxa with zero control or exposed counts was excluded, leaving 189 taxa/tow combinations ('taxa/tow') for comparison. The ratios of exposed divided by control abundance have been expressed as percentage reductions, or [1-Ratio] × 100. To compare abundance trends for taxa with range, drift-corrected impact ranges were used and power curves of the form $y = a \times x^b + c$ fitted to data, where y is ratio exposed/control abundance, x is range (m), and a, b and c are fitted constants. Correlation coefficients were calculated for all fits.

General analysis. All air gun, sonar and spatial analysis was carried out in the MATLAB (Mathworks) environment using purpose-built software. All times given are Australian eastern standard time daylight saving, or universal time + 11 h. Errors given against mean values are indicated as ±95% confidence intervals or standard deviation as s.d. Samples sizes are given as *N*.

Data availability. The sonar data that support the findings of this study are available on request from the corresponding author, while the zooplankton abundance and vital staining results are available in the Supplementary Information.

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Author contributions
R.D.M., R.D.D., Q.P.F. and J.M.S. conceived the study, with R.D.M. setting the initial study plan based on previous experiences. All authors but R.A.W. contributed to the final study design and field planning. R.D.M. and R.D.D. collected field data. K.M.S. and R.D.D. analysed plankton tows. R.D.M. analysed air gun and sonar data, and wrote the main manuscript. All authors reviewed and revised the manuscript.

Additional information
Supplementary information is available for this paper.

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Competing interests
The authors declare no competing financial interests.

Calif. State Lands Commission lack of monitoring and enforcement of survey work done in Northern California June 2020

Written by Ken Bates

Avoidance and minimization of Impacts to fishing relies on three factors.

1. permit conditions,
2. best practice policy
3. enforcement of permit conditions

State Lands Commission (SLC), the Army Corps of Engineers, NOAA, and Bureau of Ocean Energy Management (BOEM) may all have permitting responsibilities for OSW site survey work conducted on California's Community Fishing Grounds. What is lacking is any explicit enforcement authority by agencies to monitor "real time", "at sea" site survey operations. For fishermen, non-enforcement of site survey operations looks like this:

Humboldt County, California June 20th - July 20th, 2020

This account of site survey impacts in Humboldt County is excerpted from Humboldt Fishermen's Marketing Association comment letter to the State Lands Commission opposing the permitting of submarine cables and comments on the State Land's finding of a "Mitigated Negative Declaration (MND)" concerning the Echo Cable project in March 2020. The entire HFMA document with exhibits comprises forty-nine written pages. The following is an excerpt from that document.

"*The RTI subcontractor, EGS Americas, Inc. (EGS) was hired and directed by RTI to survey potential subsea cable paths across the Humboldt County community fishing grounds from June 20 to July 20, 2020 under* ***SLC permit # 9215****. The surveyor EGS reported in both the SLC permit application and the application to the USCG Notice to Mariners that "the vessel Bold Explorer would be towing acoustical survey equipment (Edgetech 2000-DSS Towfish) behind and below the survey vessel on a tow cable three times the depth of the water at a tow speed of 3-4 knots. All vessels and fishing activity were requested to maintain one nautical mile distance from the cable lane (MSA) to prevent gear conflicts". (See* ***Exhibit E, SLC Permit # 9215****)*

Significantly, in the SLC permit application, neither the applicant EGS nor its employer RTI mentions potential interactions with fixed bottom contact fishing gear (crab traps) in the MSA in spite of the fact that EGS and RTI were proposing to tow survey equipment through the legally permitted Dungeness crab fishery during the open season to harvest Dungeness crabs commercially. The Dungeness crab fishery is the largest bottom contact fishery in the state and employs hundreds of vessels and over 107,000 permitted traps. The Humboldt County fishing grounds are the center of this fishery north of Cape Mendocino. The season's timing and area of operation are common knowledge to almost anyone in coastal Northern California and fishery regulations are disseminated by California Fish and Wildlife.

In late June 2020, HFMA Board Members began receiving calls from local crab fishermen that a large orange colored survey ship was towing through strings of legally set crab gear. On July 1, *2020 Captain Dave Helliwell, owner of the F/V Corregidor, called to report to HFMA that he was actively losing crab gear to the survey ship. On July 5th, 7th, and 9th, emails were sent to SLC and CCC to request a "Cease and Desist" order on the "Bold Explorer" to stop survey work in legally set crab gear. HFMA requested the survey work stop until the close of the crab season on July 15, 2020 (**See Exhibit F**). HFMA further requested that SLC and CCC require the applicant to hire two "guard vessels" to remove crab gear from the MSA path, place a fisherman observer on the "Bold Explorer" and compensate fishermen working within ten nautical miles of the survey work for disruption of fishing activities. This is standard operating procedure for survey and cable vessels in the Southern and Central part of California.*

The HFMA request was denied. The "Bold Explorer" continued to tow through legally set crab gear in spite of the SLC permit conditions that "no survey work take place within 100 feet of observed gear. The survey crew shall not remove or relocate any fishing gear: removal or relocation shall only be accomplished by the owner of the gear upon notification by the survey operator of the potential conflict".

The surveyor EGS working at the request of RTI failed to report observed fishing gear to SLC, CCC, or local fishermen's associations, instead, they towed right through the gear. Only when fishermen began reporting missing fishing gear did the applicant EGS, through another subcontractor working for RTI, admit to observing and towing through fishermen's gear. That subcontractor, Sea Risk Solutions, acts as the "fixer" for cable companies and cable company subcontractors when these same companies choose to violate permit conditions and ignore damage done to local fishing communities.

*On Friday, July 2 2020, a Sea Risk Solutions employee emailed Capt. Helliwell. He introduced himself as the "fishery liaison" for the RTI Eureka cable project and stated "we were all a bit surprised by the advanced schedule of the Bold Explorer which we didn't expect on site until after the close of Dungeness season". The best possible description for the above comment is pure bullshit. RTI, EGS and Sea Risk Solutions knew exactly when the permitted work window for the survey would take place — June 20 - July 20, 2020. RTI, EGS, Sea Risk Solutions and their alleged "fishery liaison" also knew when Dungeness crab season was open and when it would close - July 15, 2020. (**See Exhibit E**) These cable operators planned to and did survey on the Dungeness crab grounds through strings of Dungeness crab. traps which they documented. (**See Exhibit G**) As they continued to survey, the crab gear was moved, damaged or disappeared.*

The Sea Risk Solutions "fishery liaison" went on to state "they [Bold Explorer] got back out this afternoon and were running [survey] lines toward shore but they stopped about three miles off because there's a lot of gear set close in".

*In a second email to Captain Helliwell, sent on July 3, 2020 the "fishery liaison" again admitted to " a dense line of gear" in the survey path. The Sea Risk Solutions employee made no effort to employ the services of local Dungeness crab fishermen in the capacity as "guard boats" to move and relocate legally set gear in the vessel survey path.(**See Exhibit H**)*

On July 6 and July 7 2020, HFMA requested the SLC and CCC to stop all of the survey work on the Humboldt County Fishing grounds until the close of Dungeness crab season on July 15, 2020. Fishermen were not part of any conversation between SLC and CCC agency staff and RTI, EGS or Sea Risk Solutions. What fishermen observed after numerous efforts to stop the loss of legally set crab gear by RTI, EGS and Sea Risk Solutions was continuing transects through fishing gear. The "fishery liaison" for RTI/Sea Risk Solutions informed Capt. Helliwell during a telephone conversation that it was the intent of the vessel "Bold Explorer" and its charterer RTI/EGS "to forge ahead", regardless of the damage to the local fishing gear, but "they might consider some sort of reimbursement for fishermen that can prove gear loss and damage by the survey vessel". (Personal Communication, Capt. Helliwell, July, 2020)

RTI and its subcontractors knowingly and intentionally operated in violation of SLC and CCC policy, permit conditions and California state law. Sea Risk Solutions, the "fixer" for these companies provided substantial monetary benefit to RTI by ignoring requests and industry protocols to hire guard boats, fishermen observers and preventing the termination of survey work by the vessel "Bold Explorer" during Dungeness crab season. After conversations with fishermen in the Morro Bay/Avila Bay area of Central California who have 20 years experience with cable companies, the financial benefit to RTI provided by the Sea Risk Solutions, "fix", probably amounted to hundreds of thousands of dollars. Of the Dungeness crab fishermen who lost legally set crab gear in the RTI MSA, only Capt. Helliwell was able to meet Sea Risk Solutions criteria for reimbursement from EGS. Capt. Helliwell was not compensated for loss of catch, disruption of fishing activity or time at sea. He was required to sign a binding non-disclosure agreement with EGS to get paid. ***Fishermen should not be required to sign a "non-disclosure agreement " to hide from the public and state agencies that RTI and its subcontractors damaged fishing gear and violated the terms of their permits.***

RTI and Sea Risk Solutions actions constitute a significant effect on the environment and are in conflict with state and federal law.

Lack of Enforcement

At least until October 2020, there has been little evidence of the ability of the State Lands Commission and/or the California Coastal Commission to actively enforce permit conditions protective of commercial fishing operations on cable companies and their subcontractors. Continued budget cuts and other State of California issues have hampered both the SLC and CCC enforcement efforts. The lack of serious and timely enforcement actions against cable companies have deeply eroded the fishing fleet's confidence that either agency is able to promote and protect a prioritized coastal dependent activity —commercial fishing. It is the opinion of HFMA that the best way for fishermen to protect themselves from the negative impacts to the environment posed by submarine cables is to advocate against such cables. ***HFMA opposes the survey, installation and operation of subsea cables on the community fishing grounds of Humboldt County."***

Enforcement of State Permit Conditions

Fishermen are not the only group of stakeholders aware of the lack of enforcement for site survey activities. In August of 2013, California Ocean Protection Council (OPC) funded the following report titled "Low Energy Offshore Geophysical Permit Program Review. This report was prepared by CSA International, Inc., of Stuart, Florida. Here is what this report had to say about the enforcement of state permit conditions:

"ENFORCEMENT

As noted previously, the CSLC's authorities related to low energy geophysical permits are outlined under Public Resources Code section 6826 and California Code of Regulations, Title 2, Article 2.9, section 2100. These statutes, originally construed for purposes of oil and gas (hydrocarbon) exploration, do not contain enforcement procedures or provisions, such as vessel impoundment or fines. This lack of explicit enforcement authority constrains the CSLC's options when it finds vessels operating without a permit or when a permitted entity is out of compliance.

Without explicit authority to develop and implement an enforcement program, the CSLC currently must rely on word of mouth or tips from other ocean users (generally other surveyors) to learn of activities being conducted without a valid CSLC permit in place. When called to the attention of the CSLC, a contractor conducting geophysical survey work without a permit is officially notified and asked to submit an application and pay the necessary permit application fees.

With regard to violation of permit terms and conditions by a surveyor who does have a permit, the CSLC's only option is to revoke the permit. If such a violation of permit conditions violated other laws (e.g., the Marine Mammal Protection Act, Clean Water Act, etc.), the applicable jurisdictional agency could pursue action.

Summary: There is currently no mechanism in the Public Resources Code relating to the CSLC's geophysical permit authorities to establish or implement enforcement or penalties for non-compliance. As a result, there is an obvious financial advantage, in terms of compliance costs, to a contractor if they are working without a permit. For permittee contractors who violate the terms and conditions of a geophysical permit, the Commission's only clear remedial action is to revoke the permit.

Issue: The CSLC cannot enforce the requirement that a permit be obtained beyond requesting from a contractor that an application be submitted, nor can the Commission enforce compliance with permit conditions, except to revoke the permit. This potentially puts those entities who are trying to comply at a disadvantage because they absorb additional costs and requirements that are avoided by entities that operate without a permit. This may create an atmosphere of distrust among surveyors because the CLSC only discovers these non-permitted contractors through word-of-mouth. The lack of enforcement also prevents the CSLC from having a complete data set related to the number, type, and location of surveys for tracking and monitoring purposes because not all surveys are permitted and provide such notice.

Recommendations: The primary tool needed for improving enforcement and compliance is new legislation and subsequent rulemaking to institute clear authority and regulatory guidance for the CSLC to enforce penalties against entities operating without a permit. This would decrease the incentive to avoid operating without a permit and would

increase the equity among operators. Short of that, CSLC staff could take several steps within the current regulatory and statutory framework to improve compliance."

Conclusion: As noted above, lack of enforcement by state and federal permitting agencies not only creates an atmosphere of distrust among surveyors, it causes financial harm to fishermen, and fishing communities (through gear loss and fishing disruptions) and has created a pervasive pessimistic attitude toward agencies tasked with protecting the marine environment and its users. A lack of agency enforcement is a significant negative impact to fisheries and coastal communities.

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SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF SAN LUIS OBISPO

MORRO BAY COMMERCIAL FISHERMEN'S ORGANIZATION, PORT SAN LUIS COMMERCIAL FISHERMAN ASSOCIATION, Petitioners/Plaintiffs v. **CALIFORNIA STATE LANDS COMMISSION, CALIFORNIA COASTAL COMMISSION, DOES 1** through **20;** Respondents/Defendants. A**LTAS WIND I, LLC, aka EQUINOR; CSA OCEAN SCIENCES INCORPORATED; GOLDEN STATE WIND, LLC, aka CENTRAL CALIFORNIA OFFSHORE WIND, LLC; EVEN KEEL WIND, LLC, aka INVENERGY CALIFORNIA OFFSHORE LLC,** Real Parties In Interest	Case No.: 24CV-0152 ERRATA EXHIBIT PACKAGE IN SUPPORT OF REPLY TO OPPOSITION TO EX PARTE APPLICATION FOR ORDER TO SHOW CAUSE TO SHOW CAUSE WHY PRELIMINARY INJUNCITON SHOULD NOT ISSUE; ERRATA PLAINTIFFS'/PETITIONERS' SELECITONS OF SUBMITTALS FOR INCLUSION IN ADMINISTRATIVE RECORDS OF COASTAL COMMISSION AND STATE LANDS COMMISSION EXHIBIT PAGES 1-286 ACTION FILED: FEBRUARY 29, 2024 JUDGE: HON. CRAIG VAN ROOYEN DEPT: 2 EX PARTE APPLICATION HEARING DATE: ARPIL 22, 2024

DECLARATION OF WILLIAM S. WALTER IN SUPPORT OF OPPOSITION

I, William S. Walter, do declare and state that:

1. I am the attorney of record for Petitioners/Plaintiffs in the above captioned action. Attached hereto are true and correct materials which have been submitted for inclusion in the Administrative Records of the California Coastal Commission and the California State Lands Commission, and the California State Water Resources Control Board, consisting of consecutively number pages in the lower left-hand corner from page 1 through page 286 inclusive. These items were filed and served in consecutive volumes but after processing was completed within less than two full weekend days after service of the Opposition to the Ex Parte application it was discovered that various items were omitted or out of order or too large to serve electronically by attachment to email service. We have previously requested the preparation of administrative records of the Coastal Commission and the State Lands Commission. The Water Resources Control Board was considering Equinor's application for site surveys during the week of April 15th, 2024 and these materials have previously been submitted with a request for inclusion in the Water Board's Administrative Record. Since the matter was pending this last week, it was premature to name the Water Board or formally request the preparation of the Administrative Record. However, these materials have been presented to the Water Board for Inclusion in the Administrative Record.

2. The administrative records of the Coastal Commission and State Lands Commission have been requested to be prepared, as attached to the Verified Petition and Complaint on file herein. That administrative record has not been prepared and therefore is unavailable for consideration by the Court in this matter at this time; however, the Opposition filed by Equinor raises various issues beyond the original scope of the Application for Order to Show Cause now

pending before this Court. As these attached materials were submitted to the agencies, they will be obligated to include them in the administrative records they prepare. These copies of submittals in behalf of the Petitioners/Plaintiffs are true and correct copies of materials, studies, legal authorities, submitted to the respondents/defendants which must be included in the Administrative Records when the process of collecting them has been completed by the agencies.

3. The Court is requested to consider these excerpts of items submitted for inclusion in the Administrative Records of the agencies because Equinor has submitted only limited items within those records which have been selected for the Opposition to the Ex Parte Applications.

I declare under penalty of perjury under the laws of the State of California that the items attached hereto are true and correct copies of submittals to the agencies for inclusion in their respective records.

Executed this 28th day of April, 2024, at San Luis Obispo, California.

William S. Walter /s/

DECLARATION OF SERVICE BY E-MAIL

Case Name: Morro Bay Fisherman Org. v. State Lands Com. Case No.: 24CV-0152

I, WILLIAM S. WALTER, DO DECLARE AND STATE:

I am the attorney of record for Petitioners/Plaintiffs in the above captioned action; and am 18 years of age or older and not a party to this matter.. On April 21, 2024, I served the attached PLAINTIFFS/PETITIONERS'ERRATA EXHIBIT PACKAGE IN SUPPORT OF REPLY TO OPPOSITION TO EX PARTE APPLICATION FOR ORDER TO SHOW CAUSE WHY PRELIMINARY INJUNCTION SHOULD NOT ISSUE, CONSISTING OF CONSECUTIVELY NUMBER PAGES, 1 – THROUGH 286 NUMBERED PAGES by transmitting a true copy via electronic mail.

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  Attorneys for Real Party in Interest CSA Ocean Sciences Incorporated

I declare under penalty of perjury under the laws of the State of California and the United States of America the foregoing is true and correct and that this declaration was executed on April 28, 2024, at San Luis Obispo, California.

William S. Walter /s/

Signiture

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CONCERNS, SUGGESTIONS AND OBJECTIONS OF THE MORRO BAY COMMERCIAL FISHERMEN'S ORGANIZATION (MBCFO) AND PORT SAN LUIS COMMERCIAL FISHERMAN ASSOCIATION (PSLCFA) REGARDING IRREVERSIBLE IMPACTS TO COMMERCIAL FISHING FROM OFFSHORE WIND SITE SURVEYS WITHIN THE BOEM MORRO BAY LEASE AREAS

November 14, 2023

TO: BOEM c/o douglas.boren@boem.gov; jennifer.miller@boem.gov

California Coastal Commission c/o
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OVERVIEW OF MORRO BAY AND PORT SAN LUIS COMMERCIAL FISHING

The size, scope and location of offshore wind generation and to-shoreline transmission off the Central Coast of California represents an unprecedented industrialization of open ocean coastal resources extending across and through the State of California's three-mile public trust jurisdiction to federal public trust jurisdiction under the leasing jurisdiction of BOEM.

Unless carefully monitored and effectively mitigated it is the consensus view of MBCFO and SLCFA the that commercial fishing will cease to be physically and economically viable well before the massive, expansive, and industrial scale build-out of currently planned wind energy developments. There is substantial evidence and new information of potential impacts to commercial fishing and fishing stocks from the site survey stage onward.

There are currently no enforceable mitigation measures or monitoring conditions/programs for the potential impacts on commercial fishing in the BOEM Morro Bay Lease Areas. This unnecessary risk and uncertainty place the future of commercial fishing and the members of the Associations at risk and directly conflict with clear public policy mandates, Public Trust Doctrine mandates, the California Constitution expressly and unconditionally "reserving in the people the absolute right to fish thereupon," California Coastal Act policies, duly Certified Morro Bay and San Luis Obispo County Local Coastal Programs, and BOEM mitigation regulations.

Until comprehensive commercial fishing and fish stock mitigations are adopted and enforceable, subject to open public scrutiny, with complete mitigation monitoring and full "before and after" site survey baselines studies, it is premature and would violate various legal requirements to authorize site surveys which may destroy the baseline fishing resources before they are documented. Neither NEPA nor CEQA allow the physical disturbance, denial, spatial displacement of public trust values and resources to commence (e.g., site surveys) based upon completely deferred mitigation, guided by no defined and precise mitigation standards, with no careful and approved program of mitigation monitoring of all potential impacts and policy conflicts.

This review will include documenting the failure of efforts by the MBCFO and the PSLCFA to obtain the cooperation of the three project developers to implement the comprehensive mitigation measures under the Bylaws of the Morro Bay Lease Areas Mutual Benefits Corporation and approved Charter of the Morro Bay Lease Commercial Fishing Fund Management Trustees' Committee. The project developers, expressly contrary to the Coastal Commission's Consistency determination and findings, deny that their projects will have any significant effect upon commercial fishing activities and related policy conflicts despite contrary admissions of such impacts by Castle Wind and TotalEnergies in entering into prospective project mitigation agreements leading to the incorporation of the MBLA MBC and chartering the Trustees' Committee under a comprehensive mitigation program. It is inexplicable why these three project developers after the final meeting and presentations by fishermen would continue to be "impact deniers" while their competing company, TotalEnergies, would acknowledge the impacts and enter into agreements for permanent mitigation processes. This will be documented below.

SUMMARY OF AGENCY ACTION ITEMS REQUESTED BY MBCFO AND PSLCFA IN BEHALF OF THEIR MEMBERSHIP

1. New Information requires that BOEM prepare and circulate a Supplemental EA under NEPA, and in doing so, fully comply with the President's Council on Environmental Quality, NEPA Implementing regulations Revisions, 40 CFR Parts 1502, 1507, and 1508.[1] 87 Federal Register, No. 76, p. 23453 et seq. and the deadline for Agency compliance extended to September 14, 2023. 87, No. 76, Federal Register, 23462.

2. New information requires that the State Lands Commission hold a noticed public hearing before issuing any Permits for Site Surveys in the Morro Bay Lease Areas, and include an express condition in all site survey permits as required by California Constitution, Article I, Declaration of Rights, Section 25, and related Coastal Act Policies:

   "The temporary privileges granted by this permit are expressly subject to the Constitution of the State of California, Article I, Declaration of Rights, Section 25, "reserving in the people the absolute right to fish thereupon."

   "Appropriate mitigation and mitigation monitoring of impacts on fish stocks and habitat, commercial fishing, and public policy conflicts with

[1] "CEQ is issuing this final rule to amend three provisions of its regulations implementing the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. 4321 *et seq.*, which are set forth in 40 CFR parts 1500 through 1508 ("NEPA regulations" or "CEQ regulations"). First, CEQ is revising 40 CFR 1502.13 on the requirement for a purpose and need statement in an environmental impact statement. The revision clarifies that agencies have discretion to consider a variety of factors when assessing an application for an authorization, removing the requirement that an agency base the purpose and need on the goals of an applicant and the agency's statutory authority. The final rule also makes a conforming edit to the definition of "reasonable alternatives" in 40 CFR 1508.1(z). Second, CEQ is revising 40 CFR 1507.3 to remove language that could be construed to limit agencies' flexibility to develop or revise procedures to implement NEPA specific to their programs and functions that may go beyond the CEQ regulatory requirements. Third, CEQ is revising the definition of "effects" in paragraph (g) of 40 CFR 1508.1 to include direct, indirect, and cumulative effects. CEQ is making these changes in order to better align the provisions with CEQ's extensive experience implementing NEPA and unique perspective on how NEPA can best inform agency decision making, as well as longstanding Federal agency experience and practice, NEPA's statutory text and purpose to protect and enhance the quality of the human environment, including making decisions informed by science, and case law interpreting NEPA's requirements. CEQ established a docket for this action under docket number CEQ–2021–0002. All documents in the docket are listed on *www.regulations.gov*."

priority uses for commercial fishing shall be subject to public review and approved at a noticed public hearing of the State Lands Commission."

The definitive interpretation of Section 15 is discussed below by the California Supreme Court in a San Luis Obispo County decision upstream from the submerged lands to be subjected to site surveys and permanent transmission and landing facilities under State ownership (ocean bottom) which clearly articulates the priority of fishing rights contemplated by the nearly unanimous California Constitutional Amendment in 1910. *State of California v. San Luis Obispo Sportsman's Association* (1978) 22 Cal.3d 443.

Even when the United States Government acquires by eminent domain California public trust properties for a federal purpose, the Judgment in favor of the Government is expressly subject and subordinated to Section 25 of the California Constitution. See, e.g., *United States of America v. 160 Acres of Land, More or Less* (2017) Case No. EDCV 16-1957 (KKx), United States District Court, Central District of California, "Judgment" entered November 9, 2017, separately stated with regard to Parcel A and Parcel B acquired by the Government:

"Therefore upon compliance with the conditions ...and further reserving in the People the Absolute right to fish thereupon as provided by Section 15 of Article I of the Constitution of the State of California, as reserved by the State of California by Deed recorded...." (Capped initials "People" and "Absolute" in original filed District Court Judgment.)

The State Lands Commission is obligated to comply with the same Constitutional declaration of rights recognized under federal comity principles as the United States Government in considering permitting site surveys which can damage the ocean bottom and related habitats, attempting to exclude commercial fishing activities indefinitely and permanently, in violation of clearly recognized Constitutional policies of the State of California protecting the "Absolute right to fish" reserved in the "People." (Discussed below.)

The Bylaws of the MBLA Mutual Benefits Corporation and the Trustees' Committee Bylaws resolves this policy conflict by a voluntary Fishermen Letter to be signed by all participating fishermen with a prior history of fishing in the affected fishing habitats.

3. New information and evolving and uncertain permit parameters pending with the California Coastal Commission ("mitigation by email") require that that the Commission hold noticed public hearings before approving any permits or other entitlements or permissions to conduct site surveys to any of the wind project developers, and complete the functional equivalent of an EIR analysis of impacts and full mitigation measures and a mitigation monitoring plan for commercial fishing and fish stock sustainability during all phases of the proposed developments including site surveys through de-commissioning.

These are routine and well recognized requests to assure mitigation and monitoring compliance which can preserve the future of commercial fishing stocks and commercial fishing and related coastal dependent uses. The MBCFO and SLCFA only ask the regulatory and trustee agencies to follow the prescribed path approved by the Executive Office of the President, Council on Environmental Quality, and the Governor's Office of Planning and Research, State of California, which jointly authorized the guidance provided by *"NEPA and CEQA: Integrating Federal and State Environmental Reviews"* (February 2014) in both definitive, "user friendly," and understandable language regarding when environmental documents must be supplemented or re-released (p. 36):

"6. When Should an EIS/EIR be Supplemented or Re-Released?
Under NEPA and CEQA, agencies consider a similar set of circumstances under which an environmental document must be re-released for public and agency review when new information becomes available after publication of the draft or final document.

"NEPA Requirement: NEPA dictates a process for incorporating new information into an already published EIS called supplementation. A supplemental EIS must be prepared if there are "substantial changes in the proposed action" relevant to environmental concerns, or "significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts" (40 C.F.R. § 1502.9(c)(1)). The supplement should focus on the new information (40 C.F.R. § 1502.9(c)(1)). The CEQ has clarified that new alternatives outside the range of alternatives already analyzed would trigger the

> requirement for a supplemental review (NEPA's 40 Most Asked Questions, 29b). Supplements may be prepared for either draft or final EISs.
>
> . . .
>
> **"CEQA Requirement:** CEQA provides a similar process for recirculation of draft documents, and supplementation of certified final documents. An agency must recirculate an
>
> EIR when "significant new information" is added after the draft EIR is made available for public review, but before the lead agency certifies the final EIR. Significant new information can include changes to the project or circumstances surrounding the project leading to a new significant environmental impact, a substantial increase in severity of an impact, or another feasible alternative that would reduce impacts and is considerably different from other alternatives (CEQA Guidelines, § 15088.5, subd. (a)). Recirculation is not necessary for new information that merely clarifies, amplifies, or makes insignificant modifications to information that was already presented to the public (*id.* at § 15088.5, subd. (b)). An agency must provide adequate notice of a recirculation (*id.* at § 15088.5, subd. (d)), and if the new information only affects a few sections of the EIR, only those sections must be recirculated (*id.* at § 15088.5, subd. (c)).
>
> "Following certification of an EIR, new information will only trigger a subsequent or supplemental EIR in limited circumstances. Supplemental review is required only if (1) the project requires a further discretionary approval and (2) new information reveals that the project will cause a new or substantially more severe impact or that mitigation measures or alternatives would substantially reduce one or more significant impacts, but the project proponent declines to adopt such measures or alternatives (CEQA Guidelines, § 15162). Where new information triggers the need for supplemental review, no further discretionary approvals may be granted until after the supplemental review is completed."

In describing "Opportunities for Coordination," when new information is presented, the advice of both the Federal and California environmental review agencies should be followed by BOEM, the Coastal Commission, and State Lands Commission:

> "The two laws' [NEPA and CEQA] requirements for recirculating/supplementing environmental documents are similar enough that agencies presented with new information or project changes should generally treat that information the same way (i.e., by supplementing or substantiating their determination not to). Just as with the draft EIS/EIR, agencies should be able to release a joint supplemental analysis with a joint public review period." (P. 37.)

DEFINED MITIGATION AND APPROVED MONITORING MAY NOT BE DEFERRED BEYOND THE PHYSICAL COMMENCEMENT OF THE "WHOLE OF THE ACTION"; WITHOUT ANY MITIGATION MONITORING PLAN APPROVED OR REQUIRED

The California Coastal Commission has pending permits under review for the first physical phase of three developer commercial offshore wind projects – the site surveys. The process of environmental and policy review for the Coastal Commission is defined as the "functional equivalent" of a full environmental impact report; and will require additional public hearings and formal approval of the permit terms including required mitigation and mitigation monitoring. For instance, the definitive texts on CEQA state:

> **§18.4 B. Functionally Equivalent Documents**
>
> In addition, requirements for mitigation monitoring or the equivalent apply to functionally equivalent documents prepared under certified regulatory programs. See generally §21.14 (exemption for such programs limited to Pub Res C §§21100–21154 and 21167). See *Dunn-Edwards Corp. v South Coast Air Quality Mgmt. Dist.* (1993) 19 CA4th 519, 525 (referencing such a mitigation monitoring program).

Functional equivalence is not a reduced standard of mitigation or monitoring and the Commission's processes must be equivalent to the requirements which would apply to the highest standards of CEQA compliance, including objectively recognized legal requirements[2] articulated for the education of the California Bench and Bar, and summarized in Appendix I – Legal Policies against Deferred Mitigation and Monitoring. The functional equivalent processes must follow the "whole of an action" provisions in CEQA Guidelines 14 Cal. Code Regs Section 15378 definition of a "project":

> "(a) 'Project' means the whole of an action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment...."

[2] These references are from the standard California Treatise on CEQA, CEB Practice Under the California Environmental Quality Act, references to sections in updated text.

The "whole of an action" – which means from site surveys through decommissioning – requires mitigation and monitoring. It is fundamental that no

portion of the project which involves physical impacts and the most fundamental public policy conflicts, including site surveys as suggested by more recent literature and new evidence, without comprehensive, enforceable, definite mitigation and mitigation monitoring program.

Recently enacted Public Resources Code Section 30001.3 expressly found the conditions requiring mitigation of commercial fishing impacts which "are not yet fully understood":

(b) While offshore wind energy generation can provide significant climate and economic benefits, industrial scale development and deployment of offshore wind energy will also have impacts on coastal and ocean resources, fisheries, and coastal communities that are not yet fully understood.

Newly enacted Public Resources Code, Section 30616 provides, in relevant parts:

(c) The statewide strategy developed pursuant to this section shall include best practices for addressing impacts to the commercial and recreational fishing industries, tribal fisheries, and environmental resources associated with offshore wind energy projects, including, but not limited to, the following:

(3) Best practices for offshore surveys and data collection to assess impacts.

(8) A recognition of locally negotiated agreements between the fishing industry and offshore wind energy leaseholders.

(d) (1) The working group shall complete the statewide strategy, including the framework for reasonable compensatory mitigation for unavoidable impacts, on or before January 1, 2026.

Assuming that this new process is intended to provide one of several possible methods for mitigation of commercial fishing impacts from offshore wind development, the site surveys cannot be allowed to commence before the completion of the "best practices" for "offshore surveys and data collection to assess impacts" (subd. (c)(3) before the statewide strategy is completed by January 1, 2026. The only exception would be under (c) (8) "A recognition of locally negotiated agreements between the fishing industry and offshore wind energy leaseholders."

The MBLC MBC Bylaws and Trustees' Committee Charter would provide an approved method for required commercial fishing mitigation. It would be a futile and inconsistent interpretation of the new statute to allow site surveys to proceed without completion of "best practices" for such surveys. Such an interpretation is consistent with the basic CEQA mitigation principles outlined in Appendix I hereto. Determining that process can be processed through the revised EA requested from BOEM above and the joint NEPA/CEQA processes described jointly by the Presidents' CEQ and the Governor's Office of Planning and Research referenced above.

MITIGATION AND MITIGATION MONITORING MUST BE COMPLETED BEFORE COMMENCEMENT OF SITE SURVEYS OR ANY OTHER PHASE OF THE PROJECT TO RESOLVE AND ADDRESS FUNDAMENTAL PUBLIC POLICY CONFLICTS BETWEEN OFFSHORE WIND DEVELOPMENT AND COMMERCIAL FISHING AND FISH STOCKS

The industrial scale, scope and location of Morro Bay Lease Areas create the most profound and intractable of conflicts between fundamental public policies, constitutional requirements, which mandate and protect commercial fishing. Any possibility for any reconciliation of these policy conflicts require mitigation and monitoring which is operable from the site surveys through decommissioning – the "whole of the project." Deferred mitigation without monitoring cannot be allowed when the "whole of the project" presents conflicts with public trust values, the Constitutional mandate "reserving in the people the absolute right to fish thereupon," etc., Coastal Act policies, Certified Local Coastal Programs of the County of San Luis Obispo and City of Morro Bay,

A. **The Public Trust Doctrine.** The Public Trust Doctrine is based upon ancient Roman, Spanish[3] and English legal principles which protect the right to fish, the right to navigate, and the right to access public tidelands and submerged lands. The United States Supreme Court, *Martin v. Waddell* (1842) 41 U.S. (16 Pet) 367, 410, held that the state's title to its tide and submerged lands,

   "…is a title held in trust for the people of the State that they may enjoy the navigation of the waters, carry on commerce over them, and have liberty of fishing" free from obstruction or interference from private parties.

B. Act for the Admission of the State of California Into the Union, 1849, (Pub. L. 31-49), Section 3 provides in pertinent part:[4]

[3] The Spanish legal principles are significant because of the provisions of the 1848 Treaty of GuadalupeHildalgo recognizing Spanish land grants ("ranchos") and other agreements recognized in adjudicated patents some of which relate to submerged lands and retained fishing rights.
[4] "An Act for The Admission Of The State of California into the Union", *Our Documents*. The National Archives and Records Administration, September 9, 1850.

Obispo Sportsman's Association (1978) 22 Cal.3d 443, Note 5, describes the history and purposes of the initiative amendment establishing this "absolute right".

"Evidence of this intent may be found in the argument submitted to the voters in support of the amendment (Carter v. Com. On Qualifications, etc. (1939) 14 Cal.2d 179, 93 P.2d140.) The argument submitted to the voters in 1910 indicates that the amendment was aimed at protecting the public's right to fish upon and from state-owned land and to prevent the state from disposing of land without reserving that right."

The California Supreme Court noted the narrow exclusion from this "absolute right" for State uses such as prisons and mental institutions which are incompatible "with use by the public for fishing." (Id. 186) The Supreme Court then quotes from the ballot initiative argument submitted to California Voters who agreed and adopted the Constitutional Amendment:

"The ballot argument stated: 'The inland streams and coast waters of the State of California abound in a great variety of fish, and aside from the sport of taking them, they furnish a very large portion of the state's free food supply. That the fish may not be exterminated and this great item of popular food depleted the people of the state are spending large sums annually for its protection and propagation.

"For many years the people of California have enjoyed the right to take fish from the waters of the state pretty generally, but since the vigorous development of California's natural resources by individuals and large corporations, many of the streams have been closed to the public and trespass notices warning the public not to fish are displayed to an alarming extent. [bolding added.]

"The people are paying for the protection and propagation of the fish; for this reason if for no other they should have the right to take them. It is not fair that a few should enjoy the right to take the fish that all the people are paying to protect and propagate.

"...and that all the navigable waters within the said state shall be common highways, and forever free, as well to the inhabitants of said state as to the citizens of the United States, without any tax, impost, or duty therefore...."

C. **California Constitution, Article I, Declaration of Rights, Section 25,** provides:

Added in 1910 by Initiative Amendment during the height of California's Progressive Erra, the intent of the near unanimous approval by the Assembly and Senate and approved by California voters is to protect fishing from being lost to continued" vigorous **development of California's natural resources by individuals and large corporations";** the same impacts posed on a vastly larger scale than ever imaginable in 1910 by ocean wind projects of the three BOEM selected "highest bidder" developers:

"SEC. 25. The people shall have the right to fish upon and from the public lands of the State and in the waters thereof, excepting upon lands set aside for fish hatcheries, and no land owned by the State shall ever be sold or transferred without reserving in the people the absolute right to fish thereupon; and no law shall ever be passed making it a crime for the people to enter upon the public lands within this State for the purpose of fishing in any water containing fish that have been planted therein by the State; provided, that the legislature may by statute, provide for the season when and the conditions under which the different species of fish may be taken."

The California Supreme Court has provided the definitive interpretation of the language and the purposes of the authors of the Initiative Constitutional Amendment in 1910 which echoes of the same concerns today with unmitigated offshore wind industrial scale development of now undisturbed ocean bottoms and navigable waterways by "large corporations" to the detriment of the "absolute right of the people to fish thereupon." *State of California v. San Luis*

"To reserve the right to fish in a portion of the waters of the state at least, for the people, Assembly Constitutional Amendment No. 14 was introduced and adopted at the last session of the legislature of the State of California, and as an evidence of its popularity it was unanimously adopted by the assembly and by the senate with but two dissenting votes.

"If the people of the state vote favorably upon this proposed amendment to the constitution it will give them the right to fish upon and from the public lands of the state and in the waters thereof, and will prevent the state from disposing of any of the lands it now owns or what it may hereafter acquire without reserving in the people the right to fish."

In violation of the California Constitution and principles of comity rooted in federalism,[5] there is no enforceable mitigation and monitoring to protect fishing from displacement and potential fish stock damage during all phases of the massive developments -- from site surveys, utilizing sonic levels with documented damage to fish stocks and other marine life forms, through an unimaginable scale of future decommissioning,[6] spanning open oceans through the tidelines and submerged lands with on-shore transmission and support facilities.

D. California Constitution, Article X Water, Section 4, provides:

"SEC. 4. No individual, partnership, or corporation, claiming or possessing the frontage or tidal lands of a harbor, bay, inlet, estuary, or other navigable water in this State, shall be permitted to exclude the right of way to such water whenever it is required for any public purpose, or to destroy or obstruct the free navigation of such water; and the Legislature shall enact such laws as will give the most liberal construction to this provision, so that access to the navigable waters of this State shall be always attainable for the people thereof."

[5] Comity as part of the fundament federal structure of our governments is well known to agency lawyers, but beyond a long explanation here. See, e.g., Gil Seinfeld, *Reflections on Comity in the Law of American Federalism,* 90 Notre Dame L. Rev. 1309 (2015).

[6] See Appendices attached to this correspondence and various emails calling this substantial evidence to the attention of the regulatory and trustee agencies, which have responded with vague representations that some non-public process will address the concerns.

E. Commercial Fishing Protected Property Rights and Privileges

Members of the Organizations and other qualified fishermen engaged in commercial fishing businesses have vested property rights and interests which should be protected, enhanced and mitigated, including, without limitation:

1. The California Constitution only uses the word "absolute" in reference to one fundamental right – it's not freedom of speech, press, privacy, or religion which some might expect. It is the freedom enjoyed and protected by all who fish in the public trust waters of the State of California: "reserving in the people the absolute right to fish thereupon…" "Absolute" means "something that is free from any restriction or condition." Only people who fish can waive this right in any portion of the public trust properties belonging to the State of California, which is why the mitigation model presented by the MBLA MBC and Trustees' Committee and provides for written consent of participating fishermen as part of comprehensive mitigation processes.
2. Commercial fishing businesses have vested property rights including commercial fishing vessels, technology, extensive
3. personal property, equipment, machinery, supporting onshore personal and real property.
4. Commercial fishing businesses have vested "good will" value under California Civil Code Section 1263.510 which include "the benefit that a business gains as a result of its location," including Morro Bay Harbor, Port San Luis and proximity to commercial fishing areas; "reputation for dependability, skill or quality"; and any other circumstances contributing to the "going concern" value of commercial fishing businesses.
5. Commercial fishing businesses have various licenses including master's licenses, commercial fishing vessel licenses, and "commercial fishing license, permit or other entitlement" issued

by the California Department of Fish and Wildlife pursuant to California Fish and Game Code (Section 7857, et seq.). These licenses, permits and other entitlements are protected by the principles of due process and should be recognized as vested property interests of commercial fishing businesses.

6. Commercial fishing businesses also have docking, mooring, anchorage and other rights and privileges issued by the governing authorities of the respective harbors, and priority to the allocation of those entitlements.

F. Statutory Priorities for Commercial Fishing Activities, both On-Shore and Off-Shore

1. Commercial Fishing Priorities under the California Coastal Act (California Public Resources Code):

The clear conflicts between Coastal Act Policies and wind project developments requires that enforceable mitigation and monitoring be established to resolve these conflicts *before any phase of the project commences,* including:

a. Coastal Act Section 30230 states:

"Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the

marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes."

b. Coastal Act Section 30234 states:

"Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not

be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry."

c. Coastal Act Section 30234.5 states:

"The economic, commercial, and recreational importance of fishing activities shall be recognized and protected."

2. The Federal Coastal Zone Management Act establishes and recognizes the priorities for coastal dependent uses including commercial fishing activities.
3. The Certified Local Coastal Programs for the County of San Luis Obispo and for the City of Morro Bay protect and give priority to commercial fishing activities and on-shore support facilities through specific policies implementing Coastal Act policies.

G. Contractual Protections for Commercial Fishing Businesses are substantial evidence of appropriate mitigation measures, and certainly better than nothing.

1. Castle Wind Agreement (October 6, 2018): This was an arms-length multi-year process of negotiations between Castle Wind and subsequently TotalEnergies which are substantial evidence of a full range of commercial fishing mitigations, including substantial evidence of the informed, arms-length fair market valuation agreed between the prospective developers and the Associations in behalf of their individual members.[7] In fact, the terms of the Agreement and the

[7] The typical BOEM economic studies of economic impacts on commercial fishing are admitted to be limited by their completeness of data and the assumptions made identifying impacts from non-segregated data; they are projections which cannot be verified by real word data. The Associations and participating Wind Developers pursued a different valuational approach for mitigation and fishermen compensation by utilizing the established

subsequent Bylaws of the MBLA MBC and the Trustees' Committee were approved by the memberships of both Associations and the corporate boards of the participating developer companies.

a. The Trustees' Charter and the MBC Bylaws are the result and evolution of an Agreement Between Morro Bay Commercial Fishermen's Organization, Port San Luis Commercial Fishermen's Association ("Organizations") and Castle Wind LLC ("Castle Wind Agreement") entered into on October 6, 2018, concerning a potential offshore wind project, or projects, off the coast of San Luis Obispo County subject to various governmental reviews and approvals ("Project").[8]

b. The Agreement recognizes that the Project has the potential to impact the Qualified Members of the Organizations operating from the Morro Bay Harbor and Port San Luis through, for instance, the potential loss of fishing grounds within the "Covered Area."[9]

c. The Agreement acknowledges "that commercial fishing activities are coastal dependent uses receiving the highest priority under the California Coastal Act and the Federal Coastal Zone Management Act, the continuing viability of which is of critical importance to maintaining the Commercial fishing industry along the California coast."

California definition of "fair market value" of mitigation/compensation as "the highest price" that "a willing buyer would have paid in cash to a willing seller" (i.e. developer paying to fishermen) where "there is no pressure on either one to buy or sell" and "the buyer and seller know all of the uses and purposes" of the fishing rights being "taken/damaged/displaced" by the developers' projects. See Cal. Code Civil Proc. 1263.320; Evidence Code Section 823; Cal BAJI Jury Instruction 3501., et seq. In addition to fishermen displacement compensation, the freely negotiated Bylaws of the Morro Bay Lease Areas Mutual Benefits Corporation, authorizing the Commercial Fishing Mitigation Fund Trustees' Committee Charter, addresses methods of full mitigation processes responding to the project developments as they progress and change which address community wide mitigation with annual developer contributions based on a percentage of the BOEM lease payments, and include representation for Sport Fishing and the Morro Bay Harbor and Port San Luis District Managers and participation by fishermen who are not from either port.

[1] Terms are defined in the Bylaws of the Morro Bay Lease Areas Mutual Benefits Corporation.

d. The Agreement provides that "the Parties acknowledge that the commercial fishing industry, represented by the Organizations, is subject to substantial economic pressures, is vulnerable from a range of regulatory, economic, and market impacts, and that the cumulative effects of the Project coupled with these pressures, may impact Qualified Members of the Organizations."

e. The Agreement acknowledges that "the Organizations are relying upon the good faith and representations by Castle Wind that the provisions of this Agreement are enforceable and will be implemented in conjunction with any offshore wind project developed by Castle Wind within the Covered Area."

f. The Agreement established various mitigation measures to be implemented by a California mutual benefit corporation, which is now referred to as the Morro Bay Lease Areas Mutual Benefits Corporation ("MBLA MBC") in accordance with the California Corporations Code Section 7110 et. seq. (Section 1.1(a).) which is intended to minimize the anticipated impacts of the Project on the members of the Organizations.

g. The Morro Bay Lease Areas Mutual Benefits Corporation Bylaws and the Mitigation Fund Trustees' Committee Charter implement and adopt the mitigation measures contemplated by the Charter Wind Agreement into comprehensive and empowered institutions capable of protecting the long- term viability of the commercial fishing activities from Morro Bay Harbor and Port San Luis during all phases of off-shore wind projects in the BOEM Morro Bay Lease Areas.

h. The Bylaws provide a mechanism for any and all of the potential project developers to participate in the comprehensive mitigation and monitoring program with minor technical changes to reflect the current BOEM lessees/developers.

2. City of Morro Bay, Castle Wind Community Benefits Agreement (November 29, 2018)

The priority, preservation and enhancement of the commercial fishing activities from Morro Bay Harbor and Port San Luis has been expressly recognized by the City of Morro Bay which entered into a "Community Benefits Agreement, Castle Wind Morro Bay Offshore Wind Farm Project," effective November 29, 2018, which granted to Castle Wind an exclusive option to lease the City owned outfall conduit lease regarding "the City owned and controlled submerged outfall structure formerly utilized by the Morro Bay Power Plant capable of being effectively reutilized to route the export cable that will electrically connect the Project to the Morro Bay substation," and "thereby interconnect with the high-voltage transmission system operated by the California Independent System Operator."[10] The City required Castle Wind to comply with the Commercial Fishermen's Agreement as a condition of the exclusive option for on-shore support facilities granted to Castle Wind: "The Parties acknowledge the Morro Bay community will benefit from the Fisherman's Agreement, entered into between Fishermen's Organizations and Castle Wind, Dated October 6, 2018 ('Fisherman's Agreement'). Under the Fishermen's Agreement, Castle Wind has committed to minimize and mitigate the anticipated impacts to the commercial fishermen from the Morro Bay and Port San Luis communities who operate within the Covered Area and are proximate to the Project."

H. California Coastal Commission Conditions Protecting Commercial Fishing Activities from Morro Bay Harbor and Port San Luis Require Complete Mitigation and Monitoring of Commercial Fishing Impacts

On June 14, 2022, the California Coastal Commission considered and conditionally concurred in Consistency Determination CE-0004-22, for the Bureau of Ocean Energy Management (BOEM) in federal waters offshore of

[10] "Community Benefits Agreement, Castle Wind Morro Bay Offshore Wind Farm Project," November 29, 2018, Section 4 (a), pp. 5-6.

San Luis Obispo County, approximately 20 miles off Cambria, to conduct a lease sale for up to 240,898 acres of federal waters for the future development of offshore wind energy facilities. The Consistency Determination "allows lessees to conduct site characterization and assessment activities and submit a construction and operations plan for development of offshore wind energy on their leases." The Commission found that, "Lease activities and future offshore wind development also have the potential to adversely affect fishing and fishermen through exclusion and displacement from fishing grounds, increase costs and time at sea to reach new fishing grounds, loss of future fishing grounds and loss or disruption of harbor space and fishing infrastructure at ports." (CCC Adopted Findings, p.5.)

No definitive mitigations or monitoring programs were adopted, but the Commission committed itself to completing a robust mitigation, which under CEQA compliant functional equivalency must be completed *before any phase of the project commences so that mitigation will not be illegally deferred* (p. 73):

> "In short, the information and analysis presented here and in CD-0001-22 should be viewed as a starting point. The data discussed in this document reflect information about fisheries more broadly but cannot fully capture the nuance of fisheries operations for individual operators. Doing this will require a robust social and economic analysis to understand what the full suite of impacts are and what measures can be implemented to avoid, minimize, and where necessary, mitigate impacts to the commercial and recreational fishing industry of California."

This mitigation process must be completed *before* any phase of the projects begin, including site surveys, especially since the new legislation quoted above requires development of "best practices" for "offshore surveys and data collection to assess impacts." There is no point to establishing best survey and data collection practices to assess impacts *after* site surveys have occurred.

THE ORGANIZATIONS HAVE ATTEMPTED IN GOOD FAITH TO WORK WITH THE THREE PROJECT DEVELOPERS BUT THE DEVELOPERS ARE "IMPACT DENIERS", OFFER ONLY TO FIX WHAT THEY BREAK, AND ARE MARRIED TO AN ERONEOUS UNDERSTANDING THE NEPA REQUIREMENTS FOR ANANLYZING IMPACTS AND FORMULATING MITIGATIONS CLEARLY REJECTED BY THE PRESIDENT'S COUNSEL ON THE ENVIRONMENT

Condition 7 b of the Coastal Commission Consistency Review placed tremendous importance on the outreach of the developers to the fishing communities and harbor districts:

> "b. BOEM will require lessees to submit reports on process, outreach, and outcomes of engagement with fishing communities and harbor districts and will provide copies of these reports to the Commission. All documents and analysis will be made publicly available and readily accessible, to the maximum extent practicable." (p. 16)"

A recent response of BOEM to a FOIA request indicates non-compliance with this mandatory condition of approval of the Consistency Review, identifying no records in response to this condition.

The MBCFO and PSLCFA have made serious efforts and commitment of time, energy and money to work with the three developers on commercial fishing mitigation, a subject the Organizations have been working on for several years and obtained the approval of the memberships and the Organizations of the Castle Wind Agreement, and later the duly incorporated Morro Bay Lease Areas Mutual Benefits Corporation, the Bylaws and Trustees' Charter.

The first three meetings with developers were perceived by the Organizations' representatives as non-substantive, and seemed to merely be "checking a box on the list." I attended those meetings and was surprised at the lack of meaningful discussions of mitigations already articulated in a multi-year process of arms-length negotiations, and were "project ready." It was also evident that the organizations' representatives were unhappy about loosing fishing opportunities while making no substantive progress, which is inconsistent with complying with "process, outreach, and outcomes of engagement" with commercial fishing communities as required by the Commission's Condition 7 of theBOEM Consistency Determination by the Commission.

In an effort to improve the process and keep it from dis-integrating completely, I engaged in outreach to the project developers candidly discuss the problem:

1. Oct. 2, 2023 – OUTREACH TO WIND DEVELOPERS – FISHERMEN PROPOSE AGENDA FOR FUTURE MEETING TO AVOID FRUSTRATION OF UNFOCUSSED MEETINGS REGARDING MITIGATION

a. Email from Walter to Developers attaching a 6 page discussion format Agenda (copy attached in Appendix) concerning mitigation of commercial fishing impacts:

"Here is the Agenda for the meeting on October 9, 2023 which I thought could give us a discussion structure or checklist so that by the end of the meeting the fishing organizations will know the position of the OW developers. …

"You indicated that you had mentioned to Kate Hucklebridge at CCC that the prior meetings had been "acrimonious" (a strong word, "angry" and "bitter") which I attribute to fishermen frustration with the lack of focus on specifics at each of the prior meetings. I think this agenda can facilitate the focus on specifics and avoid acrimony or frustration from a sense of lack of progress.

"A major area of concern is the impacts of the site surveys, timing, environmental review, and whether any enforceable commercial fishing mitigations are in effect prior to commencement of any phase of the project. That is a very important issue, but I thought it was pre-mature before we see whether there will be any progress on commercial fishing mitigations.

"Thank you.

"Bill Walter"

b. One of the most important items on the Fishermen's Proposed Agenda was discussion of using California Mutual Benefit Corporation and Trustees' Committee Structure for Commercial Fishing Mitigation:

1. "CHOICE CALIFORNIA MUTUAL BENEFIT CORPORATIONS CODE SECTION 7110 etc. FOR CREATION OF NON-PROFIT CORPORATION FOR COMMERCIAL FISHING MITIGATION IN THE MORRO BAY LEASE AREAS
    - Widely Used Type Of Corporation; Established Legal Procedures, Fiduciary Duties, Achieves Non-Profit Purposes; Stable And Perpetual Management until projects decommissioned
    - Reliable And Effective Supervision Provided By The California Department Of Justice, Charitable Trusts Section, detailed In "*Attorney General's Guide For Charities, Best Practices For Nonprofits That Operate Or Fundraise In California*,"
    - Successful Experience For Twenty Years With The *Central California Coast Joint Cable/Fisheries Liaison Committee, A California Nonprofit Mutual Benefit Corporation.*
    - In response to documented commercial fishing impacts from offshore wind development, the Crown Estate of The United Kingdon has utilized a not-for-profit company structure to administer donations to the "direct benefit to the fishing industry operating in within the vicinity" of the wind farms by the owners of UK offshore windfarms "in line with their corporate social responsibility objectives." Gray, M., Stromberg, P0L., Rodmell, D. 2016 'Changes to fishing practices around the UK as a result of the development of offshore windfarms – Phase 1 (Revised). The Crown Estate, 121 pages. ISBN: 978-1-9064 10-63-3, pg. 121."

"Acceptable to Developers: ______________________________
"Reasons Developers Disagree:______________________________
"Developers' Alternative Proposal:______________________________"

c. The Developers simply ignored the Fishermen's Agenda who had to request the Developer's "agenda" for the meeting: Walter Email to Developers expressing concerns and frustration with the "process", October 7, 2023:

"Hello Tyler,

- Can you provide the agenda ahead of time – the same courtesy I showed the developers by providing an agenda which has been unilaterally "tabled" in advance of the meeting?
- Please recognize the frustration of four meetings – collectively costing individual fishermen hundreds of thousands of dollars in lost fishing time. After those meetings, we know no more about an enforceable mitigation regime than before the meetings. That's sort of astonishing to me and I am sure many others.
- Please recognize that after these four meetings, there has been not a single suggestion or feedback from any of the developers.
- My fear is that the frustration is being stoked, perhaps unintentionally, to make the fishing industry look unreasonable, "threatening", "name calling," and "intimidating" – to then report those items ex parte to Coastal Staff without an opportunity to balance the picture. It forces us to "tell the other side of this story" to Commission staff so that there is some "balance."
- The value of most fishing businesses had decreased by a substantial factor (some estimate 50% or more) due to the risk and uncertainty of the proposed industrial scale development in traditional fishing areas for hundreds of years. On land, we call that "unreasonable pre-condemnation activity" which has been unconstitutional in California for decades; that is, the implementation of the project which depresses the value of the business interests subject to injuries for alternative "winners'" purposes.
- I agree with staying "on topic" – but when the developers control t[he] "topics" without providing an agenda – it seems condescending and disrespectful of the existential threat of these projects to the survival of the fishing industry over the next decade and beyond.
- Let me add -- 'listening' to the concerns of the commercial fishing industry by the developers. I think the tone will improve if the developers show that they are listening and can point to any example where they have in the past provided meaningful compensation to affected fishing interests.

- There is currently no enforceable mitigation for commercial fishing or any hint of what the developers think that looks like and is viable. These projects affect people's lives, businesses, and the foundations of the coastal visitor serving economies – which the broader local community is beginning to learn about. It creates fear and distrust when proposed by for-profit businesses permanently changing the coastal environment without first committing to written mitigation. … Sincerely,"

d. After receiving the Developer's ground rules and "agenda," Walter email October 8, 2023:

"Hello Tyler,
"Can we add:

- Respect the fishermen's suggestions concerning the agenda topics they proposed
- Respect the time and expense (lost income) of the individual fishermen participants in the meeting
- Acknowledge the frustration throughout the fishing community of not getting any substantive suggestion on mitigation during the first four meetings and the lack of commitments to commercial fishing mitigations which has stoked strong resentments and distrust towards the project developers' intentions
- Acknowledge that the project phases will impact commercial fishing and that the uncertainty the proposed projects pose for the fishing industry, the willingness to buy and sell businesses, invest further in businesses, value of business assets, etc.
- Do not presume or imply that fishermen collectively engage in threatening, intimidating or name calling behavior
- Agree that any communications about the meeting to any government agencies (e.g., Coastal Commission) will be in writing and copied to the participants to avoid undocumented oral ex parte communications which could prejudice either party with those agencies."

Because the selection of the Working Group was in process, the Organizations were concerned that oral, ex parte comments to Coastal Staff could prejudice the selection of fishing representatives on the Working Group. The Fishermen only asked that those "communications" – which had become negative about the fishermen – be put in writing and documented as required in the Consistency Condition 7b and so that false, mistaken, or discrediting comments could be documented as part of the reviewable record of the "process."

e. During the meeting of October 9, 2023, the Organizations' representatives presented substantial evidence based on personal knowledge, expertise, education, background and commercial fishing experience clearly establishing impacts on commercial fishing from the projects:

Owen Hacklemen - I have a question, so does that "loss of fishing time" include the indefinite loss of fishing time within the lease areas? Long silence.

Owen - But I will never be able to fish again in those areas with the gear type I use. Right? I mean it seems pretty apparent to me.

Owen - Let me clarify, I fish with a long line multiple miles long with an anchor at each end and many times it will drift a mile or more before it hits the bottom in 3000 ft. of water. I don't see how it is possible to fish there.

. . .

Chris Pavone - I also have a question about loss of fish time. It seems to me that the agreement we worked so hard on might be giving a false allusion that anybody even wanted these wind farms. You are proposing massive changes at our ports, you might kill fish. What do you mean by loss of fishing time. There is going to be more congestion at our port, you are going to be building and doing things at our ports, the whole area is going to change. I have said this from the beginning, it is not just the call area. It is changing the coast. Period. Fishing is a delicate thing. Fishing is already at a very delicate place where permits are so expensive and regulations are so tight that if our fish numbers go down once we start doing all this, it will be really bad. So, we need to clarify what we mean by loss of fishing. We have fish tickets where we can show what we have caught historically. I know what my guys do on average every day. And we will know if it goes down. That is what I am curious about. I believe a jet engine or a rock concert is around 120 decibels and I don't think anyone in this room could stand 220 decibels. There may be something I am not understanding about the frequency but that sounds very loud to me. And if it doesn't kill the fish, they are going to leave. So, what is loss of fishing?

. . .

Chris - Yes, I was reviewing some of the research about what decibels fish die at, and that doesn't even include a large mammal, that would be horrifying. They would definitely leave the area at least. I have guys that pay their rent and live paycheck to paycheck by how much they can fish. That is directly related to good weather and everything going smoothly, no body getting in the way, nothing broken down. No hiccups. It doesn't take much, even a rocket launch. If you have taken a look at the waterfront port study that REACH did. Some of the ideas they had for changes at our port are significant. The further we get away from our agreement, it's going to get bad. People will reject you and reject me for letting them down. So, I want a clear definition about what loss of fishing really means.

The fact that you get to decide what loss of fishing means, in the most respectfully way, doesn't sound like a 50-50 negotiation, it feels like a parent/child teacher / student relationship. We were the ones that wanted to make the meeting. It's cool we collaborated but for you to take over and say this is what loss of fishing is. You are not going to take fishermen's hands and control them like that, they will rebel on you. It's not in their nature. You have to treat people with respect.

...

Chris - I am just trying to digest all this. You said there were 5 things that we could agree on. These are all things that are minor and you would be forced to do anyways. They are not really considering that we will be losing the value of our permits, how much fish we catch. This is scary for a lot of guys. My phone has been ringing nonstop. We should always approach this with respect. Just because we are fishermen, there are people in our group that are very accomplished in business, in academics, they are not just stereotypical fishermen. Our livelihoods are on the line. I think you know that. It is not like the old days where they gave these permits out for free and it wasn't controlled. We are also dealing with fishery closures; rocket launches and I think it is odd that the Federal government is stepping in right when this is happening to close a fishery over a fish we don't even catch here.

...

Bill Blue - I have been doing this a long time and I was here when the seismic testing for the oil platforms went on in the 70's. Our main concern is not the end product, our main concern is what is happening in the near future way before the 7-c working group probably even has its first meeting. From what I have seen how things go. The Site Surveys and the Construction are going to be the most damage to our industry and how we work. The Site Surveys need to be addressed. Your communication is great, we had the same type of communication plan with the cables, but there was mitigation in place before we agreed to the communication plan and everything worked really good and it still works really well. So, you wanting us to sign a communication plan and the things you agree too without mitigation in place for the damage that is going to be done by the Site Surveys, is a problem. It's going to kill things and disrupt things, it's documented, you guys need to admit that. That is our fear, our fear is that if mitigation is not in place before the Site Surveys begin, there will be no mitigation for all the damage from Site Surveys and construction caused which is the majority of damage that will take place. This is important because our livelihoods depend on it. Thanks.

...

Chris - I have had some conversations about the Guard Boat thing. We have very few guys that even have boats big enough to do that. Alot of these things are not really benefitting fishermen. The vast majority of our fishermen are hook and line and stay within 3 miles. It's more about the disruption of our habitat in the area. In our port. So, if someone did happen to get Guard Duty, it may just cause division at the port since there will only be a few guys that could benefit from that. Again, we have been thru this for years. We spent years having heated discussions about this stuff.

...

Tom Hafer- So I hear fish tickets being mentioned. So, when the cables were here, they were pounding and digging. For every day they were doing that, they would take our fish tickets and triple it (or other people were paid another way giving the wind companies their average fish ticket for the same time period and multiplying it by the number of days they were doing their geophysical surveys/laying the cable.) *Added comment. It would be a lot more than our agreement, but that is one way you could do it.

...

Chris - I did collect data on the cable work. You know I am a Math professor and I know statistics. I collected data 3 months before the work and 3 months after and it showed a 15-25% decrease. Fish tickets are a real thing and undeniable. But it is a little convoluted because what if fishermen notice there are not that much fish being caught and they just stop fishing. So that is not good either. That is my 2 cents on that.

...

Chris - Fish tickets are the only real data. I don't know what other data you would look at. Cause that is where the rubber meets the road.

...

Chris - No that is from the California Department of Fish and Game. They know exactly what we catch and have records for years back. You should have that.

...

Bill B - So again when you tell us about the East Coast approach, you are going to come in and do the damage and then you are going to figure out what to do about it afterwards. You guys are supposed to be professionals and I don't understand if you know there is going to be an issue, you are going to ignore the issue. I am a crab fisherman, the sonic surveys are going to kill the larvae floating around, these are cyclic fisheries, if you miss one year of spawning, you may not see the damage from that for 3 or 4 years down the road. So, the site survey, is the main thing, that is what we are concerned about now. We would appreciate something done. Mitigate, talk about, or compensate in some way before you start killing stuff. So that is how we feel. We know what is going to happen. I saw it happen in the 70's, I fished rock cod down between Point Arguello and Point Conception. They came in, the fishing went away. It went away for several years before it came back. So, I know what is going to happen. I have been there done that. We would like to know what you guys are going to do in that regard.

...

Tom - Can we move back to the first comment about the Trustee committee? About a 3rd party. Who are you thinking about as a third party?

...

Tom - Can we move back to the first comment about the Trustee committee? About a 3rd party. Who are you thinking about as a third party?

...

Chris - I want to reiterate what Tom was saying. The purpose of that money was to better the fisheries. We have done a lot more than he mentioned. He is being humble about it. You see real changes at port from those funds. In Port San Luis we are getting ready to change out the diesel fuel tanks for the port, we are talking about $600,000 or something crazy and we will be helping them with that. So, the idea of a 3rd party will just put barriers between the wind companies and the fishermen. We want to use this money to go fishing and to keep fishing. Get new people into fishing and to keep everything good. And that is what the cable has done. The Trustee Committee is pretty important. It is part of our agreement that we were the proudest of that we would have a better version of the cable committee. It seems pretty fair to me. It isn't like you wouldn't have a voice. It is a democratic process; we vote on everything.
I'd really like you to take a good look at the Cable Companies and what they did in I think was 1999. It is one of the best examples of the synergy of big industry and fishermen working together and it actually benefits the community. Don't lay down the Trustee Committee just yet. If we need to redefine it and polish it up, we are willing to talk about it but that is going to be the thing that you are loved for if you get that right.

...

Owen - I want to just go off what Chris was saying about the Cable Committee. I was also on the cable committee. Any 3rd party would be a pretty big barrier between your companies and the fishermen and would not be productive or beneficial to our community or your businesses.

...

Owen - Before I was a fisherman, I was a biologist. So, a big concern that I have. I have talked about this with other fishermen. An artificial reef doesn't necessarily make more fish but do act as fish aggregators. So, our concern is that all the fish will be attracted to the new structure out there and they congregate in the lease area and become less accessible to us. I would like to see that included in the analysis.

...

Tom - Did you guys read the Qualifications and see how we set it up with windows for qualification during a time period?

...

Chris - We did that so people wouldn't move here to basically get wind mitigation funds.

...

Tom - And that we included out of town boats that had landings in that area and could prove they fished in that area. But you know it's not just the call area. But our qualifications we set for a reason. Whenever fish and game or the feds develop a limited entry fishery permit - there is always a window to qualify and minimum landings to get that permit. So we did it the same way they do. We knew if we left it wide open, people would move here like Chris said. We did it for you guys because when people hear there could be funds coming, they will move here to get a piece of the action.

Chris - We discussed this a lot. But there is another side of the coin too. I have a handful of guys very productive. So, we have to look at the best way to work together. The new generation of fishermen need to be included in the conversation as well. Skin in the game is a serious thing. There are a lot of ways to measure someone's participation in fishing - the permits they have, vessel they own. After a lot of discussion this was the best, we could come up with. If we need to refine and discuss we can but we need to be careful when we change these things, it took a lot of energy to get it where it is.

...

Owen - One of the hardest things to come to in the plan was the Qualifications but I think everyone was satisfied with what we came up with.

...

Bill Walter - I think there were 20 drafts.

...

Bill W. And if you could, could you explain the process going forward before the site surveys? Are there further studies to be done? Who issues permits for it? Are they authorized already? Any information on that would be helpful.

...

Tom - So Tyler, on Saturday morning during our teleconference with you, Bill W, and myself, you admitted that there will be the potential for impacts from the site surveys. In your view what kind of impacts?

...

Tom - So how many decibels do you plan on using to map the bottom, to see where the cables are going and to get around the hard bottom?

...

Tom - So on the East Coast Ocean Wind 1 project, there was a paper written that Ocean Wind went over the decibels they were supposed to use. Am I right on that?

...

Tom - If they are killing whales back there, 74 -75 now

. . .

Tom - Ok that statement right there is not a very good statement. Because if you look at all the data, the site survey work correlates directly with the increase in whale strandings. There was a massive kill off of whales, humpbacks, and even Right whales from the wind company site surveys using decibels that are hurting the whales, fish, and porpoise. I don't know why you guys say it isn't happening but everybody else say that it is. And if you are killing whales, you can kill fish a lot easier.

. . .

Tom - But it is the whole deal. Holly Wyer said that you guys will use 228 decibels. At 120 decibels rockfish are impacted with changes in behavior and even death, at 219 dcb. Salmon die. We have a lot of rockfish and salmon right in the cable area where you will be surveying. It's going to be a problem. I don't know why you guys don't admit that. We know it is going to be a problem. That's why the cable companies knew it would be a problem when they were doing it, the oil companies knew it would be a problem when they did it. But you guys are saying it is not going to be a problem. But it is going to be a problem. We have a humpback highway that goes right thru Morro Bay all the way to Big Sur right where you guys are going to be doing your work. If we start getting a lot of dead whales on the beach, you guys are going to have a problem with more than the fishermen, there are a lot of Californians that love whales. If you are killing whales, you are killing fish too.

. . .

Owen - You said that the impacts are "perceived" by us. I guess that implies that they are not real? It seems like I don't see mitigation for impacts. I don't see how telling us to get out of the way as mitigation somehow. If I can't fish somewhere for a week or a month and you guys are where the fish are or the fishing shuts off. I have 3 kids. I need to feed my family. That is really why I am here.

. . .

Owen - You're saying that we have to go elsewhere if you guys are where the fish are or to be a kind of guard boat. But I think I told you before that my market is really competitive and if I don't provide fish for it, they will just go elsewhere and I lose my market and I am out of luck.

. . .

Owen - That's great but if I am not bringing fish to my market, I am going to lose my market. If I can't fish where the fish are or the fish leave and I can't bring fish to the market, then I am up a creek.

. . .

Owen - I fish 2000 to 3000 ft deep. In the same area as the wind farms.

[Meeting adjourned by developer presider, noting 15 minutes overtime.]

f. After the meeting, Walter email, 10-9-2023: requesting, "As part of my due diligence, would you all be kind enough to provide me copies of the California Secretary of State filings for each of the three developers." Only one of the companies replied by providing courtesy copies of filings required to do business in California. The refusal of the other companies to document their legal qualifications to do business in California, their corporate compliance, location, members, affiliates, agents for service of

process, etc., is arguable evidence of the bad faith of the developers to meaningful engage in liaison efforts with the commercial fishing industry as required by the Condition 7 of the Coastal Commission consistency findings.

g. Walter email, 10-11-23, to the Wind Developers addressed two issues:

[1] "After our fourth meeting with the Developers, there was a consensus among the commercial fishing representatives that the position of the Developers about process and substance renders further meetings futile. The associations will address their concerns about the absence of enforceable commercial fishing mitigation and site survey monitoring/impacts/mitigation to the regulatory and trustee agencies." [This correspondence serves that purpose.]

[2] **There is a meaningful and simple process forward which is readily available to the Developers:**

"It's unfortunate that the process has come to an impasse when the solutions are simple and would achieve the developer goals with appropriate mitigation:

- "Perkins Coie attorneys wrote and approved the Bylaws, have the original work product on their computers, and now represent at least one of the developers. They could expeditiously process the technical, ministerial amendments (number of developer trustees) reflecting the current three project developers where referenced in the Bylaws and Attachments. The mitigation and coordination processes could be implemented immediately.

- "The developers can then submit the requests for meetings concerning site surveys to the Trustees' Committee, as currently constituted, which can meet, review, coordinate and address concerns about impacts, monitoring, mitigation, timing, etc., of the site surveys. The names and officers of the duly appointed Trustees' Committee are shown on the Committee Charter. This avoids tying up two fishing fleets with more meetings with no end in sight or prospect of agreement, and growing frustration, risk, uncertainty, and resentment. The "process" the developers can follow has been approved by the associations and the votes of their members and laid out already. The mechanisms for funding the costs of the coordination work which directly benefits the developers is provided and overseen by developer representation in the

MBC Bylaws with the few technical, ministerial, "clean-up" amendments to the Bylaws. It's appropriate and necessary to internalize those costs as part of the projects rather than externalize administrative costs on the individual fishermen and their organizations who don't benefit from the displacements or the projects.
Sincerely,"

h. At least one of the Project Developers and their "fishing liaison" have engaged in systematic personal attacks on fishing representatives from the Central Coast in an effort to distract from the failure in good faith to engage the fishing industry in mitigation and monitoring discussions and to discredit recognized and respected commercial fishing representatives. Such conduct only damages the processes of the agencies and the public's confidence in those procedures, which is critical if the wind projects are to succeed and commercial fishing in California is to survive.

As some of the trustee and regulatory agency representatives are aware, at least one of the Project Developers' has engaged in repeated personal attacks on local fishing representatives. While these are matters for which there are judicial remedies, these comments must be recognized as having infected fishing industry perceptions of fairness and credibility in the regulatory and trustee processes, including the selection of commercial fishing representation in the Working Group. It is a developer "strategy" which should be clearly, soundly and consistently rejected by the regulatory and trustee agency representatives who are ultimately responsible for the integrity of the collective processes.

There is no place in mitigation and monitoring processes of the regulatory and trustee agencies which carry out very heavy responsibilities imposed by statutes, Common law, and State and Federal Constitutions for personal attacks, or to use agency required fishing liaison(s) for the purposes of misrepresenting differences of opinion in a manner intended to discredit respected fishing representatives. Such conduct casts a "chilling effect" upon active and open participation and expression of professional opinions, legal arguments, presentation of substantial evidence, without fear of being personal discredited.

Both Associations encourage the trustee and regulatory agencies to preserve fair and open processes in which commercial fishing representatives can actively participate without being subject to personal attacks, to actively discourage such

developer conduct, proper use of fishery liaisons in which the agencies have posed the most serious responsibilities, and thereby foster confidence in the public processes to produce fair, balanced and unbiased results which will determine the future of the commercial fishing industry in the California Coast.

THE PROJECT DEVELOPERS' APPROACH TO MITIGATION – FIX IT AFTER IT BREAKS – IS BASED UPON LEGAL PRINCIPLES WHICH THE PRESIDENT'S COUNCIL ON ENVIRONMENTAL QUALITY HAS REJECTED AS A VALID MITIGATION STRATEGY IN AMENDING NEPA REGULATIONS

The EA prepared by BOEM occurred during a brief suspension of basic NEPA principles which is no longer in effect. The EA fails to address these basic principles and contains a flawed and incomplete analysis of potential impacts to commercial fishing and the impacts from site survey activities. In revising NEPA regulations returning to long standing NEPA principles, the President's Council on Environmental Quality has articulated reasons which rebuke the gaps in the EA's analysis and the approach of the Project Developers adopting a "wait till it's broken" (e.g., gear loss) approach to commercial fishing mitigation, denying the potential impacts to commercial fishing, being only able to agree to "gear replacement" as mitigation. The President's Council on Environmental Quality has been very clear on the mandates for this type of project review and analysis and terminated the brief time period where narrower impact and mitigation procedures were being followed:

"CEQ has reexamined the phrase "reasonably close causal relationship," which the 2020 rule added to the definition of "effects" in part on the basis that consideration of effects should be limited by proximate cause principles from tort law.[38] CEQ now considers this phrase unnecessary and unhelpful because an agency's ability to exclude effects too attenuated from its actions is adequately addressed by the longstanding principle of reasonable foreseeability that has guided NEPA analysis for decades. *See Robertson* v. *Methow Valley Citizens Council,* 490 U.S. 332, 356 (1989). *See also Sierra Club* v. *FERC,* 867 F.3d 1357, 1371 (D.C. Cir. 2017) (citing *EarthReports, Inc.* v. *FERC,* 828 F.3d 949, 955 (D.C. Cir. 2016)). Furthermore, CEQ no longer deems it necessary to import principles of tort law into the NEPA regulations. Environmental review under NEPA serves different purposes, such as guiding sound agency decision making and future planning, that may reasonably entail a different scope of effects analysis than the distinct tort law context. *See Metro. Edison Co.,* 460 U.S. at 775, FN 7 (1983) ("[W]e do not mean to suggest that any cause-effect relation too attenuated to merit damages in a tort suit would also be too attenuated to merit notice in an EIS; nor do we mean to suggest the converse. In the context of both tort law and NEPA, courts must look to the underlying policies or legislative intent in order to draw a manageable line between those causal changes that may make an actor responsible for an effect and those that do not."). Keeping the 2020 limitation also would suggest that agency NEPA practitioners are required to apply a tort law legal standard where they would still have to exercise professional judgement in determining the scope of the effects analysis. CEQ is removing the phrase "reasonably close causal relationship" from the definition of "effects"; the definition will continue to include the phrase "reasonably foreseeable" consistent with longstanding interpretation to allow agencies the flexibility to conduct appropriate effects analysis in line with their discretion and NEPA's requirements"

"As discussed in responding to comments above, restoring language on direct, indirect, and cumulative effects better promotes NEPA's statutory purposes and is more consistent with the extensive NEPA case law. *See*42 U.S.C. 4321–4332. Restoring these phrases to the regulations also is consistent with this Administration's policies to be guided by science and to address environmental protection, climate change, and environmental justice. *See, e.g.,*E.O. 13990 [39] and E.O. 14008.[40] Returning to the approach in the 1978 regulations provides regulatory consistency and stability for Federal agencies, affected stakeholders, and the public. CEQ is not returning to these definitions because this is what has always been done, but because longstanding CEQ and Federal agency experience and practice has demonstrated that these interpretations promote the aims of the NEPA statute and are practical to implement. These interpretations also reasonably reflect the plain meaning of the statutory phrase "environmental impact," and explicitly capture the indirect and cumulative nature of many environmental impacts.

> "CEQ is including direct, indirect, and cumulative effects as part of the definition of "effects" or "impacts" because they have long provided an understandable and effective framework for agencies to consider the effects of their proposed actions in a manner that is understandable to NEPA practitioners and the public. CEQ considers this approach to result in a more practical and easily implementable definition than the 2020 rule's definition of "effects" that explicitly captures the indirect and cumulative nature of many environmental effects, such as greenhouse gas emissions or habitat fragmentation. Upon further evaluation of the rationale for the 2020 rule and the comments CEQ received on the NPRM, CEQ does not consider the tort law standards of "close causal relationship" and "but for" causation to be ones that provide more clarity or predictability for NEPA practitioners, agency decision makers, or the public. Furthermore, as discussed in this section, CEQ does not consider the existing case law interpreting the 1978 definition of "effects" to require that the NEPA regulations limit agency discretion to identify reasonably foreseeable effects under such a standard. CEQ also is removing the potential limitations on consideration of temporally or geographically removed environmental effects, effects that are a product of a lengthy causal chain, and "effects that the agency has no ability to prevent due to its limited statutory authority or would occur regardless of the proposed action." These qualifications may unduly limit agency discretion and stating them as categorical rules that limit effects analyses is in tension with NEPA's directives to produce a detailed statement on the "environmental impact of [a] proposed action," "any adverse environmental effects which cannot be avoided," and "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity." 42 U.S.C. 4332(2)(C). Furthermore, this language could lead Federal agencies to omit from analysis or disclosure critical categories of reasonably foreseeable effects that are temporally or geographically removed, such as climate effects, frustrating NEPA's core purpose and Congressional intent."

Applying these fundamental, restored NEPA standards provides the only method of appropriately addressing impacts and mitigations regarding offshore wind projects impacts on commercial fishing in a BOEM revised EA for the site surveys and properly scoped broader impact analysis and a broadening of the mitigations BOEM can apply for commercial fishing mitigations consistent with these restored Regulations.

Respectfully submitted,

WILLIAM S. WALTER

Appendix I – Legal Policies and Authorities against Deferred Mitigation and Monitoring.

Source: *California Continuing Education of the BAR, Practice under the California Environmental Quality Act* (On-line Current Update):

"§14.6 A. Definition of Mitigation

An EIR must include proposed mitigation measures designed to minimize the project's significant environmental impact. Pub Res C §§21002.1(a), 21100(b)(3); 14 Cal Code Regs §15126.4(a)(1).

"§14.11 C. Level of Specificity Required

Lead agencies should avoid vague, incomplete, or untested mitigation measures. Mitigation measures must not be remote and speculative. *Federation of Hillside & Canyon Ass'ns v City of Los Angeles* (2000) 83 CA4th 1252, 1260. A court may find mitigation measures identified in an EIR legally inadequate if they are so undefined that it is impossible to gauge their effectiveness. *Sierra Watch v County of Placer* (2021) 69 CA5th 86, 110 (upholding noise mitigation measure that contained concrete requirements but rejecting vague noise measure which did not identify specific mitigation actions or performance standards); *Preserve Wild Santee v City of Santee* (2012) 210 CA4th 260, 281 (plan for active habitat management did not describe anticipated management actions or include standards or guidelines for actions that might be taken); *San Franciscans for Reasonable Growth v City & County of San Francisco* (1984) 151 CA3d 61, 79 (requirement that fee of undetermined amount be paid for unspecified transit funding mechanism was inadequate mitigation measure); *Kings County Farm Bureau v City of Hanford* (1990) 221 CA3d 692, 727 (mitigation agreement that called for purchases of replacement groundwater supplies without specifying whether water was available was inadequate measure for mitigating project's effect on groundwater supplies).

"§14.12 D. Deferred Formulation of Mitigation Measures

Mitigation measures should describe the specific actions that will be taken to reduce or avoid an impact. It is ordinarily inappropriate to defer formulation of a mitigation measure to the future. 14 Cal Code Regs §15126.4(a)(1)(B).

"Such deferral is not appropriate, however, when the result expected from the agency permitting process is left undefined. See *San Joaquin Raptor Rescue Ctr. v County of Merced* (2007) 149 CA4th 645.

"Impermissible deferral can occur when an EIR calls for mitigation measures to be created based on future studies or describes mitigation measures in general terms but the agency fails to commit itself to specific performance standards. *League to Save Lake Tahoe Mtn. Area Preservation Found. v County of Placer* (2022) 75 CA5th 63, 122 (mitigation measure for greenhouse gas emissions impermissibly deferred determining significance of impact and establishing appropriate mitigation to undisclosed time in future); *Cleveland Nat'l Forest Found. v San Diego Ass'n of Gov'ts* (2017) 17 CA5th 413, 442 (generalized air quality measures failed to set performance standards); *California Clean Energy Comm. v City of Woodland* (2014) 225 CA4th 173, 195 (agency could not rely on future report on urban decay with no standards for determining whether mitigation required); *POET, LLC v State Air Resources Bd.* (2013) 218 CA4th 681, 740 (agency could not rely on future rulemaking to establish specifications to ensure emissions of nitrogen oxide would not increase because it did not establish objective performance criteria for measuring whether that goal would be achieved); *Gray v County of Madera* (2008) 167 CA4th 1099, 1119 (rejecting mitigation measure requiring replacement water to be provided to neighboring landowners because it identified general goal for mitigation rather than specific performance standard). A mitigation measure that identifies only a general goal rather than a specific performance standard, defers formulation of a specific mitigation measure, and then allows the adequacy of that measure to be determined based on subjective criteria, is improper. *Sierra Watch v County of Placer* (2021) 69 CA5th 86, 110; *Golden Door Props., LLC v County of San Diego* (2020) 50 CA5th 467, 517; *King & Gardiner Farms, LLC v County of Kern* (2020) 45 CA5th 814, 858.

A mitigation measure calling for a mitigation plan to be devised on the basis of further study also can be found legally inadequate if it does not identify specific steps that might be taken to mitigate the impact once the study is completed. See *Preserve Wild Santee v City of Santee* (2012) 210 CA4th 260, 280 (mitigation measure providing for active habitat management did not describe anticipated management actions and did not include management guidelines or performance criteria); *Communities for a Better Env't v City of Richmond* (2010) 184 CA4th 70, 95 (rejecting mitigation measure that required project applicant to develop plan for reducing greenhouse gas emissions because it identified undefined and untested measures of unknown efficacy and did not contain any objective criteria for measuring success); *San Joaquin Raptor Rescue Ctr. v County of Merced* (2007) 149 CA4th 645, 669 (rejecting mitigation measure calling for future surveys for special status species and development of undefined habitat management plan in response to surveys); *Endangered Habitats League, Inc. v County of Orange* (2005) 131 CA4th 777, 794 (rejecting mitigation measure requiring submission of acoustical analysis and approval of mitigation measures recommended by analysis because no mitigation criteria or potential mitigation measures were identified). "Impermissible deferral of mitigation measures occurs when an EIR puts off analysis or orders a report without either setting standards or demonstrating how the impact can be mitigated in the manner described in the EIR." *City of Long Beach v Los Angeles Unified Sch. Dist.* (2009) 176 CA4th 889, 915.

"When an agency defers formulation of a mitigation measure, it should explain why deferral is appropriate. Deferral can be found improper if no reason for it is given. *San Joaquin Raptor Rescue Ctr.*, 149 CA4th at 670 (citing this text). See also *Cleveland Nat'l Forest Found. v San Diego Ass'n of Gov'ts* (2017) 17 CA5th 413, 442 (rejecting deferred mitigation partly because agency did not proffer any evidence supporting deferral).

"Later actions taken to flesh out a mitigation measure that calls for the details to be deferred must be consistent with the measure's terms, comply with its requirements, and be designed to implement its performance standards. See *Sierra Club v County of San Diego* (2014) 231 CA4th 1152.

...*Preserve Wild Santee v City of Santee* (2012) 210 CA4th 260 (post-approval formulation of active habitat management plan invalid because EIR did not describe expected management actions or include management standards)

...

" J. Mitigation of Cumulative Impacts

§14.18 1. Duty to Mitigate

An EIR must discuss a project's cumulative impacts when they are cumulatively considerable (Pub Res C §21083(b)(3); 14 Cal Code Regs §15130) and must also examine reasonable options for mitigating or avoiding the project's contribution to significant cumulative impacts (14 Cal Code Regs §15130(b)(3)). See *Fort Mojave Indian Tribe v Department of Health Servs.* (1995) 38 CA4th 1574, 1603.

"VI. ENFORCEABILITY OF MITIGATION MEASURES

"§14.22 A. Mitigation Measures Must Be Enforceable

"A lead or responsible agency adopts mitigation measures described in the EIR when it approves the project. See §§17.19–17.31. The mitigation measures that are adopted must be enforceable through conditions of approval, contracts or other means that are legally binding. Pub Res C §21081.6(b); 14 Cal Code Regs §15126.4(a)(2). Incorporating mitigation measures into conditions of approval is sufficient to demonstrate that the measures are enforceable. Pub Res C §21081.6(b); *Gray v County of Madera* (2008) 167 CA4th 1099, 1116.
This requirement is designed to ensure that mitigation measures will actually be implemented, not merely adopted and then ignored. *Federation of Hillside & Canyon Ass'ns v City of Los Angeles* (2000) 83 CA4th 1252, 1261; *Anderson First Coalition v City of Anderson* (2005) 130 CA4th 1173, 1186. The project proponent's agreement to a mitigation measure, by itself, is insufficient; the mitigation measure must be adopted in a way that makes it a legally enforceable requirement. *Woodward Park Homeowners Ass'n v City of Fresno* (2007) 150 CA4th 683, 730.

"Mitigation measures that are incorporated in conditions of approval for a project may not be avoided by treating phases of the project as separate projects. *Lincoln Place Tenants Ass'n v City of Los Angeles* (2005) 130 CA4th 1491 (rejecting claim that conditions of approval adopted for redevelopment of property which were designed to mitigate effects of demolition of buildings of historic interest did not apply when separate permit was obtained for demolition of structures).

"§14.23 B. Agency Must Adopt Mitigation Monitoring Program

When approving a project that includes mitigation measures, the agency must adopt a mitigation monitoring or reporting program. Pub Res C §21081.6.

"§18.3 A. Projects Based on EIRs or Mitigated Negative Declarations

The mitigation monitoring or reporting requirement applies by definition to projects that include mitigation measures to reduce environmental impacts."

In a situation where there are Trustee and Responsible agencies, coordination of mitigation monitoring programs are required:

"18.16 C. Coordination With Responsible and Trustee Agencies

"Several requirements on coordinating mitigation monitoring programs between the lead agency and other agencies in the CEQA process are set forth in CEQA and the CEQA Guidelines. First, the Guidelines recognize that lead and responsible agencies for a project will usually adopt different monitoring or reporting programs but that those programs should be coordinated. 14 Cal Code Regs §15097(d). See §18.17. Second, when an agency adopts a mitigation measure requested by a responsible or trustee agency, the agency requesting the mitigation measure must submit a proposed monitoring or reporting program for the measure. Pub Res C §21081.6(a)(1); 14 Cal Code Regs §15097(f). See §18.17. In addition, when a responsible or trustee agency identifies potentially significant impacts of a project, that agency must provide the lead agency with performance objectives or guidelines for mitigation of the identified impacts. Any mitigation measures that are submitted must relate to impacts within the submitting agency's jurisdiction. Pub Res C §21081.6(c). See §18.18."

Appendix II – SCIENTIFIC STUDIES AND RELATED EXPERT COMMENTS SUPPORTING THE POSITION AND REQUESTS OF THE MBCFO AND PSLCFA AGAINST DEFERRED MITIGATION AND MONITORING AND UPDATED NEPA/CEQA COMPLIANCE DUE TO NEW INFORMATION NOT CONSIDERED IN THE BOEM EA FOR SITE SURVEYS.

- Arthur N. Popper, Anthony D. Hawkins, Review Paper, "An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes," Journal of Fish Biology (Accepted 7 March 2019), pp. 692-713.
- Arill Engas, Svein Lokkeborg, Egil Ona, Aud Vold Solal, "Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus)", Can. J. Fish. Aquat. Sci Vol. 53, 1996.
- Gray, M., Stromberg, P-L, D.2016. 'Changes to fishing practices around the UK as a result of the development of offshore windfarms – Phase 1 (Revised.) The Crown Estate, 121 pages. ISBN: 978-1-906410-64-3.) (Due to the size of the document, it is not attached, but is readily available and is incorporated herein by this reference.)
- Alliance of Communities for Sustainable Fisheries, Principal Author, Steve Scheiblauer, collaborative effort between various California Fishing Ports, "Impacts from OSW to Fisheries and their Communities".
- The fishing studies cited in the BOEM EA are not relevant to analyzing the impacts on fish from site surveys because one study is based on speculation and not about fish per se and the other is based on dredging which is completely different than the signals which will be used in the site surveys.
- Bibliography of additional sources concerning potential impacts from offshore wind energy development, entitled, "Lease the Ocean Alone".
- Documentary on Fishing Impacts, Atlantic Coast, BOEM Lease Areas https://youtu.be/LVjYRgkuK2A?si=Rk7BP11lPBi69o6-

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REVIEW PAPER

An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes*

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Fishes use a variety of sensory systems to learn about their environments and to communicate. Of the various senses, hearing plays a particularly important role for fishes in providing information, often from great distances, from all around these animals. This information is in all three spatial dimensions, often overcoming the limitations of other senses such as vision, touch, taste and smell. Sound is used for communication between fishes, mating behaviour, the detection of prey and predators, orientation and migration and habitat selection. Thus, anything that interferes with the ability of a fish to detect and respond to biologically relevant sounds can decrease survival and fitness of individuals and populations.

Since the onset of the Industrial Revolution, there has been a growing increase in the noise that humans put into the water. These anthropogenic sounds are from a wide range of sources that include shipping, sonars, construction activities (*e.g.*, wind farms, harbours), trawling, dredging and exploration for oil and gas. Anthropogenic sounds may be sufficiently intense to result in death or mortal injury. However, anthropogenic sounds at lower levels may result in temporary hearing impairment, physiological changes including stress effects, changes in behaviour or the masking of biologically important sounds.

The intent of this paper is to review the potential effects of anthropogenic sounds upon fishes, the potential consequences for populations and ecosystems and the need to develop sound exposure criteria and relevant regulations. However, assuming that many readers may not have a background in fish bioacoustics, the paper first provides information on underwater acoustics, with a focus on introducing the very important concept of particle motion, the primary acoustic stimulus for all fishes, including elasmobranchs. The paper then provides background material on fish hearing, sound production and acoustic behaviour. This is followed by an overview of what is known about effects of anthropogenic sounds on fishes and considers the current guidelines and criteria being used world-wide to assess potential effects on fishes.

Most importantly, the paper provides the most complete summary of the effects of anthropogenic noise on fishes to date. It is also made clear that there are currently so many information gaps that it is almost impossible to reach clear conclusions on the nature and levels of anthropogenic sounds that have potential to cause changes in animal behaviour, or even result in physical harm. Further research is required on the responses of a range of fish species to different sound sources, under different conditions. There is a need both to examine the immediate effects of sound exposure and the longer-term effects, in terms of fitness and likely impacts upon populations.

KEYWORDS
behaviour, criteria, effects, guidelines, hearing, sound

*This paper is dedicated to two long-time friends and colleagues, Colin Chapman and Richard R. Fay. Colin and Dick have been major contributors to our understanding of fish bioacoustics. Moreover, their work and their thinking has inspired many of the studies described in this review.

1 | INTRODUCTION

The past several decades have seen an increasing level of interest in the potential effects of anthropogenic sounds on aquatic life. The sounds added by humans into aquatic environments (both marine and freshwater), include those from shipping, dredging, sonars, seismic airguns used for oil and gas exploration, underwater explosions and construction, including pile driving, as well as many other activities. Anthropogenic sounds such as these have increased in recent times as a result of increases in shipping, harbour developments, the construction and operation of offshore wind farms, tidal and wave energy generation, dredging and cable and pipe laying, seismic surveys for oil and gas and offshore oil developments. Although initial concern regarding anthropogenic sound focussed on the effects upon marine mammals (NMFS, 2018; NRC, 1994; Southall *et al.*, 2007), there is now growing concern over potential effects upon those organisms that make up a much larger part of the aquatic biomass, fishes and more recently, invertebrates and zooplankton (Popper & Hawkins, 2016). Concern has also been expressed recently over effects upon freshwater fishes (Bolgan *et al.*, 2016; Mickle & Higgs, 2018), since they have received far less attention in research on noise effects studies.

The added sounds in the aquatic environment may have a wide range of effects on fishes. Exposure to very intense sounds may result in mortal injuries, but far more important issues are associated with sounds that are detectable by fishes and which may affect their behaviour, causing them to move away from their migration routes, leave favoured habitats in which they feed or breed, interfere with communication using sound, affect reproductive behaviour (where sound is used to attract mates and facilitate spawning), or prevent the detection of other biologically important sounds. As a consequence, the addition of anthropogenic sounds to the aquatic environment has the potential to do significant harm to fishes.

From an historical perspective, fish bioacoustic studies up until the early 21st century asked basic questions about hearing, sound communication and behaviour. While such studies continue, many studies since about 2005 have focussed on the potential adverse effects of sounds on fishes. A driving force in this change has been the need by regulators, industry, environmental groups and scientists to develop guidelines and criteria that can be used to assess whether particular sounds have deleterious effects on individual fishes or affect populations. There has also been a need to employ such information in regulations intended to protect fishes and ecosystems.

2 | OVERVIEW

The purpose of this paper is to improve understanding of the issues related to the potential effects of anthropogenic sounds on fishes and to point to the need to examine effects not only on individual animals, but also to those on fish populations and ecosystems. However, since many readers may not be familiar with fish bioacoustics, we also include some background material to assist readers in understanding and interpreting data on the effects of anthropogenic sound. Accordingly, the paper starts with a brief discussion of underwater sound in order to introduce major concepts that are critical for understanding potential effects of anthropogenic sound. This is followed by a discussion of fish bioacoustics for those not familiar with the topic. We then focus on data on the potential effects of anthropogenic sound on fishes. It will become clear that there are major gaps in our knowledge that need to be filled in order to facilitate the development of appropriate and effective sound exposure criteria and the guidelines to implement them. Indeed, it is critical to understand that current criteria are still provisional and that substantially more data are required before firm criteria can be set. The review therefore ends with suggestions as to the most critical current data needs.

This paper is not intended to be a complete review of all the literature. Rather, our focus is on the major issues related to potential effects of anthropogenic sound on fishes and to help readers understand those aspects that are especially important. However, we do provide further citations so that those interested can delve deeper into the growing literature on the topic and we include a number of recent reviews that refer to the wider literature. Furthermore, the papers we do include are those we think are amongst the most informative and critical to understanding the main issues. At the same time, we do include a number of papers that we see as being problematic, so that as well as providing insight into work that is critical to understanding the effects of sound on fishes, we also provide information on work that may lead to misunderstanding.

3 | ADDITIONAL BACKGROUND INFORMATION

For those interested in broadening their understanding of general issues of fish bioacoustics (hearing, sound production, behaviour *etc.*), there are papers in a volume by Webb *et al.* (2008) as well as several more recent reviews (Ladich, 2014; Ladich & Fay, 2013; Mickle & Higgs, 2018; Putland *et al.*, 2018). More detailed reviews of potential effects of anthropogenic sound on fishes (and other aquatic animals) can be found in papers by the authors of this review (Hawkins *et al.*, 2015; Hawkins & Popper, 2014; Popper & Hawkins, 2018) and in the reports of several meetings on the *Effects of Noise on Aquatic Life* (www.an-2019.org; Hawkins *et al.*, 2008; Popper & Hawkins, 2012, 2016 and the open access *Proceedings of Meetings on Acoustics* (www.go.umd.edu/UcA). Finally, a general overview of effects of anthropogenic sound on animals is provided by Slabbekoorn *et al.* (2018).

4 | THE IMPORTANCE OF HEARING

Of all the senses, hearing provides fishes with information, often from great distances, in the widest variety of environments, by day and night and from all directions around the animal. The limitations of other senses such as vision, touch, taste and smell in the aquatic environment, particularly in providing rapid, long-distance and 3-D information, make sound an exceptionally important cue for many (perhaps most) aquatic animals.

Detection of the acoustic scene (often referred to as the soundscape), which is the ensemble of ambient sound, including sound events, associated with a specific location at a particular time, is found in all vertebrates (Bregman, 1994; Fay, 2009; Slabbekoorn, 2018). Indeed, many of the most important aspects of hearing are likely to have evolved to enhance analysis of the soundscape. For example, the ability to determine the direction of a sound (sound source localisation) enables fishes (and other vertebrates) to locate predators and move away from them or detect potential prey and move towards them (Hawkins & Popper, 2018; Sand & Bleckmann, 2008). Likewise, the ability to discriminate between different sounds enables fishes to tell friend from foe or recognise and select members of their own species for mating. Once hearing evolved in fishes, acoustic communication became possible. However, while sound production is found in some fishes, many, including some that hear very well (*e.g.*, many otophysans), do not produce sounds. Instead, these species use hearing primarily for detection of those natural sounds that make up the acoustic scene. Because of the importance of sound to fishes, it becomes clear that any interference with detecting the acoustic scene or with those sounds used by some fishes to communicate, has the potential to affect fitness and survival!

5 | UNDERWATER SOUND

While the basic physics of sound in water are similar to those in air, the density of the medium is greater and as a result sound travels about 4.8 times faster than in air (1500 m s^{-1} *v.* 343 m s^{-1}). As a result, a 100 Hz sound has a wavelength of 3.43 m in air, but it is 15 m in water (see www.dosits.org for an excellent primer on underwater sound). While we do not go into underwater acoustics in any detail, a number of terms and ideas are presented since they are critical to understanding fish bioacoustics and the analysis of sounds that have the potential to affect fishes.

5.1 | Acoustic terminology

It is important to distinguish between sound and vibration. Sound is generated by the movement of an object, such as a loudspeaker, or a pile being driven, in a medium such as air or water (Urick, 1983). The term vibration refers to the actual motion of the sound source. As the sound propagates from the source it can be detected as the pressure fluctuations in the medium, above and below the local hydrostatic pressure (the sound pressure). However, sound is also accompanied by a back-and-forth motion of the medium, referred to as the particle motion. (For a clear visualisation of sound pressure and particle motion see: www.dosits.org/science/sound/what-is-sound/).

The term noise is often used to describe unwanted sounds that are considered to be unpleasant, loud or disruptive to hearing, or that can hinder detection of a particular signal. In some cases, however, the terms ambient noise or background noise may also be used, as it is in this paper, to describe sound generated by natural sources, as well as by anthropogenic sources, especially where they may interfere with the detection of animal and other sounds.

5.2 | Sound pressure, particle motion and the substrate

Sound pressure is a scalar quantity that acts in all directions. It can be described in terms of its magnitude, as well as its temporal and frequency characteristics. In contrast, particle motion is a back-and-forth motion and, as such, is a vector quantity. Accordingly, particle motion is described not only by specifying its magnitude and temporal and frequency characteristics, but also its direction of motion.

Sound pressure is expressed in SI units of pascals (Pa) or micropascals (μPa). Particle motion may be expressed in terms of the particle displacement (SI unit: metre m), or its time derivatives: particle velocity (meter per second m s^{-1}) or particle acceleration (meter per second squared (m/s^2). Sound intensity is the product of the sound pressure and the particle velocity, for which the SI units are watts m^{-2}.

A fundamental point is that all fishes (including elasmobranchs) detect and use particle motion, particularly at frequencies below several hundred Hz (Nedelec *et al.*, 2016; Popper & Hawkins, 2018). Thus, the detection of particle motion is integral to hearing in all fishes (and invertebrates) and it is used to locate the direction of the source, even in those fishes that are also sensitive to sound pressure (Hawkins *et al.*, 2015; Nedelec *et al.*, 2016). As a consequence, when investigating the effects of sounds upon fishes, it is important to describe the sounds in terms of particle motion (Popper & Hawkins, 2018), as well as sound pressure. This may be done by measuring the particle motion directly (Amorim *et al.*, 2018; Mickle *et al.*, 2018; Roberts & Breithaupt, 2016) or by conducting experiments under free-field acoustic conditions, where the particle motion can be predicted from measurements of the sound pressure (Hawkins *et al.*, 2014). Until recently, most studies of sound and fishes have only included measurement of the sound pressure and very few have considered particle motion in a biologically relevant context. This was not just because investigators did not fully appreciate the importance of particle motion, but also because of the difficulty in obtaining instrumentation to measure the particle motion (*e.g.*, Lumsdon *et al.*, 2018; Martin *et al.*, 2016).

While it is possible to estimate particle velocity from measurements of the sound pressure (or by measuring the pressure gradient), this can only be done in locales that are distant from reflecting boundaries (the water surface or bottom) or other acoustic discontinuities (MacGillivray *et al.*, 2004), since such surfaces have significant influence on the sound field and thus, on the levels and directionality of particle motion. Under such conditions, sensors are needed that not only detect particle motion (whether particle displacement or its time derivatives: particle velocity or particle acceleration) *per se* but are also able to detect the vector components in three dimensions.

Passage of sound and vibration into the substrate, which can be caused by sources such as pile driving, dredging and seismic surveys, may result in waves propagating through the substrate, both as compression waves and interface waves (Popper & Hawkins, 2018). The interface waves are often referred to as ground roll (Hazelwood *et al.*, 2018). These waves travel slower than the speed of sound and can have strong particle motion components. They may also generate evanescent sound pressure and particle motion waves that propagate through the water.

5.3 | Sound metrics

It is very important to always refer to a sound using the proper measures, or metrics, that best describes that sound.

5.3.1 | Continuous sound

Continuous sound (*e.g.*, from shipping) is generally presented as the root mean square (dB_{rms}) sound pressure or particle motion level, measured over a specified time interval, for a specified frequency range. The roughness of continuous sounds may be especially important when considering effects, using a statistic often called kurtosis (Henderson & Hamernik, 2012). However, while of potential importance, and while mentioned more and more frequently, kurtosis has yet to be applied to fish (or marine mammal) bioacoustics.

5.3.2 | Impulsive sounds

Impulsive sounds (*e.g.*, from pile driving) are best presented as the instantaneous peak level, the dB_{peak}. That is, the level of the zero-to-peak sound pressure or particle motion. Alternatively, the total energy within the pulse may be described by the sound exposure level (SEL; Popper & Hastings, 2009). The SEL is the integral, over time, of the squared sound pressure, normalised to a reference time of 1 s. The SI unit of sound exposure is the Pascal squared for 1 s ($Pa^2\ s^{-1}$). The SEL may be specified for a single impulse or strike (the SEL_{ss}). However, when impulsive sounds are repeated, for example when fishes are exposed to pile driving for a long period, it is appropriate to estimate the cumulative SEL (SEL_{cum}) associated with a series of pile strikes. The SEL_{cum} is the total noise energy to which the animal is exposed over a defined time period (Popper & Hastings, 2009).

Another important characteristic of impulsive sounds is the rise time, which is the time a signal takes to increase from 10% to 90% of its highest peak value. The rise time may affect the response of animals and may be especially important in terms of injury, where sharp rise times may be especially damaging.

5.3.3 | Frequency spectrum

The frequency spectrum is also important. The sound pulse is composed of a range of frequencies, expressed in terms of the level at each frequency measured over a given bandwidth. The bandwidths utilised are generally 1 Hz or $^1/_3$ octave (an octave is a doubling of frequency). It is important to specify the frequency bandwidth as different animals respond to different frequency ranges.

6 | NATURAL SOUNDS IN THE AQUATIC ENVIRONMENT

6.1 | Ambient sound

Aquatic environments are rarely silent. Ambient sound (often termed ambient noise) consists of sounds generated by physical sources such as wind, waves, precipitation and ground movement (geophony) together with biotic sounds (biophony) produced by a variety of marine organisms, including mammals, fishes and invertebrates. Examining the soundscape involves describing the characterisation of ambient sound in terms of its spatial, temporal and frequency attributes and the types of sources contributing to the sound field.

6.2 | Fish sounds

Of the more than 33,000 species of fish, at least 800, from over 100 families, are known to produce sounds (Bass & Ladich, 2008). It is likely that with more studies, including freshwater fishes, many additional species will be shown to be sound producers. Many commercially important fish species produce sounds, including the Atlantic cod, *Gadus morhua* L. 1758 and haddock, *Melanogrammus aeglefinus* (L. 1758), both Gadidae (Hawkins *et al.*, 1974; Hawkins & Chapman, 1966) and many croakers and drums (Sciaenidae; Ramcharitar *et al.*, 2006). Sounds are produced in a wide range of contexts such as feeding, mating, or fighting (Hawkins & Myrberg Jr, 1983; Moulton, 1963). The detection of sounds may be used by female fishes to locate vocal males and identify suitable mates (Casaretto *et al.*, 2015). As a consequence, anything, including sounds from anthropogenic sources, that impedes the detection of these sounds can have an adverse effect on such fishes.

7 | ANTHROPOGENIC SOUND SOURCES

There are many sources of anthropogenic sound in the sea, lakes and rivers, with quite different acoustical characteristics (Hawkins *et al.*, 2015; Popper *et al.*, 2014). Many commercial human activities introduce sound, either intentionally for a specific purpose, such as seismic surveys, or unintentionally as a by-product of activities such as shipping and offshore and even onshore construction work. Coastal areas and areas where a high degree of human activity takes place, may be quite noisy; including harbours and shipping lanes. However, some high-intensity sources of underwater sound, such as pile drivers and seismic airguns, can be detected over distances of several thousand kilometres. Thus, effects upon fishes may occur well away from the source itself.

There are two main classes of anthropogenic sound. Some sounds are transient or impulsive, while others are continuous. Impulsive sounds are often of short duration (generally well less than 1 s) and may show large changes in amplitude over their time course. They can either be single or repetitive. Examples of such sounds are those produced by seismic airguns, pile driving and underwater explosions. (Various anthropogenic sounds can be heard at: www.go.umd.edu/Ucd.) Most often, such sounds are only present over the course of a particular project and then end.

Continuous sounds are produced by shipping (both commercial and pleasure boats), operational wind turbines, seabed drilling *etc.* and may continue for months or even years (*e.g.*, in a harbour or wind farm). A few of these, described below, are perhaps the most ubiquitous sounds potentially affecting fishes over the widest geographic areas. Sonar systems, while used very widely, generally operate within frequency ranges that are not detectable by fishes (Halvorsen *et al.*, 2012d; Popper *et al.*, 2007).

7.1 | Seismic airguns

Airguns are impulsive sources used for seismic exploration for sub-sea gas and oil reserves as well as for geological research (Gisiner, 2016). These devices use compressed air to produce a gas bubble which expands rapidly when released, creating a high intensity impulsive sound, primarily composed of energy below 200 Hz, but with the bulk of the sound from 20 to 50 Hz (Mattsson *et al.*, 2012). The sounds are directed downward into the seabed, though there is also some spreading laterally and they are reflected from various geological formations and then detected by a long array of hydrophones towed by the seismic vessel (see Gisiner, 2016 for a detailed description of seismic surveys).

7.2 | Impact pile driving

Impact pile driving is widely used for the construction of bridges, harbours, wind farms and other offshore structures (Dahl *et al.*, 2015; Popper & Hastings, 2009). Striking by the hammer results in vibration of the pile in water and in the substrate, thereby generating sounds that potentially affect nearby animals (Dahl *et al.*, 2015; Hazelwood & Macey, 2016). The sounds produced by pile driving are impulsive, short (of the order of μs) and most of their energy lies below 500 Hz, though some energy may extend up to 1 kHz (Dahl *et al.*, 2015). The sound levels (both sound pressure and particle motion) vary substantially, depending on numerous factors such as pile diameter, hammer size, substrate characteristics, *etc.* The sounds produced by pile drivers are often very intense with SEL_{ss} often well-exceeding 180 to 200 dB re 1 $\mu Pa^2 s^{-1}$ and with very sharp rise times.

7.3 | Other industrial activities

Many other industrial activities contribute to underwater noise. Such activities generally produce sound that has the most energy at low frequencies (*i.e.*, <1 kHz). Dredging, for example produces high levels of broadband noise (de Jong *et al.*, 2016; Wenger *et al.*, 2017) and is used to extract sand and gravel from the seabed and from lakes, maintain shipping lanes and to install pipelines and cables within the seabed. Activities onshore, including the passage of vehicles, may increase noise levels in the sea, lakes and rivers, especially if they generate substrate vibration.

7.4 | Operating wind turbines

Since *c.* 2000 there has been an enormous increase in the generation of electricity by wind farms located in coastal waters, especially in European seas. There is some concern that sounds from operating offshore wind turbines might affect fish behaviour, although the sounds generated are very different to those generated during wind-farm construction (Cheesman, 2016). Most sound from a wind turbine is concentrated in a narrow band, centred around 180 Hz and the sounds are generally below about 700 Hz (Madsen *et al.*, 2006; Pangerc *et al.*, 2016). However, there is also a particle motion component to the sounds generated by wind turbines, accompanying substrate transmission (Sigray & Andersson, 2012; P. Gopu and J. Miller, personal communication, 2018), although this has rarely been monitored and has often been ignored. There is currently limited information available on the acoustic characteristics of offshore turbines, including those utilising tidal and wave energy (Lossent *et al.*, 2018; Schramm *et al.*, 2017).

7.5 | Vessel noise

A significant proportion of anthropogenic noise in the ocean and other water bodies is created by motorised vessels, including large ships, fishing and pleasure boats (Pine *et al.*, 2016; Rossi *et al.*, 2016). Most vessels, and especially large ships, produce predominately low frequency sound (*i.e.*, <1 kHz) from onboard machinery and hydrodynamic flow around the hull. Cavitation at propeller blade tips is also a significant source of noise across all frequencies (Ross, 1987, 1993). Low frequency sounds from ships can travel hundreds of kilometres and can increase ambient noise levels over large areas of the ocean (Ellison *et al.*, 2012; Southall, 2005).

Ambient noise levels in busy shipping lanes have recently increased (Hildebrand, 2009), across much of the frequency spectrum (Sertlek *et al.*, 2016), but especially at lower frequencies (<500 Hz; Erbe *et al.*, 2012; Bittencourt *et al.*, 2014). Large numbers of smaller pleasure and recreational vessels, including things like jet skis (Erbe, 2013), may also result in substantial increases in noise levels in coastal waters, lakes and rivers. Ice-breaking ships can be a significant source of sound in polar regions.

8 | FISH HEARING

8.1 | Hearing capabilities

8.1.1 | Hearing sensitivity

There is a long history of fish hearing studies (Moulton, 1963; Tavolga, 1971). It is likely that all fishes (including elasmobranchs) detect sound and use it to learn about their environment (e.g., Ladich & Fay, 2013). Until recently, however, most studies have focussed on determination of hearing capabilities of fishes to sound pressure signals, despite it being clear that most fishes (and all elasmobranchs) primarily detect particle motion (Popper & Hawkins, 2018). (As an aside, lampreys (Petromyzontidae) also have an ear that has many characteristics in common with other vertebrates and both morphological (Popper & Hoxter, 1987) and recent physiological results (Mickle *et al.*, 2018) suggest that they only detect particle motion). There is a need to investigate the hearing abilities of lampreys and many other fishes, under conditions where the particle motion can be monitored or estimated and the ratios of these two potential stimuli can be varied. Such experiments have been reviewed in a number of recent papers, including Hawkins (2014) and Putland *et al.* (2018).

In addition to not focussing on particle motion, many studies have been conducted in tanks, or in poorly designed enclosures in open waters (*e.g.*, the experiments by Debusschere *et al.*, 2016, which examined effects of pile driving during off-shore wind-farm construction on young European sea bass *Dicentrarchus labrax* (L. 1758) placed in glass 500 ml vials). In such environments, the sound fields presented to the fish are generally very complex and quite unlike the sound fields that a fish would encounter in a normal aquatic environment (Rogers *et al.*, 2016). As a result, such experiments often leave open questions regarding the actual nature of the sound field to which the animals were exposed and the stimuli to which they responded (Hawkins *et al.*, 2015). Ideally, hearing experiments should be carried out in specially designed tanks (Duncan *et al.*, 2016; Hawkins & MacLennan, 1976; Rogers *et al.*, 2016) or in natural aquatic environments, where both the particle motion and the sound pressure levels can be monitored precisely.

Keeping these caveats in mind, it is possible to get some appreciation of hearing capabilities of fishes. For example, every species studied to date is able to hear. In addition, the majority of fishes detect sounds from <50 Hz, even as low as 10–30 Hz, or even lower (Sand & Karlsen, 2000) to perhaps 300–500 Hz. Fishes that can detect sound pressure hear to perhaps 1000 Hz. And, a much smaller number of species have specialisations that enable them to detect sounds to 3–4000 Hz (Ladich & Fay, 2013).

Because relatively few experiments on the hearing of fishes have been carried out under suitable acoustic conditions, valid data that provide actual hearing thresholds are available for only a few species (thresholds are generally defined as the lowest level of sound that can be detected 50% of the time). Figure 1 shows the measures of hearing, expressed as audiograms. determined in the open-sea, rather than in a laboratory tank, for: the flatfish common dab *Limanda limanda*

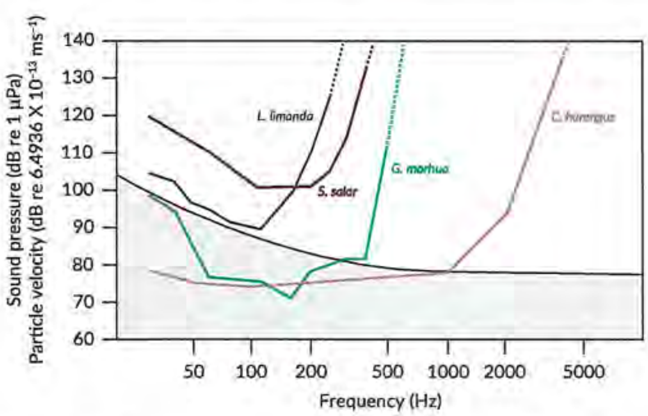

FIGURE 1 Fish hearing sensitivity (thresholds) obtained under open sea, free-field, conditions in response to pure tone stimuli at different frequencies. The lower the thresholds (y-axis), the more sensitive the fish is to a sound. Thus, *Clupea harengus* has best hearing of all of these species over a wider range of frequencies. Note that the thresholds in *Gadus morhua* and *C. harengus* obtained under quiet conditions may be below natural ambient noise levels, especially at their most sensitive frequencies. In the presence of higher levels of noise, the thresholds would be raised, a phenomenon referred to as masking. *Gadus morhua* and *C. harengus* are sensitive to both sound pressure and particle motion, whereas *Limanda limanda* and *Salmo salar* are only sensitive to particle motion. The reference level for the particle velocity is based on the level that exists in a free sound field for the given sound pressure level. *n.b.*, For the particle velocity levels in this figure to match the sound pressure levels in a free sound field it is necessary to calculate an appropriate particle velocity reference level. If the standard reference levels are used, then the curves will not match one another and so they are not included here to keep the figure relatively simple.

(L. 1758) (Chapman & Sand, 1974); the Atlantic salmon, *Salmo salar* L. 1758 (Hawkins & Johnstone, 1978); the *G. morhua*; (Chapman & Hawkins, 1973); the Atlantic herring, *Clupea harengus* L. 1758 (Enger, 1967). The *L. limanda* and *S. salar* are only sensitive to particle motion and have a relatively narrow bandwidth of hearing (up to *c.* 300–500 Hz), whereas species like *G. morhua*, where the gas-filled swimbladder is close to the ear, are sensitive to sound pressure and show an increased hearing bandwidth (Fay & Popper, 1974; Sand & Hawkins, 1973).

It is important to understand that the swimbladder (and other gas-filled cavities) potentially plays a major role in fish hearing. This is because the gas within the swimbladder is compressible and changes volume in response to fluctuating sound pressures (sound) and this results in the swim bladder serving as an acoustic transformer, translating sound pressure into re-radiated particle motion (Sand & Hawkins, 1973). This produces higher levels of particle motion at the ears that stimulates the otolith organs (Popper *et al.*, 2003). Thus, having a gas bubble or a swimbladder close to, or connected to, the ear enhances the hearing abilities of fishes since the ear is not only stimulated directly by the particle motion component of the sound, but also indirectly by the particle motion reradiated from the gas bubble to the ear in response to sound pressure. The actual contribution of the indirect stimulation varies by species and depends on the distance between the bubble and the ear. For example, in *G. morhua*, hearing at low frequencies (<110 Hz), is based on the detection of particle motion, but at higher frequencies it is based on sound pressure due to the closeness of the anterior end of the swimbladder to the ear. Indeed, deflation of the swimbladder in *G. morhua* reduces sensitivity to sound pressure (Sand & Enger, 1973) and similar results have been shown for the goldfish *Carassius auratus* (L. 1758) (Fay & Popper, 1974).

In contrast, species like *S. salar*, despite having a swim bladder, are only sensitive to particle motion since the swimbladder is more distant from the ear (Hawkins & Johnstone, 1978; Knudsen *et al.*, 1992). Other species, such as *C. harengus* (as all Clupeiformes) has a specialised connection between a gas bubble as the ear and shows sensitivity to a much wider range of frequencies and this can extend to >100 kHz in clupeids of the shad family Alosinae (Mann *et al.*, 1998; Mann *et al.*, 2001). Finally, species that do not have a swimbladder or other gas bubble, such as flatfishes, some scombrids and some gobies, only detect particle motion and hear over a narrower bandwidth than *G. morhua*.

In addition to having a gas bubble that improves hearing sensitivity and bandwidth, a number of fish species have additional adaptations that mechanically link the swimbladder to the ear, thereby carrying the motion of the swimbladder to the ear without attenuation of the signal as a result of distance of travel. Best known of these adaptations are the Weberian ossicles, a series of bones that connect the swimbladder to the inner ear in otophysan fishes. (Popper *et al.*, 2003; Popper & Fay, 2011). In other species, the swimbladder has extensions that come close to, or may actually contact, portions of the inner ear and most notably to the saccule, the otolith organ most frequently associated with hearing (Ramcharitar *et al.*, 2006; Schulz-Mirbach *et al.*, 2013).

8.1.2 | Limits to hearing sensitivity: masking

For the more sensitive fishes, hearing is not limited by the lowest level they can hear in a quiet environment, but by their ability to detect and discriminate biologically important sounds against the ambient noise background (Figures 1 and 2). In such conditions, the level of noise limits the lowest sound level that an animal can detect. This interference with detection of a biologically relevant sound by another sound, or noise, is generally known as masking and it is commonly found in all vertebrates, including fishes (Fay & Megela Simmons, 1999). As an example of masking, *G.morhua* only show best hearing sensitivity under the quietest sea conditions (Figure 2; Chapman & Hawkins, 1973). Any increase in the level of ambient sea noise results in a raising of the auditory threshold and a decline in the ability of the fish to detect, locate and recognise particular sounds. Critically, the masking of biologically relevant sounds occurs not only as a result of increases in natural ambient sea noise (caused by wind and rain) but also by any additional sounds added to the environment by humans. However, fishes that do not hear well may be less likely to have their hearing sensitivity affected by masking noise, since the lowest sound level they can detect may be above the level of the background noise (Hawkins & Johnstone, 1978).

Although the detection of sounds may be affected by the presence of masking sounds, it is also clear that fishes can use frequency filters to improve sound detection. They can also discriminate between different sound frequencies and intensities. They are also able to determine the direction from which sounds come (sound source localisation), a critical ability since this enables fishes to move towards potential food sources or away from predators (Fay, 2005; Fay & Megela Simmons, 1999; Hawkins & Popper, 2018; Sand & Bleckmann, 2008).

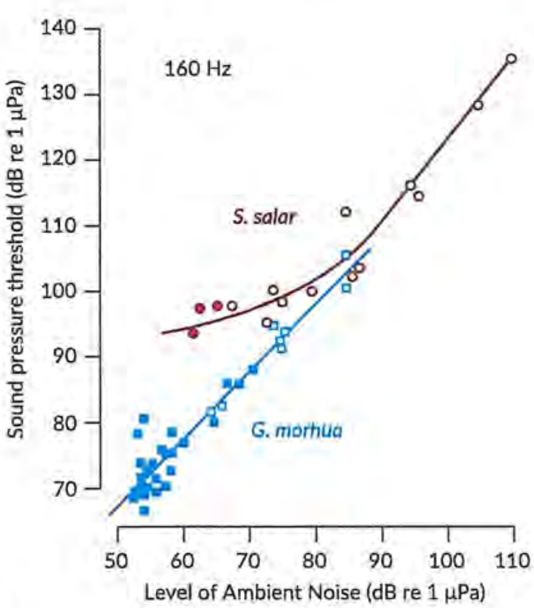

FIGURE 2 Masking in the *Gadus morhua* and *Salmo salar* by ambient noise. The thresholds were determined using a pure tone signal at a frequency of 160 Hz. The ambient noise (natural sea noise, augmented by white noise from a loudspeaker) is expressed as the spectrum level at that same frequency (dB re 1 μPa/Hz). Closed symbols, thresholds to natural levels of ambient noise; open symbols, thresholds to anthropogenic noise. *n.b.*, The thresholds in *S. salar* were only influenced by high noise levels, above the natural ambient levels of noise (data from Hawkins, 1993). Fig. © 2018 Anthony D. Hawkins, all rights reserved.

8.2 | The ear

Fishes detect sound with paired inner ears (Figure 3), located in the cranial cavity lateral to the brain at the level of the medulla (Figures 3 and 4), that closely resembles ears found in other vertebrates. Since a fish's body is the same density as water, there is no need for any external structures (external or middle ears) to carry sound to the sensory regions of the ear. The ear consists of three semi-circular canals and associated sensory regions (ampullae) that are primarily involved in detection of angular acceleration and three otolith organs (saccule, lagena, utricle) that are involved in hearing and positional senses (Popper *et al.*, 2003). There is very substantial variation in the morphology of the ears of fishes and particularly in the regions associated with hearing (Ladich & Schulz-Mirbach, 2016; Retzius, 1881; Schulz-Mirbach *et al.*, 2018; Schulz-Mirbach & Ladich, 2016), leading to the suggestion that there is very substantial diversity in hearing mechanisms (and potentially capabilities) in different species (Popper *et al.*, 2003).

The auditory parts of the ear, the otolith organs, each have a sensory epithelium that lies in close contact with a dense calcium carbonate structure, the otolith (Figures 3 and 4). The sensory epithelium (often referred to as a macula) has many sensory hair cells that are very similar to those found in the mammalian ear (Figure 5). When a fish is exposed to particle motion, the body, along with the sensory cells, move with the water, while the far denser otoliths move at a different amplitude and phase. This results in bending of the cilia on the apical surface of the sensory cells, releasing a neurotransmitter and sending a signal to the brain through an afferent neuron.

A critical role of the ear in fishes is involvement with determination of sound source direction (Hawkins & Popper, 2018). The sensory hair cells are morphologically polarised and the response of an individual cell changes with bending in different directions. Thus, each cell is directionally sensitive. Furthermore, the cells are organised into orientation groups in which all of the kinocilia are in the same direction (Figure 5). These hair cell orientation patterns, which vary in different species (Popper & Coombs, 1982), show graded responses to particle motion from various directions, thereby enabling a fish to determine direction by comparing information from different receptor groups (Fay, 2005; Hawkins & Popper, 2018; Sand & Bleckmann, 2008).

9 | EFFECTS OF ANTHROPOGENIC SOUND

There are very few experimental examples of sound being sufficiently loud to result in death or mortal injury to fishes. However, far more importantly from the perspective of potential effects, is that anthropogenic sound, even at levels far lower than those that might result in mortality, may result in temporary hearing impairment, physiological changes, changes in behaviour and the masking of biologically important sounds (Table 1; Popper *et al.*, 2014;

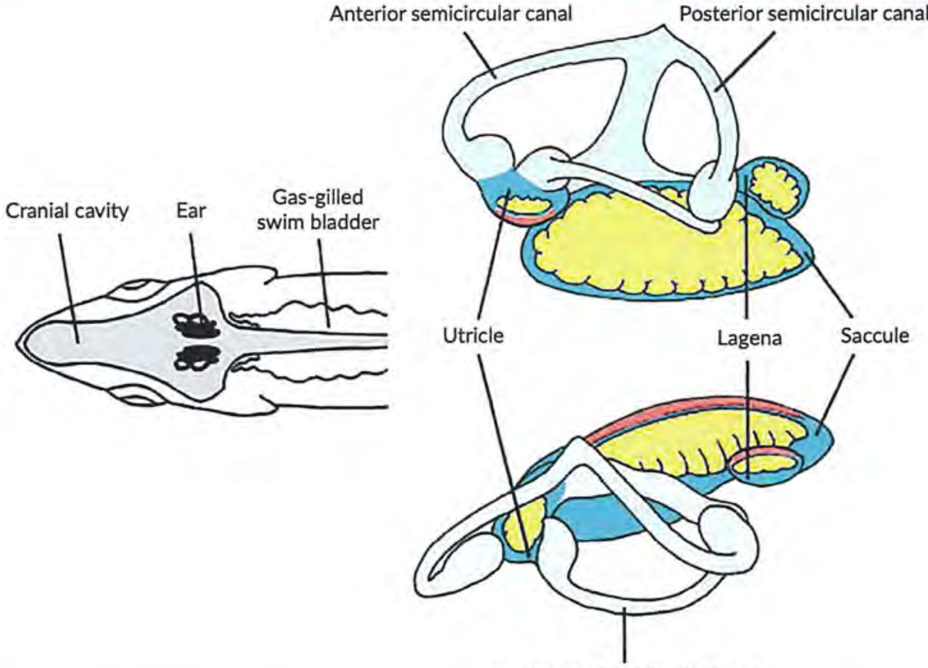

FIGURE 3 Schematic drawing of the ear of *Gadus morhua* (anterior is to the left): (a) top view of the body showing the location of the ears in the cranial cavity as well as the proximity of the rostral end of the swim bladder to the ear; (b) lateral and (c) top view of the same ear. Each ear is set at an angle relative to the midline of the fish. ▪, The otolith organs, ▫, the semicircular canals (enlarged areas are the ampullae regions that contain the sensory cells); ▫, the dense calcarious otolith lying in close proximity to the sensory epithelium (▪). Also see Figure 4. Fig. © 2018 Anthony D. Hawkins, all rights reserved

Erbe *et al*., 2016). There may be significant consequences to individuals and populations as a result of changes in behaviour, including impairment of spawning, interference with foraging and feeding, or disruption of migrations and habitat selection. Exposure to sound may also (but not always) result in physiological changes that may include stress effects (Filiciotto *et al*., 2016). However, as pointed out by Hawkins *et al*. (2015), there are large gaps in our knowledge of effects of sound on fishes that need to be filled if we are to fully understand the implications of exposure to anthropogenic sounds.

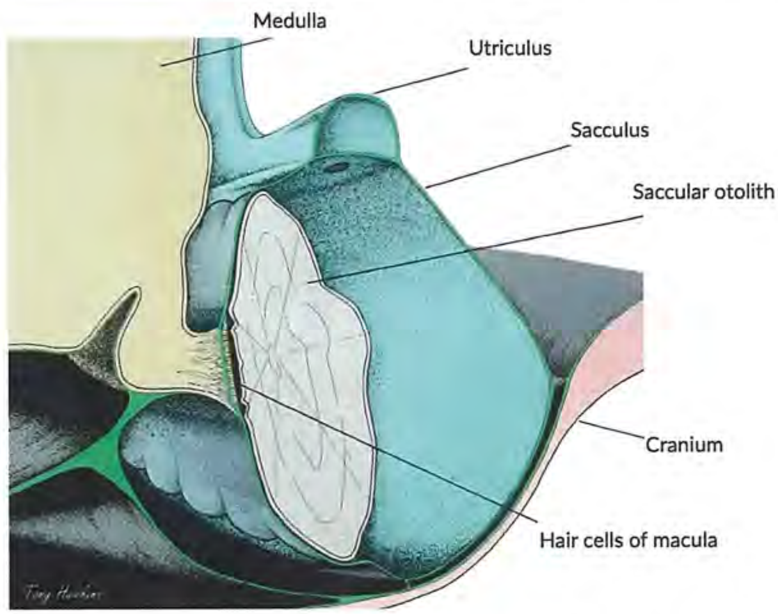

FIGURE 4 A frontal view of the head of *Gadus morhua* showing a section of the saccule (▪). The saccular chamber is filled with perilymph and contains the otolith (▪), which lies close to the sensory hair cells of the epithelium (macula). The hair cells are innervated by the eighth cranial nerve. Fig. © 2018 Anthony D. Hawkins, all rights reserved

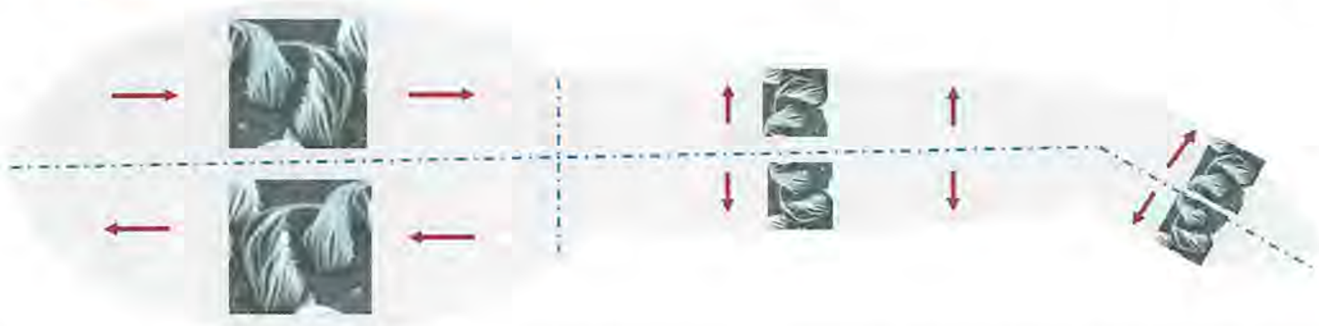

FIGURE 5 The sensory epithelia of the end organs of the inner ear have numerous mechanoreceptive sensory hair cells. The apical ends of these cells, directed into the lumen of the epithelia, have ciliary bundles (inserts in the figure) consisting of a single kinocilium (longest of the cilia) and graded stereocilia. Bending of the ciliary bundle during sound stimulation results in neurotransmitter release to stimulate the 8th cranial nerve. The sensory cells on the otolith maculae are organized into orientation groups, with all of the cells in each group having their kinocilia in the same general direction. In this typical saccular epithelium (anterior to the left, dorsal to the top), the cilia on the rostral end are oriented rostrally or caudally, while the cells on the caudal end are oriented dorsally and ventrally. ---, The approximate dividing lines between orientation groups)

TABLE 1 Potential effects of anthropogenic sound on animals

Effect	Description
Death	Sound exposure results in instantaneous or delayed mortality.
Physical injury & physiological changes	Physical injury results in temporary or permanent impairment of the structure and functioning of some parts of the body. Physiological changes result in increased stress or other effects that can lead to reduced fitness.
Hearing threshold shift	Loss of hearing, temporarily or permanently, results in decreased ability to respond to biologically relevant sounds.
Masking	Noise results in a decrease in detectability of biologically relevant sounds (*e.g.*, sounds of predators and prey, sounds of conspecifics, acoustic cues used for orientation).
Behavioural responses	Behavioural responses include any change in behaviour from small and short-duration movements to changes in migration routes and leaving a feeding or breeding site. Such responses are likely to vary from species to species, depending on numerous factors such as the animals normal behavioural repertoire, motivational state, time of day or year, age of the animal, *etc.* Some changes in behaviour, such as startle reactions, may only be transient and have little consequence for the animal or population.
No obvious behavioural responses	Animals may show transient or no responses, even if they detect the sound (*e.g.*, to a very low-level sound) or habituation may take place. However, even if there is no response, there is always the possibility that physical injury and physiological changes may take place without the animal showing overt changes in behaviour

9.1 | Effects upon behaviour

9.1.1 | Caveats in interpretation of laboratory studies

In evaluating data on potential behavioural effects of anthropogenic sound on fishes it is important to first appreciate a number of caveats that are critical to interpretation of various studies. In particular, one must be cautious when evaluating the results from behavioural studies done in tanks and even in larger enclosures (Hawkins & Popper, 2016b; Popper & Hawkins, 2018). The fundamental issue is that captive animals, no matter whether on land or in the water, often do not show the full range of behaviours observed in wild animals (Benhaïm *et al.*, 2012; Oldfield, 2011), especially if they have been bred in captivity (El Balaa & Blouin-Demers, 2011; Petersson *et al.*, 2015). As a result, data from studies using free-living fishes are very likely to differ from those with captive fishes because of the many subtle factors that determine their behaviour in a natural setting. Put another way, one must take very considerable caution in extrapolating behaviour from studies of captive animals to how wild animals may respond to the same stimulus.

A second critical caveat is that when studies are done in tanks and other enclosures the sound fields may be very different from those that fishes experience in the wild, especially in terms of the magnitude of particle motion relative to sound pressure (Duncan *et al.*, 2016; Gray *et al.*, 2016; Rogers *et al.*, 2016). Many fishes live close the substrate, or occupy burrows, coral reefs, mangroves and kelp forests, where sound transmission may be especially complex; while others may occupy open waters. None of these acoustic environments, however, are anything like that in a fish tank where walls are thin and often made of glass or flexible material. Consequently, the walls of tanks vibrate and set up highly perturbed sound fields that would have ratios of pressure and particle motion unlike those that an animal would ever encounter in the wild (Parvulescu, 1964; Rogers *et al.*, 2016). Thus, even if a fish shows a particular behaviour pattern in response to a tank-based sound, the same sound produced in the wild may have very different acoustic characteristics and thus may or may not elicit the same behaviour as in the tank. It is important to monitor the particle motion as well as the sound pressure and where possible to ensure that the acoustic conditions under which experiments are conducted are similar to those the fish would experience in the wild. Where the particle motion is properly monitored as well as the sound pressure, some physiological experiments on captive animals may provide some useful information on the levels that produce particular effects. However, it is necessary to be circumspect in extrapolating the findings to wild animals.

Finally, in considering behaviour, it is also important to recognise that the responses of fishes may vary with their age and condition, as well as under different environmental conditions. Moreover, responses may vary with different sound sources, or with the same sound when the level of sound received by the animal differs (De Robertis & Handegard, 2013; Lucke *et al.*, 2016).

9.1.2 | Behavioural responses to sound

Sounds can have several different types of behavioural effects. Some fishes may react negatively to a sound. There may be changes in feeding or mating; migratory paths may be altered; and the finding of places for larval settlement may be disrupted. Anthropogenic sounds may interfere with detection of the overall acoustic scene (or soundscape) as well as affecting sound communication by fishes. Masking may result in lessened ability to detect biologically significant sounds and may also result in the generation of signals that are similar to those produced by the fish themselves (Kaplan *et al.*, 2015; Kaplan *et al.*, 2016; Pine *et al.*, 2016).

There has been a variety of studies of the potential effects of anthropogenic sound on fish behaviour. However, many of those studies must be considered with great caution since they were done in laboratory tanks, or on species, such as the zebrafish *Danio rerio* (Hamilton 1822), that appear to thrive in captivity, unlike many other species, and which are behaviourally and physiologically very different to the important commercial species such as salmonids, gadids, sciaenids, *etc.* Extrapolation from laboratory fishes to commercially important species must be done with the greatest caution.

At the same time, some observations from recent behavioural studies do provide instructive insight and guidance. For example, while it is generally assumed that fishes with better hearing abilities, are more likely to show behavioural responses to sounds than less sensitive species, this may not always be the case. Comparisons of laboratory responses of *D. rerio* and Lake Victoria cichlids, such as *Haplochromis piceatus* Greenwood & Gee 1969, to sounds, the former having better hearing sensitivity (lower auditory thresholds) and a wider frequency range than the latter, showed that both species exhibited a significant reduction in swimming speed in the first minute of exposure that were not obviously related to differences in their hearing abilities (Shafiei Sabet *et al.*, 2016). Similarly, Hawkins *et al.* (2014) showed that changes in the behaviour of schools of wild sprat *Sprattus sprattus* (L. 1758) and mackerel *Scomber scombrus* L. 1758, to sound playback took place at similar sound levels, despite major differences in their hearing abilities.

9.1.3 | Responses to continuous sounds

Many anthropogenic sources produce long-duration signals that can increase the overall sound level in the environment for extended periods of time. Increased shipping in a harbour, increased pleasure boats on a reef, or continuous operation of an offshore wind turbine or oil rig, may change the acoustic environment to which a fish is adapted. Consequently, critical aspects of fish behaviour could be interfered with by the presence of long-term sounds that mask a fish's ability to detect sounds of biological importance to the animals. A wide range of behaviour patterns may be affected by increased background noise. For example, anthropogenic sounds may interfere with foraging behaviour either by masking the relevant sounds or by resembling the sounds that the prey may generate (Purser & Radford, 2011). Similarly, fishes may avoid predators by listening for the sounds that the predators produce, either deliberately or inadvertently. Studies have shown that elevated sound levels, including intermittent or pulsed sounds, may affect predator prey interactions (Luczkovich & Keusenkothen, 2008; Remage-Healey & Bass, 2006). It is evident that anthropogenic noise can affect predator avoidance in some fishes. At the same time, however, it must be kept in mind that all studies on predator avoidance to date have involved captive fish in enclosed environments. Clearly, there is a need to examine the behaviour of wild fishes under more natural conditions.

Another issue is that many fishes migrate to feeding areas or spawning grounds and may subsequently return to other locations. During migrations, fishes may use a variety of cues to orientate and navigate, including natural soundscapes. High level sounds may result in avoidance responses, deflecting fish away from their migration routes. For example, Montgomery *et al.* (2006) suggested that the ability of larval reef fishes to locate their home reefs by responding to their characteristic sounds might be affected by changes in the noise level (Stanley *et al.*, 2012). There are significant differences in the spectral and temporal composition of the ambient sound associated with different coastal habitat types (Radford *et al.*, 2010) and Gordon *et al.* (2018) recently pointed out that changes in habitats may negatively affect the auditory settlement behaviour of coral-reef fishes. Acoustic cues guide the orientation, habitat selection and settlement of many fishes, but these processes may be impaired if degradation alters reef soundscapes.

Sounds are also important for many fish species for spawning. In particular, any interference with detection of spawning sounds can have a significant effect on reproductive success of a population. For example, Casaretto *et al.* (2015) showed that male *M. aeglefinus* are territorial and that visits to their territories by females, induced by the sounds of males, triggered courtship behaviour, leading to the spawning embrace It has been suggested by de Jong *et al.* (2017) that acoustic communication may play a crucial role in reproductive interactions and they point out that over 800 species of fish have been found to communicate acoustically.

In addition to affecting the detection of biologically important sounds, there is also limited evidence that anthropogenic sounds will result in fishes altering their own sounds to avoid masking (Radford *et al.* (2014). Similarly, Holt and Johnstone (Holt & Johnston, 2014; Holt & Johnston, 2015) investigated effects of elevated noise levels on a sound-producing freshwater fish, the black-tail shiner *Cyprinella venusta* Girard 1856, in tanks. When elevated levels of natural river noise were played back to the fish, it was found that several acoustic features of the fish calls were altered under noisy conditions. Most notable the spectral composition of the calls was altered by the fish (termed the Lombard effect).

9.1.4 | Observed effects from impulsive sound sources

Especially important are the sounds produced by impulsive sources. Such sounds are typically transient, brief (< 1 s), broadband and show high peak sound pressure with a rapid rise time and rapid decay. The greater amount of (still very limited) data available on behavioural responses to impulsive sound comes from studies of pile driving sounds. Moreover, most of these behavioural studies have been conducted on captive fish, maintained in confined spaces (Herbert-Read *et al.*, 2017; Spiga *et al.*, 2017), though a few recent studies have been conducted on fishes in the wild (Hawkins *et al.*, 2014; Iafrate *et al.*, 2016; Roberts *et al.*, 2016a). For example, Hawkins *et al.* (2014) observed the behaviour of schools of *S. sprattus* and *S. scombrus* in mid water at a quiet coastal location, using an echosounder. *Sprattus sprattus* is sensitive to sound pressure, while the *S. scombrus* is likely to be sensitive only to particle motion. The fish were exposed to short sequences of repeated impulsive sounds, simulating the strikes from a pile driver, at different sound levels. Results showed that the incidence of behavioural responses increased with increasing sound level. The response levels suggested that both species would show changes in their behaviour at considerable distances (many kilometres) from a pile driving operation. However, the responses of *S. sprattus* at night were very different to those shown during the day. *Sprattus sprattus* schools break up at night and the individual fish did not respond to the playback of pile driving sounds at that time.Despite major differences in their hearing abilities the *S. sprattus* and *S. scombrus* responded in the daytime playback experiments to impulsive sounds at similar sound levels. This may be the result of *S. scombrus* being readier to respond to any stimulus, observations suggested that they were perhaps flightier than *S. sprattus*. However, this, like most other aspects of how fishes respond behaviorally to anthropogenic sound, still needs extensive study.

There have also been a number of studies of the response of captive demersal species to pile driving sounds. For example, Neo *et al.* (2014) found that that intermittent sounds may yield longer-lasting behavioural effects than continuous sounds (Neo *et al.* 2015). Moreover, ramp-up procedures, where sounds are slowly increased in level so as to warn fishes of impending sounds, do not necessarily lead to mitigation (Neo *et al.* 2016). At the same time, these studies were done in enclosures that did not resemble natural acoustic environments and many were done with *D. rerio*, a species that is small, thrives in small tanks and which hears far better than most (if not all) species likely to be exposed to pile driving operations.

Kastelein *et al.* (2015, 2017) determined acoustic dose–response relationships for behavioural responses to the play back of pile driving sounds by *D. labrax* in a netting enclosure within a very shallow rectangular pool, where the sound field was nothing like that in the wild. It was concluded that if wild *D. labrax* were exposed to pile driving sounds at the levels used in the study, there were unlikely to be any adverse effects on their ecology, because their initial responses were short-lived. However, the experiments were carried out on fish that had spent their whole lives in captivity.

In a more detailed series of experiments on laboratory-bred juvenile *D. labrax*, Radford *et al.* (2016) exposed fish to playbacks of pile driving sounds and seismic sounds in laboratory-based studies intended to examine how an initial response to different sound types potentially changes over time. The study found a lessened response after repeated exposure to pile driving sound and it was concluded that this was probably due to increased tolerance (habituation), or a shift in hearing threshold (temporary threshold shift; TTS or permanent threshold shift; PTS) following initial exposure.

Roberts *et al.* (2016a, 2016b) examined the responses of a number of wild demersal species to the playback of pile driving sounds and elicited behavioural responses including startle responses and directional avoidance. The exposure levels were similar to the 50% response levels determined by Hawkins *et al.* (2014) for schools of *S. sprattus* and *S. scombrus* using the same sound projector array. However, Roberts *et al.* (2016b) emphasised that while the water-borne component of the sound was accurately reproduced by the sound projectors, the projectors were not able to replicate the additional substrate-borne vibrations that pile drivers produce.

The conclusion from all of these studies is that we really know very little as to how fish behave in the wild to impulsive signals. This is because most studies were done in the laboratory where the sound stimulus is of great question and where fishes cannot show natural behaviour. Moreover, there was considerable variation in species, age of fish and whether the animals were raised in captivity or not. Nevertheless, there have been studies that examined the behavioural responses of large groups of fishes to the impulsive sound of seismic surveys in the wild. However, these studies, unlike the ones cited earlier, were not designed to examine the behaviour of individual or small groups of fishes. Instead, these studies examined changes in the distribution of wild fishes in the presence of an actual seismic survey. The horizontal and vertical distributions of both pelagic and demersal fishes have been shown to change during and after airgun operations (Løkkeborg *et al.*, 2012), although they generally returned to the original site within hours or days after the end of the seismic operation (Engås *et al.*, 1996; Engås & Løkkeborg, 2002). Other studies have shown that fish may respond to approaching vessels by diving towards the seafloor or by moving horizontally out of the vessel's path, with reactions often initiated well before the vessel reaches the fish (Ona *et al.*, 2007).

9.2 | Effects upon hearing sensitivity

Exposure to sounds may result in hearing loss as a result of damage to the sensory cells of the inner ear or the innervating neurons. While temporary hearing loss (TTS) occurs in fishes, there is no evidence for permanent hearing loss (PTS). Indeed, PTS may not occur in fishes since they can repair or replace sensory hair cells of the inner ear that have been lost or damaged (Smith *et al.*, 2006; Smith & Monroe, 2016). TTS is a short duration decrease in hearing sensitivity resulting from exposure to intense sounds or sounds of long duration. After termination of the sound, normal hearing ability returns over a period that may range from minutes to days, depending on many factors, including the intensity and duration of exposure (Amoser *et al.*, 2004; Smith *et al.*, 2006; Smith & Monroe, 2016). However, during a period of TTS, animals may be placed at some risk to survival in terms of poorer communication, inability to detect predators or prey and difficulty in assessing their environment.

TTS has been demonstrated in a number of fish species from a diverse array of sounds (Smith & Monroe, 2016) but in all cases, TTS was only found after multiple exposures to intense sounds (*e.g.*, < 190 dB re 1 μPa rms) or as a result of long-term exposure (*e.g.*, tens of minutes or hours) to somewhat less intense sounds. Even when a signal source caused TTS in some individuals or species, it did not occur in other specimens or other species (Popper *et al.*, 2005; Popper *et al.*, 2007). In most cases, normal thresholds returned within a few hours to several days. There is also evidence that, given the same type and duration of sound exposure, a much more intense sound will be required to produce TTS in fishes that do not hear well compared with fishes that do hear well (Popper *et al.*, 2007; Smith *et al.*, 2004). Since TTS can arise from prolonged exposure to sound (though this is not always so), it is not likely to be of great significance for fishes that are only briefly exposed to a source (Halvorsen *et al.*, 2013; Popper *et al.*, 2007).

Of far greater concern is that TTS may occur when there is long-term noise exposure such as in harbours and other areas where there is a long-term increase in sound level. While limited, TTS is correlated with damage to sensory hair cells of the ear and it has been shown that recovery from TTS occurs in parallel with repair or replacement of sensory cells (Smith *et al.*, 2006; Smith *et al.*, 2011). Other studies have shown that exposure to intense sound may result in hair cell damage, but they did not examine whether this was accompanied by a loss of hearing (Casper *et al.*, 2013b; Enger, 1981; Hastings *et al.*, 1996; McCauley *et al.*, 2003). At the same time, studies of other species or other types of intense sounds have not resulted either in TTS or hair cell damage (*e.g.*, Halvorsen *et al.*, 2013; Popper *et al.*, 2005; Popper *et al.*, 2007).

Clearly, there is still a question as to whether TTS occurs in fishes exposed to anthropogenic sounds and, if so, which sounds will result in TTS. Moreover, there appears to be broad species variation as to whether TTS will occur and there is even evidence that different genetic stocks of the same species may or may not show TTS (Halvorsen *et al.*, 2013; Popper *et al.*, 2007). Moreover, none of the studies on TTS to date have determined whether the loss of hearing (or lack of loss of hearing) is correlated with exposure to sound pressure or particle motion. Finally, none of the studies have been done on wild animals where there is the potential to escape from areas of intense sounds, or to test whether a small change in hearing threshold has any real impact on fitness (Popper *et al.*, 2014).

9.3 | Stress

Animals showing no overt sign of responding to an environmental stimulus may, nonetheless, experience physiological changes that are often referred to as stress responses. These are often similar to stress effects to sound exposure found in terrestrial animals (Gourévitch *et al.*, 2014; Kight & Swaddle, 2011; Weilgart, 2017; Wysocki *et al.*, 2006). Stress may include hormonal, autonomic, immune and behavioural responses that may initially allow fishes (as other animals) to adapt to adverse conditions. However, some stressors may change the state of physiological processes and affect homeostasis, thus having an adverse effect upon the animals' health and well-being. Very little is known about stress effects in fishes and the significance of such effects in response to anthropogenic sounds is even less clear (Tennessen *et al.*, 2016).

There is an increasing body of literature on potential stress effects of exposure to both continuous and impulse anthropogenic sounds (Buscaino *et al.*, 2010; Celi *et al.*, 2016; Nedelec *et al.*, 2015; Sierra-Flores *et al.*, 2015). However, as for behavioural studies, there is a wide range of species used, a diverse set of exposure paradigms, very different results depending on species and paradigm and, most importantly, all of these studies have been done in the laboratory. Consequently, one must be cautious in extrapolating to how a fish might respond to a stressor in the wild where the fish's movement is not restrained and it could, potentially, move away from a stressor. It is also important to distinguish between normal or tolerable variations in response to environmental stress from those changes that will have consequences for survival and reproduction. At present, critical examination of these long-term changes in fishes as a result of sound exposure is lacking.

In considering potential physiological effects, a critical issue is that potential effects of sounds on the physiology of fishes, as measured by various stress parameters, are quite variable and are not particularly instructive with regard to how exposure might affect fishes. In particular, all of the studies to date, including both long and short-term exposures, were made on captive animals in enclosed areas where the fishes could not avoid the sounds. Thus, the acoustics were different than those an animal would encounter in the wild and the fish could not move away from the disturbing sound. Thus, it is possible that it is not the sound itself that resulted in the stress response, but the inability of the animals to move away from the sound.

9.4 | Death and injury

Death and injury of fishes are probably the most easily observed responses to high levels of anthropogenic sound. However, there are only the most limited data on mortality in fish from sound exposure and these are when animals are very close to pile driving sources (California Department of Transportation, 2001), but not for other sound sources. Indeed, exposure of fishes to very high intensity low and mid-frequency sonars resulted in no mortality (Halvorsen *et al.*, 2013; Popper *et al.*, 2007), nor did exposure to seismic airguns (Popper *et al.*, 2005; Popper *et al.*, 2016). There are, however, some data showing that fishes receiving high intensity and particularly impulsive, sounds will experience damage to body tissues. This damage appears to result from rapid oscillation of the walls of the swimbladder when stimulated by an impulsive source. In such cases, it appears that the swimbladder expands and contracts rapidly, thereby damaging the proximate organs including liver, kidney, gonads and the swimbladder itself (Halvorsen *et al.*, 2012b; Halvorsen *et al.*, 2012c). For example, of five species exposed to high intensity simulated pile driving signals (Casper *et al.*, 2013a; Halvorsen *et al.*, 2012b; Halvorsen *et al.*, 2012c), only the hogchoker *Trinectes maculatus* (Bloch & Schneider 1801), a flatfish without a swim bladder, showed no tissue damage (Halvorsen *et al.*, 2012b). At the same time, exposure to very high intensity continuous signals that did not contain any impulsive components showed no tissue damage in five different species (Halvorsen *et al.*, 2012d; Halvorsen *et al.*, 2013; Kane *et al.*, 2010; Popper *et al.*, 2007).

A recent set of studies, using a pile driving sound as a stimulus, enabled investigators to quantify the physical effects of sound exposure on various tissues (Casper *et al.*, 2012; Casper *et al.*, 2013a, 2013b; Casper *et al.*, 2017; Halvorsen *et al.*, 2012a, 2012b, 2012c; Popper *et al.*, 2013). While these results directly relate to pile driving, they are also likely to give guidance for potential effects of other impulsive sounds on fishes and so they have been incorporated into the most recent guidelines for fishes on interim sound exposure criteria (Table 2; Popper *et al.*, 2014; Andersson *et al.*, 2017).

In brief, results from these studies showed a general correlation between the extent of tissue damage and the cumulative level of sound energy to which fish were exposed. For example, there was no tissue damage in one of the main study species, Chinook salmon *Oncorhynchus tshawytscha* (Walbaum 1792), following exposure to sounds below an SEL_{cum} of 210 dB re 1 $\mu Pa^2 s^{-1}$. At an SEL_{cum} that was a few dB higher (but with sounds given over the same time period), internal injuries started to appear and when the level reached 219 dB re 1 $\mu Pa^2 s^{-1}$ there were massive internal injuries that would likely result in death. Studies with other species showed that while there is some variation in SEL_{cum} required for onset of physiological effects, this is always at SEL_{cum} levels >203 dB re 1 $\mu Pa^2 s^{-1}$ (Casper *et al.*, 2013a; Halvorsen *et al.*, 2012b).

At the same time, results show that the effects do not support the idea of an equal energy hypothesis, which is an idea based on the premise that the same effect will show up as long as the total energy to which a fish is exposed remains the same (Woodbury & Stadler, 2008). Instead, experimental results clearly show that the degree of effect depends upon a combination of the energy within single strikes (SEL_{ss}) and the number of strikes, but the effect is not predictable from just knowing the cumulative energy (Casper *et al.*, 2016; Halvorsen *et al.*, 2012c).

Studies subsequently found that *O. tshawytscha* and hybrid white bass *Morone chrysops* (Rafinesque 1820) x striped bass *Morone saxatilis* (Walbaum 1792), recovered from all apparent physical effects within 10 days of exposure (Casper *et al.*, 2012, 2013a). However, it was made clear that recovery took place in the laboratory and that animals in the wild with similar injuries would have lower fitness and be more susceptible to predation and disease until they fully recovered. This is a concrete example of the need to be cautious in interpreting the results of laboratory experiments.

An additional question was whether hearing was affected by exposure to up to 960 sequential simulated pile strikes. Limited data showed that damage to ear tissues did not show up until the SEL_{cum} was 216 dB re 1 $\mu Pa^2 s^{-1}$ (Casper *et al.*, 2013b). However, both species studied have swim bladders that terminate some distance from the ear and so movement of the swimbladder walls would not directly affect the inner ear. It is possible that fishes with gas-filled organs near or directly associated with the ear would show damage at lower sound exposure levels due to the impulsive movement of the organ walls, much as they damage other nearby tissues.

10 | EFFECTS ON FISH POPULATIONS AND THE WIDER ECOSYSTEM

The studies described previously have largely dealt with effects upon individual animals. However, for fishes, unlike marine mammals, perhaps the greater concern lies with effects upon populations rather than individuals (Hawkins & Popper, 2016a; Pirotta *et al.*, 2018). The extent to which sound affects the structure and functioning of fish populations and ecosystems, both marine and freshwater, is probably of considerable importance, although such effects have yet to be established.

Attempts to model changes in population parameters were first addressed for marine mammals. The population consequences of acoustic disturbance (PCAD) approach (NRC, 2005), recognises that there may be significant effects at individual, population and ecosystem levels. The population consequences of disturbance (PCoD) approach (Harwood *et al.*, 2014) is a formal, mathematical version of the PCAD model that uses the opinions of experts to quantify the transfer functions that describe the relationships between the different compartments of the PCAD model. It provides a protocol that can be used by regulators and developers to examine how sound exposure might impair the ability of individual animals to survive, breed,

TABLE 2 Proposed interim criteria for mortality and recoverable injury from exposure to pile driving signals are based on 960 sound events at 1.2 s intervals (Halvorsen et al., 2012b, 2012c). Temporary threshold shift (TTS) based on Popper et al. (2005). The same peak levels are used both for mortality and recoverable injury since the same sound exposure level (SEL_{ss}) was used throughout the pile driving studies. All criteria are presented as sound pressure even for fishes without swim bladders since no data for particle motion exist. Relative risk (high, moderate, low) is given for animals at three distances from the source defined in relative terms: N, near; I, intermediate; F, far (from Popper et al., 2014)

Type of Animal	Mortality and potential mortal injury	Impairment			
		Recoverable injury	TTS	Masking	Behaviour
Fish: no swim bladder (particle motion detection)	> 219 dB SEL_{cum} or > 213 dB peak	> 216 dB SEL_{cum} or > 213 dB peak	>>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	> 186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	186 dB SEL_{cum}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Sea turtles	210 dB SEL_{cum} or > 207 dB peak	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) Moderate (F) Low
Eggs and larvae	> 210 dB SEL_{cum} or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak and rms sound pressure levels dB re 1 μPa; SEL dB re 1 $\mu Pa^2 s^{-1}$.

reproduce, or rear young and to quantify how this impairment may affect the abundance of the species concerned.

For species where there is limited knowledge of ecological interactions, an alternative risk assessment tool is required. Fisheries biologists have recently considered new risk-based approaches in assessing the effects of fishing upon species for which there are only limited data on key population parameters. The productivity susceptibility assessment (PSA) approach (Patrick *et al.*, 2010) has been applied to fish stocks to determine the effect of human activities upon fishes. Such an approach attempts to evaluate the vulnerability of fish stocks to fishing; based on their biological productivity and potential for resisting adverse effects. This approach has been increasingly used to identify species at risk within multispecies fisheries (Hobday *et al.*, 2011; Smith *et al.*, 2007) and may have wider applicability in assessing risks from noise exposure.

11 | SOUND EXPOSURE CRITERIA AND GUIDELINES

Sound exposure criteria essentially define those levels of sound from different sources that are likely to affect aquatic animals adversely, in order to regulate the generation of noise in aquatic environments. Significant efforts have been made over the past few years to develop criteria for aquatic vertebrates, including marine mammals, as well as guidelines for the use of these criteria (NMFS, 2018; Southall *et al.*, 2007).

Substantially less effort has been placed on developing criteria and guidelines for fishes. However, interim sound exposure criteria for the onset of physiological effects on fishes for use on the United States west coast were proposed by the Fisheries Hydroacoustics Working Group (FHWG, 2008) but also see Popper *et al.* (2006) and Woodbury and Stadler (2008). More recently, a new set of interim criteria was proposed (Popper *et al.*, 2014) based on a much stronger set of research and these raised the effective onset of effects levels, at least for physical effects, substantially and these interim criteria are now being used world-wide (Andersson *et al.*, 2017).

Most work to date has focussed upon effects on marine mammals and marine fishes; much less is known about these effects in fresh water. However, Mickle and Higgs (2018) have recently reviewed the literature regarding behavioural and physiological effects of noise pollution on freshwater fish and have emphasised the lack of incorporation of both behavioural and physiological measures within current studies. Marine and freshwater soundscapes differ quite markedly and the transmission of sound through shallow lakes and rivers differs substantially from that under open-water conditions in the sea. Substrate transmission of sound may be especially important in shallow freshwater environments. Thus, there is a need to examine those types and levels of sounds that are harmful to freshwater fishes and to establish relevant sound exposure criteria.

11.1 | Current interim guidelines

The term onset and the phrase onset of effect have been widely used in preparing guidelines on sound exposure criteria. However, it is clear that onset is viewed very differently by different investigators, regulators and others and that there is no clear definition of the term, particularly with regard to the potential effects of sound on fishes. In this review, onset refers to the lowest sound level that results in a statistically significant effect, in terms of physical damage to an animal or a significant change in behaviour. It should be noted that earlier papers that considered fishes used onset for any level of response, including a response by a single animal in a school (Woodbury & Stadler, 2008). Thus, if there is scale loss in one fish within a group of many animals, that would be considered onset.

11.1.1 | Onset of physical effects

The interim sound exposure criteria, which are still in use, at least on the U.S. west coast (Caltrans, 2015; www.go.umd.edu/UcP), were based on a recommendation of dual criteria of peak sound pressure (SPL_{peak}) and cumulative SEL (SEL_{cum}) (Carlson *et al.*, 2007; Popper *et al.*, 2006; Popper & Hastings, 2009).

The rationale for dual criteria was that it was sometimes hard to determine one or the other measure when trying to set a signal level for onset of an effect and having alternative approaches provides a more conservative guideline for the protection of the animals. The SEL_{cum} was suggested since animals are often exposed to many more than a single pile driving strike in succession and any effect would probably come from an accumulation of energy from the multiple strikes. However, as noted above, it is now clear that the SEL_{cum} is probably an inappropriate measure of potential effects.

In 2008, the Fisheries Hydroacoustic Working Group adopted the interim dual-criteria model for onset of physiological effects from sound exposure (FHWG, 2008). However, these criteria were immediately criticised since they were based on very limited scientific research on effects of pile driving on fishes (Carlson *et al.*, 2007; Popper & Hastings, 2009). The criteria were: Peak (SPL): 206 decibels (dB) re 1 μPa; SEL_{cum}: 187 dB re 1 $\mu Pa^2\ s^{-1}$ for fishes above 2 g; SEL_{cum}: 183 dB re 1 $\mu Pa^2\ s^{-1}$ for fishes below 2 g.

11.1.2 | Onset of behavioural effects

The U.S. National Marine Fisheries Service (NMFS), as well as other agencies, currently uses 150 dB re 1 μPa (rms) as the sound pressure level that may result in onset of behavioural effects (Caltrans, 2015). This is based on a recent NMFS guidance document (www.go.umd.edu/Ucs) that says that sound pressure above the 150 dB_{rms} level are expected to cause temporary changes in behaviour and these might include startle responses (though startle is not defined and has broad meaning to fish biologists), feeding disruption, area avoidance, *etc.* However, there are a number of problems with the 150 dB_{rms} criterion. First, its origin and scientific basis is not known (Hastings, 2008). Second, the value is based on the assumption that fishes respond to sound pressure even though, as pointed out earlier, most fishes primarily detect particle motion (see also Popper & Hawkins, 2018). Thus, any behavioural criteria should be based on the acoustic signals that the fish can actually detect and respond to. Finally, and perhaps most importantly, a single criterion value for behaviour does not take into consideration the very substantial species differences in hearing sensitivity, behaviour, etc., nor does it take into consideration response changes with animal age, season, or even motivational state (Neo *et al*., 2014).

11.2 | Recent criteria and guidelines

More recently, a set of interim criteria and guidelines for fishes was developed based on recent scientific advances (Table 2; Popper *et al*., 2014). Of major importance, the authors concluded that it was not possible to define sound exposure criteria for every possible sound source, type of response to the sound, or do an analysis for every fish species (or even all of those potentially listed in various locales). Instead, they developed an approach that focussed on fish groups based on morphology of auditory apparatus (Table 3), on major sound types (*e.g*., pile driving, shipping) and major potential effects (Table 1). The overall intent was to provide the first science-based, but clearly interim, criteria for effects of anthropogenic sound on fishes and to provide a way to deal with the potentially insurmountable combinations of species and sources. The authors very carefully, however, pointed out that the proposed criteria were not complete due to lack of data (Table 2 provides examples of the several effects tables found in the guidelines) and that they expected that as more studies were done, the suggested criteria would evolve.

Finally, the authors of the guidelines made it clear that many of the acoustic impact assessments carried out on fishes in the past and upon which the interim guidelines were based, must be amended since they only considered sound pressure and did not take into consideration the potential effects from high levels of particle motion, something that must be done in future iterations of the guidelines (Hawkins *et al*., 2015; Hawkins & Popper, 2016b; Nedelec *et al*., 2016; Popper & Hawkins, 2018). There is growing international awareness that fishes do possess particle-motion receptors and that this must be taken into account in setting future criteria, once appropriate data are available.

TABLE 3 Grouping of Fishes as per 2014 Guidelines

Group	Characteristics
1	Fishes lacking swim bladders that are sensitive only to sound particle motion and show sensitivity to only a narrow band of frequencies (*e.g*., flatfishes, Pleuronectiformes; sharks skates and rays, Chondrichthyes).
2	Fishes with a swimbladder where that organ does not appear to play a role in hearing. These fish are sensitive only to particle motion and show sensitivity to only a narrow band of frequencies. This group includes salmonids (Salmonidae) and some tunas and mackerels (Scombridae), but many other species are likely to fit into this category as well.
3	Fishes with swim bladders that are close, but not intimately connected, to the ear. These fishes are sensitive to both particle motion and sound pressure, and show a more extended frequency range than groups 1 or 2, extending up to about 500 Hz. This group includes cod fishes (Gadidae), eels (Anguillidae), some drums and croakers (Sciaenidae), and perhaps other fishes.
4	Fishes that have special structures mechanically linking the swim bladder to the ear. These fishes are primarily sensitive to sound pressure, although they also detect particle motion. They have a wider frequency range, extending to several kHz and generally show higher sensitivity to sound pressure than fishes in groups 1, 2, or 3. The group includes some of the squirrelfishes (Holocentridae), drums and croakers (Sciaenidae), herrings (Clupeidae) and the large group of otophysan fishes.
5	Eggs and larvae.

11.3 | European guidelines for fishes

The monitoring of underwater noise is included in the European Union's Marine Strategy Framework Directive (MSFD; EU, 2008), which is concerned with ensuring good environmental status (GES) of European waters (Andersson *et al*., 2017; Dekeling *et al*., 2016; Tasker *et al*., 2010; Tasker *et al*., 2012; van der Graaf *et al*., 2012). The directive requires that the introduction of energy, including underwater noise, must be at levels that do not adversely affect the marine environment. No specific criteria for fishes are provided but indicators for achieving GES are specified.

The Swedish Environmental Protection Agency recently published a review that discusses regulation of pile driving sounds (Andersson *et al*., 2017). While the review focusses on sound pressure, the authors also strongly concurred with the idea that future guidelines for fishes must also be in terms of particle motion and must also consider signals from the substrate. The proposed exposure values in the document were taken from the Popper *et al*. (2014) guidelines and follow the interim U.S. criteria. The sound pressure levels at which fish are at risk of death or sustaining serious injury to internal organs are considered to be SPL_{peak} 207 dB re 1 μPa, SEL_{ss} 174 dB re 1 $\mu Pa^2\ s^{-1}$ and SEL_{cum} 204 dB re 1 $\mu Pa^2\ s^{-1}$. Thresholds for fish larvae and eggs were based on the fact that no negative effects were observed at exposures of up to SPL_{peak} 217 dB re 1 μPa, SEL_{ss} 187 dB re 1 $\mu Pa^2\ s^{-1}$ and SEL_{cum} 207 dB re 1 $\mu Pa^2\ s^{-1}$. However, the paper notes that there are relatively few studies on the early life stages of fish. The Swedish review does not propose noise levels for flight behaviour or a temporary threshold shift (TTS) in fish because, unlike damage to internal organs, both flight behaviour and hearing damage are linked to the species' specific sensitivity to frequency and sound intensity. And using the existing literature, it is not possible to assess whether flight behaviour negatively affects the species at the population level or whether the effect is related to the area and period of time.

In the UK, Nedwell *et al*. (2007) proposed a set of guidelines for behavioural responses utilising what they referred to as the dB_{ht} (species) concept. Nedwell *et al*. (2007) suggested that specific dB_{ht} levels above the hearing threshold of a fish elicited particular responses. The dB_{ht} is based on a frequency weighting approach since animals do not hear equally well at all frequencies within their hearing range. Frequency weighting is therefore often applied in assessing the effects of sounds upon particular species (*e.g*., Houser *et al*., 2017). Weighting takes account of hearing ability by referencing sound levels to the species' hearing thresholds. The Nedwell approach has been utilised within the UK for assessing the effects of anthropogenic sounds on fishes and it appears to have the tacit approval of some UK regulatory agencies. However, the dB_{ht} approach has very serious flaws that make it totally unacceptable (Hawkins & Popper, 2014, 2016b). This is suggested since Nedwell *et al*. (2007) concluded that strong avoidance responses by fishes start at a level about 90 dB above the dB_{ht}

(species) thresholds, while different proportions of fishes respond at lower weighted levels. However, there are very few field data derived from wild fishes to support these chosen levels. Also, the concept of dB_{ht} has not been accepted in any independent peer-reviewed publications. Indeed, extreme caution must be exercised in applying the dB_{ht} (species) measure. Defining response criteria applicable to all species is a far too simplistic an approach to evaluating behaviour. Moreover, the data on hearing thresholds used for the dB_{ht} approach should ideally be based on accurate behavioural threshold determinations rather than measures of inner ear responses, as the latter are susceptible to flaws (Sisneros *et al.*, 2016).

12 | MAJOR RESEARCH GAPS AND RESEARCH RECOMMENDATIONS

In order to develop better guidelines and criteria, it will be critical to fill many gaps in understanding of the potential effects of anthropogenic sounds on fishes. The goal must be to increase knowledge in those areas that are most likely to enable sound exposure criteria to be revised, as per the expectation of the 2014 guidelines (Popper *et al.*, 2014). There are many research gaps suggested earlier in this paper and in other publications (Normandeau, 2012a,b; Hawkins *et al.*, 2015). Here we will focus on those questions and data needed to move forward most rapidly.

12.1 | Selection of species

It is clear, based on the diversity of fishes and their life styles that it is critical to obtain data from multiple species and a range of sizes and ages of fish within each species. There is likely to be substantial variation in potential effects depending on differences in anatomy, physiology and behavioural responses to various stimuli. Recent guidelines (Popper *et al.*, 2014) suggested dividing fishes into several morphological groups that relate to the presence or absence and configuration of the swimbladder (see Tables 2 and 3). Having a representative set of species or fish types will be critical for future work on all aspects of effects of anthropogenic sound on fishes.

12.2 | Behavioural responses

There is general consensus that the single most important issue is the effects of anthropogenic sound on fish behaviour. While questions about physical and physiological effects are important, the distance around the source that includes sounds of sufficient level to physically harm the fish is relatively small compared with the much greater area that is potentially ensonified, where the sounds are heard by the fish and where behavioural responses may be shown. Far fewer animals are likely to be directly harmed by sounds compared with the number of animals that may show changes in behaviour. Any anthropogenic sounds that alter the ability of animals to hear natural sounds that are important to them (*e.g.*, as a result of masking), or cause temporary loss of hearing sensitivity (TTS), may affect their natural behaviour adversely. Some anthropogenic sounds may frighten the fish away from preferred locales or from migration routes. While many behavioural effects are likely to be minimal and have little or no effect on fish fitness and survival, some behavioural responses may have substantial short and long-term effects upon them.

The currently available data on behavioural responses, as shown earlier, are highly variable and have many problems that do not even start to provide any general principles on how fishes respond to anthropogenic sound. Moreover, there are numerous additional behavioural issues that need to be examined, from the sound levels that are likely to influence hearing (*e.g.*, hearing studies, studies of hearing in the presence of maskers) to responses to sound pressure *v.* responses to particle motion (Popper & Hawkins, 2018). Data are needed on general behavioural responses to sounds at different sound levels and how these responses change over time after the introduction of an anthropogenic source, as fishes may habituate to the sounds or temporarily show hearing losses due to the presence of persistent sounds. Especially significant is what fishes do when they are exposed to a particularly intense sound (do they move away or stay in place) and what are the long-term consequences for fish populations?

Most importantly, long-term, realistic field studies are needed on the effects of anthropogenic sounds on the behaviour of fishes, taking account of cumulative and synergistic effects, along with stress indicators. It is important to carry out such studies in the wild, where there are no constraints like tank walls or netting and where the acoustics are normal.

12.3 | Effects of particle motion

It is now clear that fishes are primarily detectors of particle motion and relatively fewer species of fish use sound pressure. Thus, criteria and guidelines must be developed in terms of particle motion as well as sound pressure. Yet, very little is known about hearing sensitivity to particle motion and it is imperative that such data be obtained. Concurrently, it is imperative to measure the signal from anthropogenic sources in terms not only of sound pressure, as now done, but also in terms of particle motion.

12.4 | Development of dose–response data

Studies on physical effects of pile driving signals in fishes are needed that could lead to understanding dose–response relationships of different sound variables such as signal intensity, number of strikes, inter-strike interval, *etc.* Indeed, a recent study (Casper *et al.*, 2017) suggests that the dose–response relationship is more complex than previously thought. Studies of dose–response relationships will provide insight not only for understanding the onset of physical effects or behavioural effects, but also for determining those levels above the onset level at which potentially harmful effects start to occur. Such information will enable regulators and others to be able to make better decisions on criteria, particularly if they are willing to accept the idea that just because there is a small effect, this may not affect the fitness of the animal.

12.5 | Hearing

Though here is a body of literature on the hearing of perhaps 100 fish species (Ladich & Fay, 2013), the greater portion of these data were obtained using sound pressure measures and do not reflect the fact that most fishes primarily detect particle motion. Moreover, most of the studies (particularly recently) used physiological measures (most often auditory evoked potentials; AEP) that do not reflect the sound processing capabilities of the whole auditory system and thus, do not reflect the actual hearing capabilities of an animal (Sisneros & Rogers, 2016). In order to understand fish hearing and the sounds that potential will affect behaviour, future studies must include particle motion and be done using behavioural methods that reflect how fishes actually respond to sound. Moreover, future studies need to be done in acoustic environments where sounds can be fully calibrated, such as in open bodies of water without physical constraints to reflect sounds, or in specially designed (and very expensive) tanks.

12.6 | Population studies

In contrast with marine mammals, where populations are small and there is concern for single animals, the greater interest for fishes is with populations of animals. Loss of an individual due to exposure to anthropogenic sound does not have the same implications for a species as does the effect on a population. Effects are the broad range of potentially measurable changes that may be observed in individuals, groups of animals, or even habitats as a result of sound exposure. Impacts are effects that, with some certainty, rise to the level of deleterious ecological significance (Boehlert & Gill, 2010). Thus, the effect does not indicate the significance, whereas the impact deals with the severity, intensity, or duration of the effect upon animal populations and ecological communities. Such impacts can then be compared with those resulting from other stressors, including chemical pollution, fishing, pathogens, climate change *etc.* The ecosystem-wide consequences of exposure to sound also need to be evaluated. Effects may influence the dynamics of predation and other types of biotic interactions at the community level. Making assessments across species and communities and within the wider ecosystem, may be of considerable value.

13 | CONCLUSIONS

There is increasing concern about the effects of anthropogenic sounds upon aquatic animals, including fishes. It is evident, however, that there are major gaps in our understanding of the effects of these sounds and especially their effect upon animal populations and aquatic ecosystems. Much of the literature is limited in quality and many of the experiments have been carried out on captive fishes under laboratory conditions, rather than on free-living fishes in the wild. There is also a lack of information on the responses to particle motion, rather than sound pressure. It is evident that there are so many information gaps that it is almost impossible to come to clear conclusions on the nature and levels of anthropogenic sound that have potential to cause changes in animal behaviour, or even physical harm. There is need to carry out further research on the behavioural responses of a range of fishes to different sound sources, under different conditions. As well as investigating responses to sounds of short duration, information is also required on responses to continuous or repeated exposure. What are the immediate effects of sound exposure and what are the longer-term effects in terms of fitness and likely effect on populations?

At the same time, since there is an immediate need for updated criteria and guidelines on potential effects of anthropogenic sound on fishes, we recommend, as do our colleagues in Sweden (Andersson *et al.*, 2017), that the criteria proposed by Popper *et al.* (2014) should be used. (We recognise that the suggestion of using the 2014 guidelines is potentially self-serving since we are lead authors on that document. However, as this document is growing in acceptance, we feel it important that we share our own thoughts and that of colleagues world-wide.) However, as new data become available, these criteria need to be updated and filled in. We also suggest that there is significant need to define what onset of effect means in terms of fishes. Is this, as often now used, the start of any effect even on a single animal, or is it some level that, while easily assessed, reflects some statistical value and which focusses on the population rather than on individuals.

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A.N.P. and A.D.H. contributed equally to all aspects of this review.

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Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*)

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Abstract: To determine whether seismic exploration affected abundance or catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*), acoustic mapping and fishing trials with trawls and longlines were conducted in the central Barents Sea 7 days before, 5 days during, and 5 days after seismic shooting with air guns. Seismic shooting severely affected fish distribution, local abundance, and catch rates in the entire investigation area of 40 × 40 nautical miles.Trawl catches of cod and haddock and longline catches of haddock declined on average by about 50% (by mass) after shooting started, which agreed with the acoustic abundance estimates; longline catches of cod were reduced by 21%. Reductions in catch rates were observed 18 nautical miles from the seismic shooting area (3 × 10 nautical miles), but the most pronounced reduction occurred within the shooting area, where trawl catches of both species and longline catches of haddock were reduced by about 70% and the longline catches of cod by 45%; a relatively greater reduction was found (in catches and acoustic estimates) for large (>60 cm) than for small fish. Abundance and catch rates did not return to preshooting levels during the 5-day period after seismic shooting ended.

Résumé : Pour déterminer si l'exploration sismique nuit à l'abondance de la morue (*Gadus morhua*) et de l'églefin (*Melanogrammus aeglefinus*) ainsi qu'au taux de capture de ces espèces, on a procédé à des travaux de cartographie acoustique et à des essais de pêche au chalut et à la palangre dans la partie centrale de la mer de Barents 7 jours avant, 5 jours durant et 5 jours après une série de tirs sismiques au canon pneumatique. Les tirs ont considérablement modifié la répartition du poisson, abaissé sa densité locale et gravement réduit le taux de capture dans l'ensemble de la région d'étude (soit un secteur mesurant 40 milles marins de côté). En moyenne, les prises de morue et d'églefin au chalut et les prises d'églefin à la palangre ont diminué d'environ 50% (en masse) après que la série de tirs ait commencé. Ces résultats concordent avec ceux des relevés acoustiques d'abondance. Les prises de morues à la palangre ont été réduites de 21%. Des baisses des taux de prise ont été observées jusqu'à 18 milles marins du secteur des tirs sismiques (un secteur de 3 × 10 milles marins), mais l'effet le plus prononcé a été observé à l'intérieur de ce secteur : les prises au chalut des deux espèces et les prises à la palangre de l'églefin ont diminué d'environ 70%, les prises de morue à la palangre d'environ 45%. La réduction est proportionnellement plus marquée dans le cas des poissons de grande taille (>60 cm) que celle des poissons de petite taille, tant dans les prises que dans les estimations par relevé acoustique. Cinq jours après la fin des tirs sismiques, l'abondance et les taux de capture ne s'étaient pas encore rétablis.
[Traduit par la Rédaction]

Introduction

Since the early 1960s, seismic shooting with air guns has been conducted on the Norwegian continental shelf to map oil and gas resources. The extent of this activity continues to increase. About 40 000 linear km were "shot" in 1974 (Anonymous 1991), and by 1993 this figure had reached about 335 000 km (Anonymous 1994). Not only has the effort increased in the traditional exploration areas in the North Sea, but exploration has also been expanded to the areas north of 62°N. As search areas expand, seismic shooting will be conducted over critically important fishing grounds, often in conflict with fisheries.

Fishermen have claimed for years that catch rates decline when a seismic vessel arrives at a fishing ground and begins to shoot, presumably because the noise from the air guns scares the fish away. Air-gun arrays produce sound in the frequency range from 20 to 150 Hz (Malme et al. 1986), which is within the auditory range of many marine species (Hawkins 1993). It has been established that the auditory sensitivity of cod (*Gadus morhua*) is best in the frequency band from 60 to 310 Hz, with a maximum at 160 Hz, where the hearing threshold has been determined to be about 80 dB re 1 μPa (Chapman and Hawkins 1973). In addition to frequency and sound level, detection threshold has also been found to be influenced by signal characteristics such as pulse duration (Blaxter et al. 1981; Hawkins 1981) and pulse rise time (Schwarz 1985). For fish to detect a sound stimulus, the stimulus must exceed the ambient noise level (about 80–90 dB re 1 μPa Hz^{-1} in open sea, Wenz 1962) by about 20 dB (Hawkins 1993). The level at which fish respond to a sound stimulus, however, may lie significantly above the detection threshold. The reaction threshold for vessel noise has been shown to be approximately 20 dB above the detection threshold (Ona, unpublished data) and agrees well with the results of experimental exposures of redfish (*Sebastes* spp.) to air guns (Skalski et al. 1992). A typical

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Fig. 1. Experimental area on the North Cape Bank, also showing the centrally located shooting area. Depths are in metres.

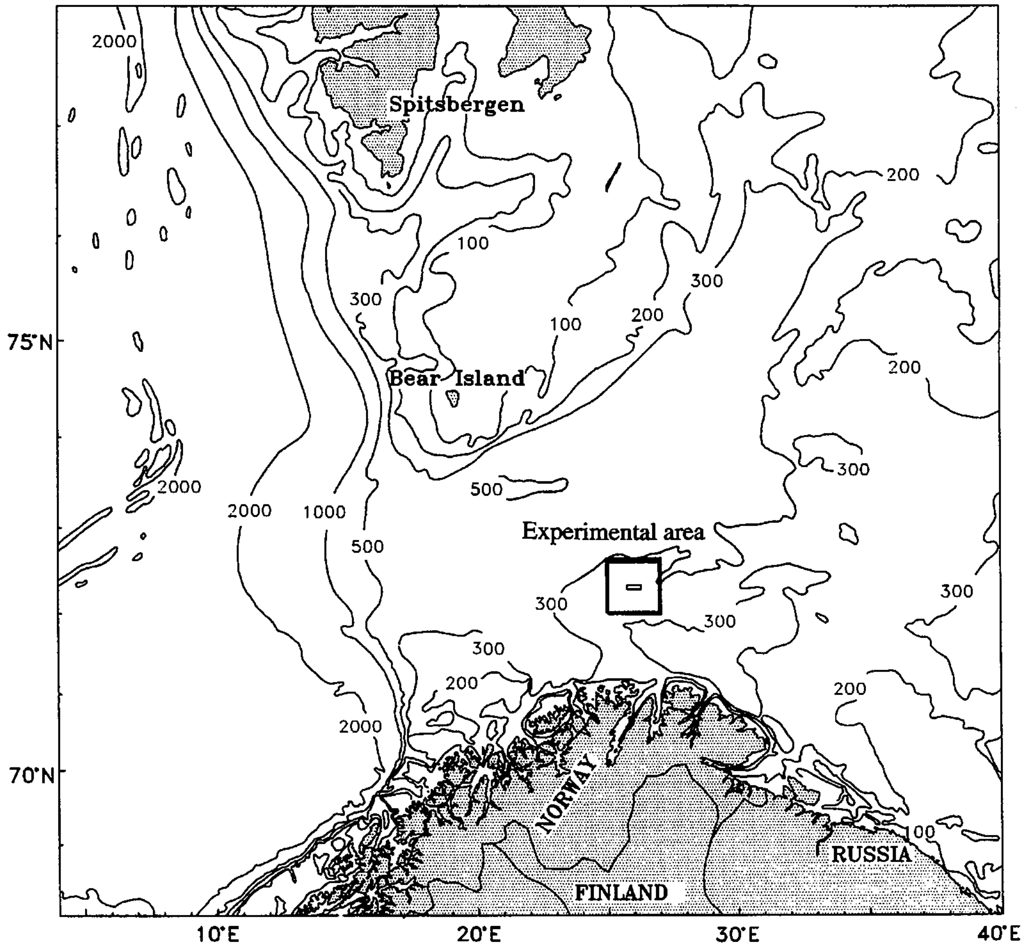


Fig. 2. Survey grid for the acoustic investigations and distribution of trawl sampling stations (solid circles) (A), and location of longline fleets (bars) and trawl hauls (open circles) (B) before shooting.

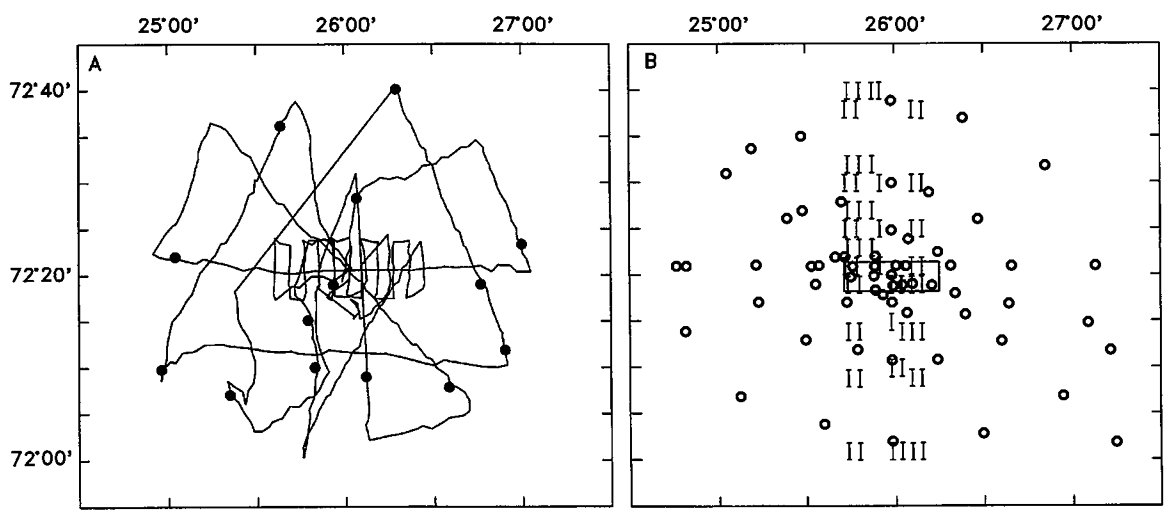


Table 1. Number of combinations of time and distance in the trawl and longline trials.

	Trawl				Longline			
	0 nmi	1–3 nmi	7–9 nmi	16–18 nmi	0 nmi	1–3 nmi	7–9 nmi	16–18 nmi
Before	12	16	16	16	7	7	7	7
During	15	16	17	17	5	5	5	5
After	12	16	16	16	5	5	4	5

1.3 m. Eight longline fleets were set and hauled each day along north–south transects at the same four distances relative to the shooting area as the trawl hauls (Fig. 2B), i.e., two fleets were set at each distance every day. These two fleets were set relatively close (0.5 nmi east–west distance) and therefore were regarded as one observation in the analysis of variance. A total of 56, 40, and 35 longline fleets were set and hauled before, during, and after shooting, respectively. The longline fleets were set between 02:00 and 08:00 (GMT) every day and soak time varied from 6 to 18 h.

Data analyses

To investigate whether seismic shooting had any effect on the catch rates of trawl and longline, the following model was used for cod and haddock:

(3) $y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk}$

where y_{ijk} is the catch in kilograms (after logarithmic transformation) per trawl haul or per longline fleet pair set at the same distance on the same day, μ is the expected catch, α_i is the distance effect, β_j is the effect of time in relation to the seismic shooting, $(\alpha\beta)_{ij}$ is the interaction between time and distance, and ε_{ijk} represents random variation. A logarithmic rather than a linear scale is used, because for marine catch data the variance is often proportional to the square of the mean (Pennington 1983; Pennington and Vølstad 1991) and a logarithmic transformation will consequently stabilize the variance (Snedecor and Cochran 1980).

The experimental design was roughly balanced (Table 1) and the model (eq. 3) adapted to application of type III sum of squares with multifactor analysis of variance (Statgraphics STSC, Inc. 1991). The approximate balance of the experimental design rendered the interpretation of factors in the analysis relatively uncomplicated. It should be emphasized that the trial area for longline fishing was a subset of that for the trawl trials (Fig. 2B).

The adequacy of the model in eq. 3 for the cod data was assessed using standard diagnostic checks of the residuals (Box et al. 1978). No lack of fit was detected, except that when the residuals were treated as a time series a slight autocorrelation was detected ($r = 0.2$). However, because the order in which the distances were sampled was varied during the experiment, this would not have a significant effect on the calculated probability levels of the model. As a final check of the time effect on catch size, time series methods (Box and Jenkins 1976) and intervention analysis (Box and Tiao 1975) were used to assess the data.

Sound monitoring

The sound level and frequency spectrum of the air-gun array and the vessels used were monitored by a hydrophone (Brüel and Kjær, type 8104) suspended at a depth of 80 m. The sound levels of the vessels were measured both during fishing operations and at their cruising speeds. The signals were logged on a digital tape recorder (Sony Dat Pro II). The vessel sounds were later analysed in 1/3-octave bands with a real-time analyzer (Brüel and Kjær, type 2143), whereas the recordings made during detonations of the air-gun array were analyzed using a frequency analyzer (Brüel and Kjær, type 2143 FFT) and a storage oscilloscope (Phillips).

Results

Effects on fish abundance and catch rates

Acoustic abundance estimates

The acoustic abundance estimates showed that the distributions of cod and haddock were reasonably uniform throughout the experimental area before shooting started (Fig. 3), with about 70% of the total abundance of cod and haddock in the pelagic region. The effects of seismic shooting on the total acoustic density of cod and haddock are shown in Fig. 4, with values combined according to distance from the shooting area. The acoustic density for the entire investigation area was reduced from an average of 129.8 to 72.0 during the shooting, i.e., by 45%. During the period following shooting, the average value was 46.2, which corresponds to a reduction from the initial situation by 64%.

A picture of the fish distribution pattern during the shooting period is given by a transect running through the shooting area in an east–west direction on 9 May (Fig. 5), with the lowest density within the shooting area, or 5 nmi on each side of the centre, with gradually increasing density further out on each side. In the period after shooting, a further reduction in the total density occurred, followed by a gradual smoothing of the horizontal distribution.

The abundance computations by mass showed an initial abundance of about 33 000 t of cod and 6000 t of haddock distributed within the investigation area, or 31 t of fish/nmi^2. Apportionment of the total mass by area was performed in proportion to the acoustic density measurements for the same area and period; within the shooting area there were thus 834 t of cod and haddock before shooting, of which 85% were cod. Expressed in terms of mass for the entire area, the quantity of cod was reduced from 33 000 t before shooting to 16 500 t during shooting, and further to 9700 t after shooting (Fig. 6). The quantity of haddock for the same area was reduced from 6000 to 3200 t during shooting and to 3100 t after shooting.

In terms of vertical distribution, the relative reduction was slightly larger in the pelagic part of the water column than in the bottom channel, at 47 and 39% reductions, respectively. For both cod and haddock, large fish were significantly more affected than small fish (data not shown; see Engås et al. 1993).

Trawls

In the trawl catches more than 90% of the average catch was cod. The catches of cod were significantly higher before shooting began than during or after shooting, at all distances from the shooting area ($p < 0.001$) (Fig. 7A). The reduction was largest within the shooting area, where the average catch of cod decreased by 69%, from 556 kg before shooting to 173 kg during shooting. In hauls taken outside the central area, the reduction was 45–50% relative to that before shooting. The catch did not increase during the 5 days surveyed after shooting stopped.

Catches of haddock also were significantly ($p < 0.001$) less during and after shooting than before shooting began. Within the shooting area, catches during shooting fell by 68% relative to those before shooting (Fig. 7B). At other distances the catches were also significantly lower during and after shooting. Here the reductions during shooting relative to those

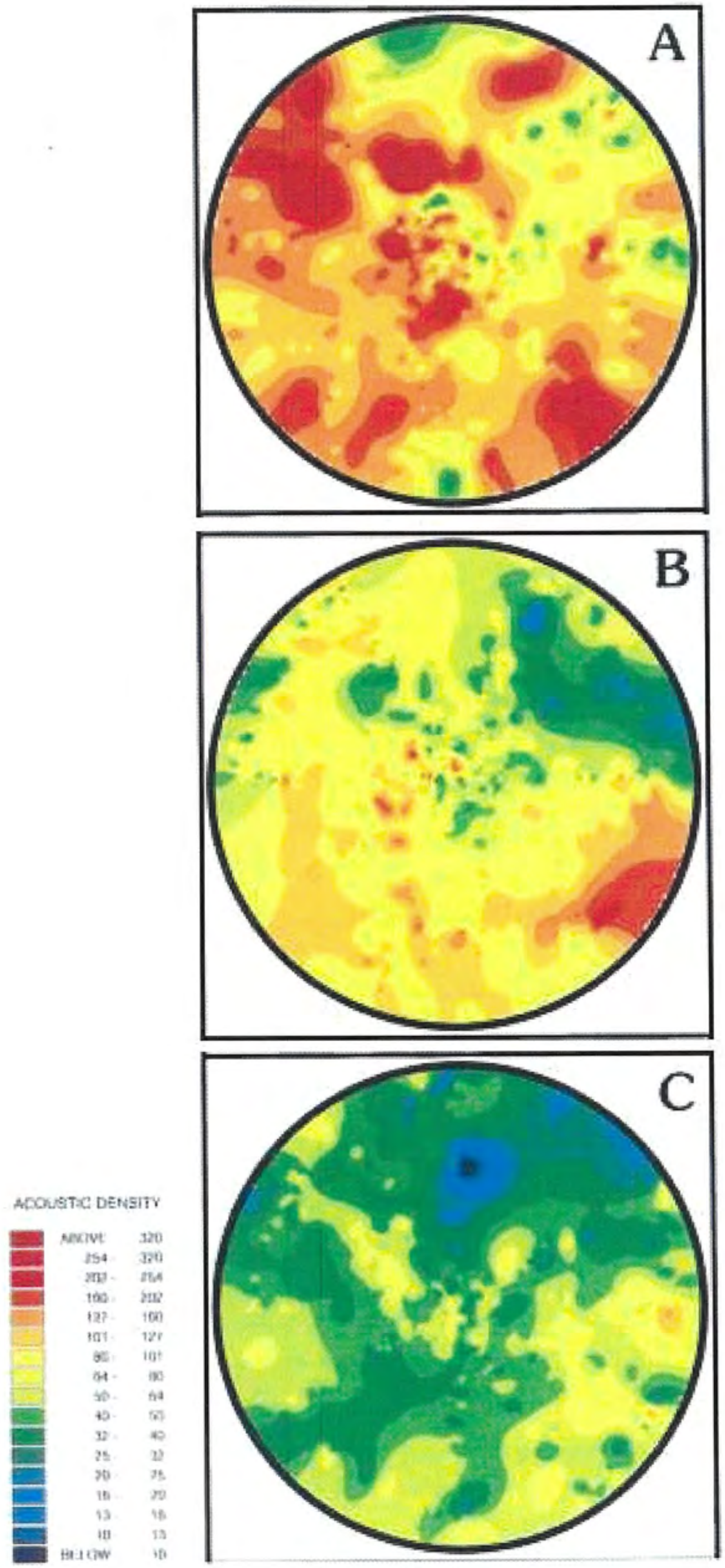

A
B
C
ACOUSTIC DENSITY
ABOVE 320
254 - 320
202 - 254
160 - 202
127 - 160
101 - 127
80 - 101
64 - 80
50 - 64
40 - 50
32 - 40
25 - 32
20 - 25
16 - 20
13 - 16
10 - 13
BELOW 10

Fig. 3. Horizontal distribution of cod and haddock in absolute units of acoustic density ($m^2 \cdot nmi^{-2}$) before (A), during (B), and after seismic shooting (C). The region displayed has a diameter of 40 nmi, with its centre at 72°20′N, 26°00′E.

Fig. 4. Total acoustic density ($+s_{geo}$) of cod and haddock before (solid), during (striped), and after (grey) shooting, by distance from the shooting region.

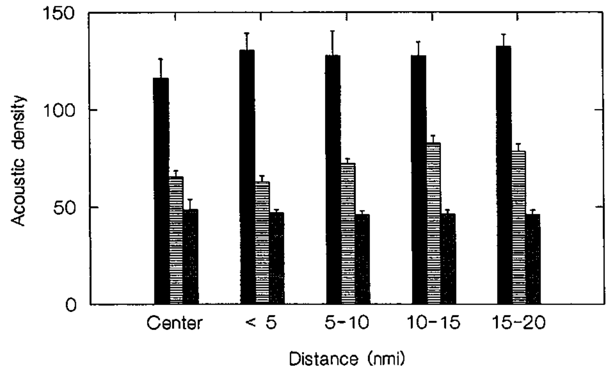
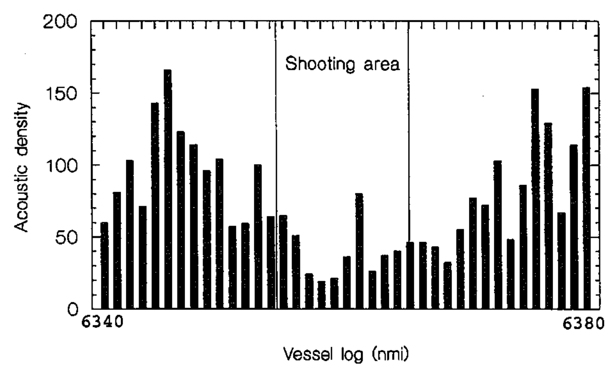


Fig. 5. Total acoustic density of cod and haddock, with 1-nmi resolution, measured along a straight transect running through the centre of the area in an east–west direction during shooting on 9 May.



before shooting were 56, 56, and 71%, respectively, at 1–3, 7–9, and 16–18 nmi. There was no increase in catch rates after shooting ceased.

Figure 8 shows the time series of catch rates for cod and haddock by trawl, where the catches are shown as a deviation from the overall average for the entire trial period. There was a significant variation in catch quantity from haul to haul throughout the trial period, but it is nevertheless clear that the catch rates of both cod and haddock fell immediately after shooting started. The low level was maintained throughout the whole shooting period (hauls 63–130) and also in the days after shooting had ceased. Both time series and intervention analysis confirmed that there was a 50% drop in catch after shooting began and no significant increase after shooting stopped. The time-by-distance interaction was not statistically significant for catch rates of either cod ($p = 0.118$) or haddock ($p = 0.559$) (see Appendix F in Engås et al. 1993).

Longlines

The most important species in the longline catches was cod,

Fig. 6. Total quantity ($+s_{geo}$) of cod and haddock by mass before (solid), during (striped), and after (grey) shooting.

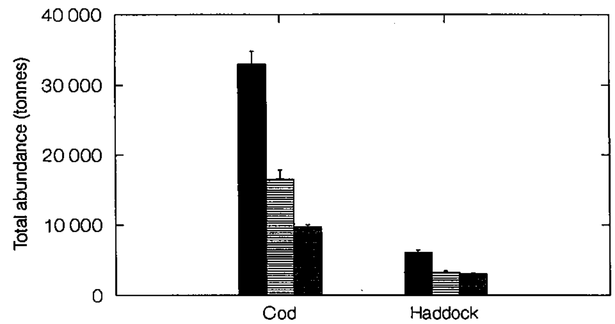
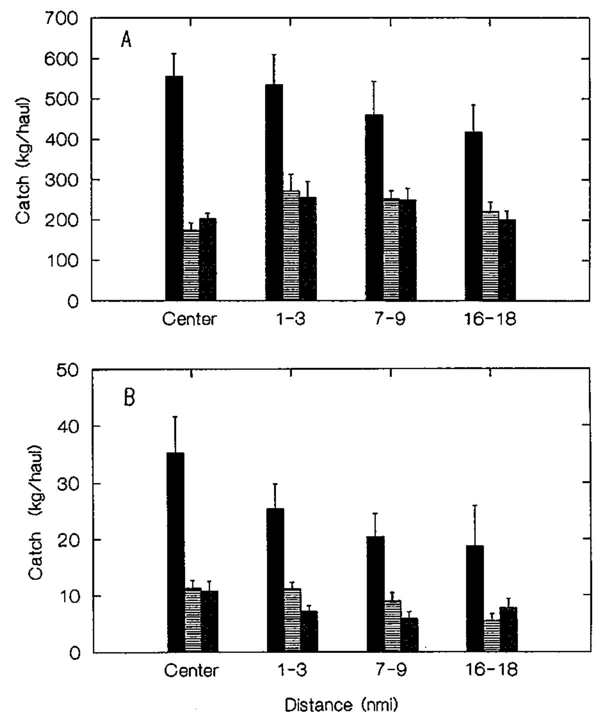


Fig. 7. Average trawl catch rates (+SE) of cod (A) and haddock (B) before (solid), during (striped), and after (grey) shooting, by distance from the shooting area.



but the proportion of haddock was greater than in the trawl catches, especially in the preshooting period (about 25% by mass). As for trawling, the statistical model showed a decrease ($p < 0.001$) in longline catch rates for cod when shooting started. In the central experimental area the catch rate declined by 45% when shooting began, but outside of this area the reduction was less (16 and 25%, respectively, at 1–3 and 7–9 nmi), with no reduction at the furthest position (Fig. 9A). There was a tendency for the longline catches of cod to increase after the conclusion of shooting, except for the furthest position where the catch rate declined.

Fig. 8. Trawl catch rates of cod (A) and haddock (B) in chronolgical order without regard to distance from shooting area. The catches are shown relative to the average (horizontal line) over the entire trial period.

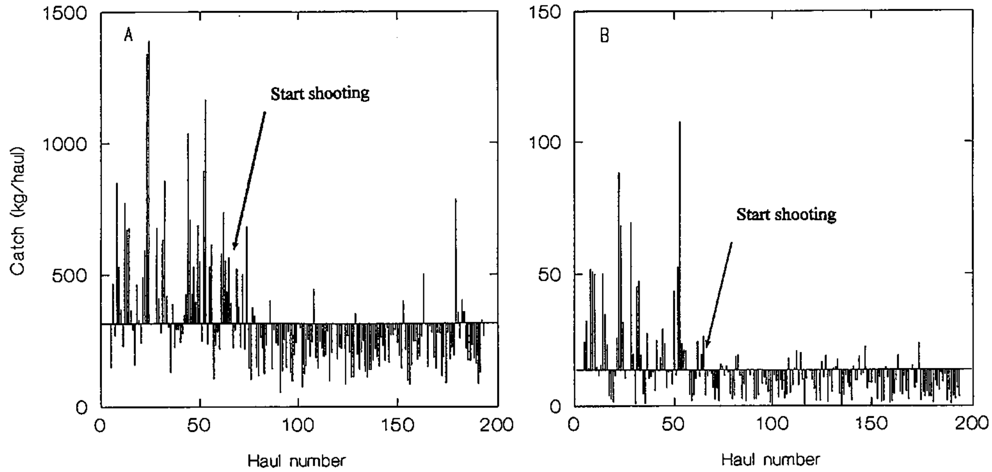
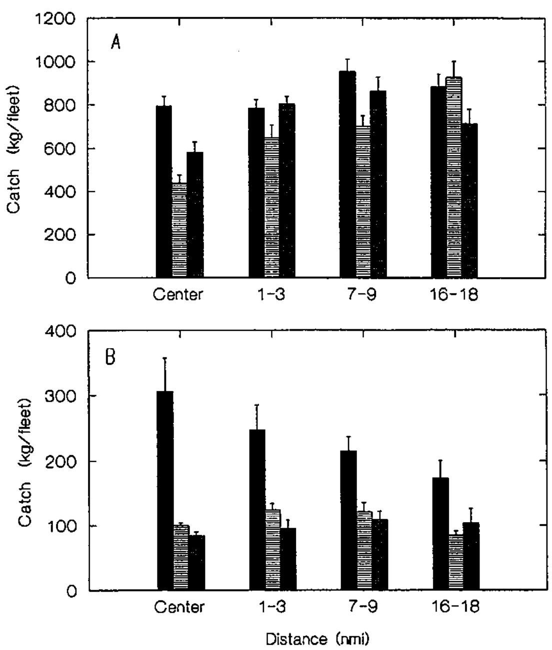


Fig. 9. Average longline catch rates (+SE) of cod (A) and haddock (B) before (solid), during (striped), and after (grey) shooting, by distance from the shooting area.



The catch reduction for haddock averaged about 50% over the entire area during shooting ($p < 0.001$). There was a reduction in catches out to the edge of the area, but the decrease was greatest in the central area where the catch rates declined by 67% (Fig. 9B). In contrast to the results for cod, there was no sign of an increase in catch after shooting had ceased.

The longline catches of cod were distinctly reduced from the moment the seismic shooting began (Fig. 10A). However, there were large variations in catch rates between longline fleets. It should be remembered that the longline fleets at all distances from the shooting area are included in Fig. 10A and, as mentioned earlier, there was no reduction in catch at the border of the experimental area. This will contribute to greater variability than in the equivalent figure for the trawl catches. It might appear that there was a distinctly negative trend in the longline catch rates for haddock before shooting started (Fig. 10B). However, the variability in catch was relatively large in this period. When shooting began, the variability in catch rates was much less, and catch rates stabilized at a low level. The time-by-distance interaction was found to be significant for longline catches of cod ($p < 0.001$), but not for haddock ($p = 0.592$).

Effects on small and large fish

When shooting started the length distributions changed, particularly in the central area. The sharpest change for cod occurred for fish larger than 60 cm, which nearly disappeared in both gears (Fig. 11, data for longline not shown). For haddock, in the trawl catches the reduction in the different size groups was more even, whereas for longlines the reduction was greater for large fish (Fig. 12).

The average mass per fish from each haul was related to distance and time using the model in eq. 3. Before shooting began, the size of cod was relatively uniform over the entire investigation area (Fig. 13). After the shooting began, masses fell significantly ($p < 0.001$) in the shooting area and in nearby areas. The changes in average mass of fish caught gradually decreased with increasing distance from the shooting area, and at the furthest position there was no significant change. Both main effects and interaction effects were significant ($p < 0.01$). After shooting operations had ceased, there was a tendency for the length distribution to return to preshooting levels. For individual mass of haddock neither the main effects nor the interaction effects were found to be significant.

Radiated noise measurements

The maximum peak value of the recorded seismic shots was measured to be 248.7 dB re 1 μPa at 1 m. A variation in peak value of about 3 dB from shot to shot was observed. The measurement point was roughly 65° off the acoustic axis and the recordings, corrected for directivity, indicate a source level of

Fig. 10. Longline catch rates of cod (A) and haddock (B) in chronological order without regard to distance from shooting area. The two longline fleets taken at the same distance each day are regarded as a single unit. The catches are shown relative to the average (horizontal line) over the entire trial period.

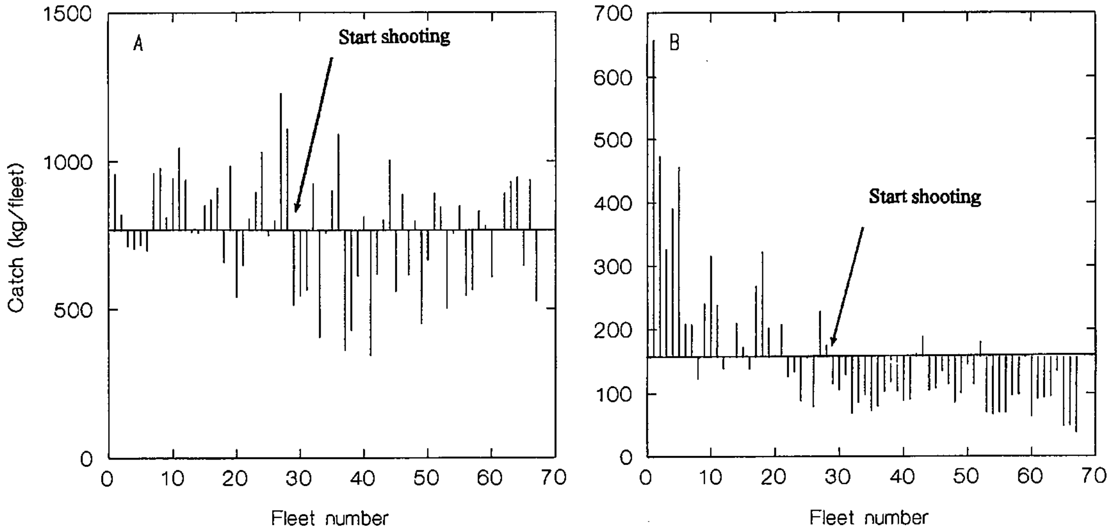
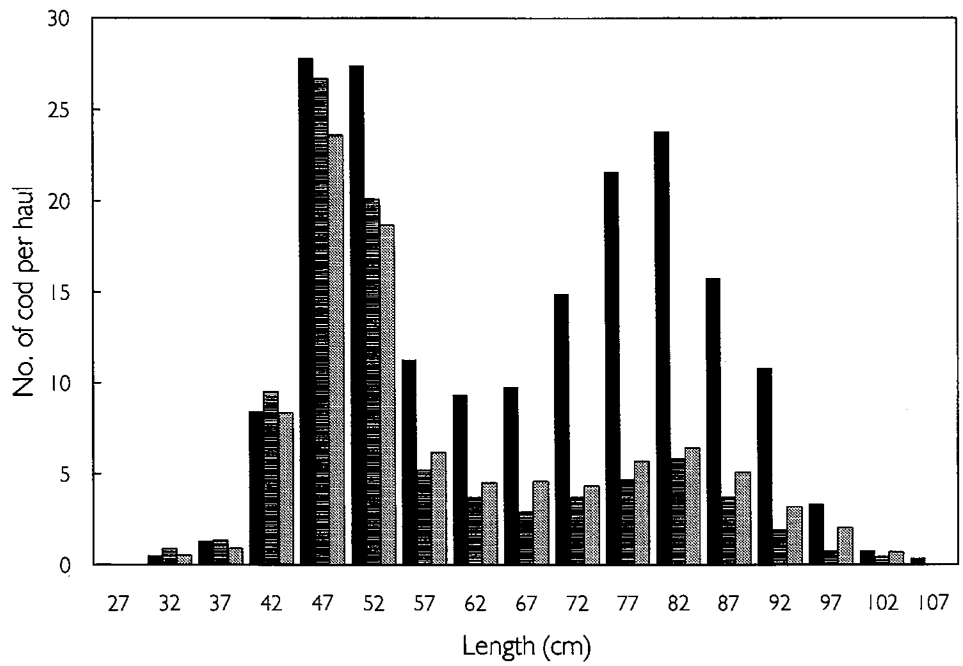


Fig. 11. Length distribution of cod in trawl hauls within the shooting area before (solid), during (striped), and after (grey) shooting.



253 dB re 1 μPa at 1 m, ±3 dB. This was somewhat higher than expected from this air-gun array, namely 250 dB re 1 μPa at 1 m. Most of the energy in the seismic shots was confined to the band 10–150 Hz (Fig. 14).

The spectral level of the sound from the air guns was about 120 dB above the measured ambient noise level and about 60 dB above the noise level from the fishing vessels. Detailed spectra of recorded ambient noise and all participating vessels at cruising and operating speeds were reported by Engås et al. (1993).

Discussion

Effects on fish abundance and catch rates

The acoustic survey and the fishing trials showed that seismic shooting with air guns affected fish distribution and caused trawl and longline catch rates of cod and haddock to fall. This effect of seismic activity was demonstrated within the region in which shooting occurred and also in surrounding areas, and the effect appeared immediately after seismic shooting started and continued after it ended.

Fig. 12. Length distribution of haddock in longline catches within the shooting area before (solid), during (striped), and after (grey) shooting.

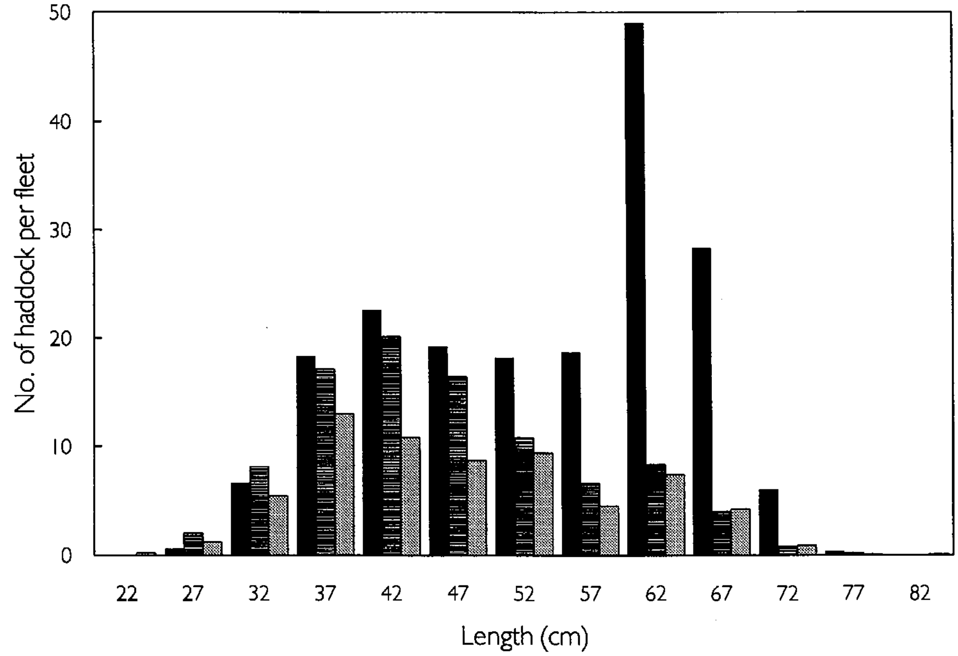


Fig. 13. Mean individual masses of cod (solid lines) and haddock (broken lines) in trawl hauls before, during, and after shooting, by distance from the shooting area.

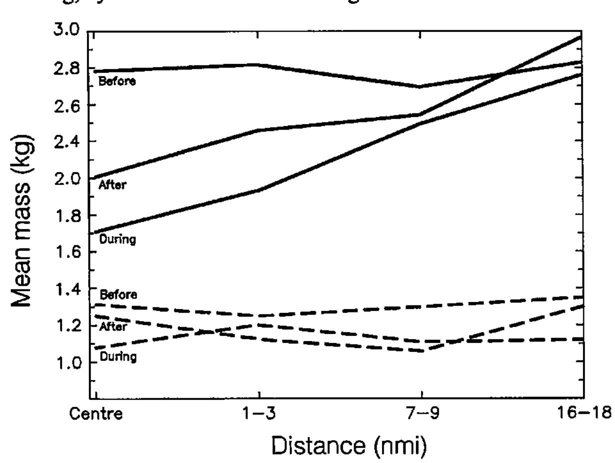
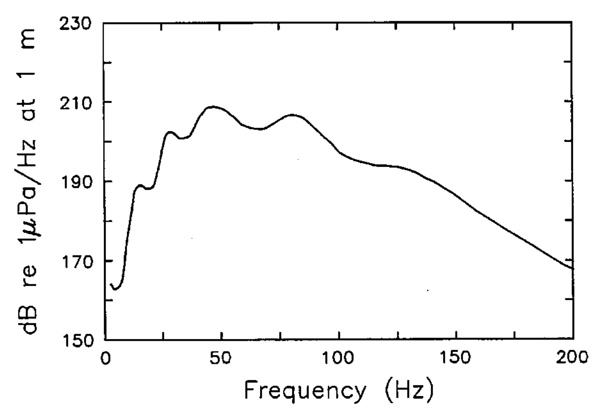


Fig. 14. Measured frequency spectrum for a single shot from the air-gun array.



While statistical tests on the main effects (time and distance) of seismic shooting on catch rates of cod and haddock generally were significant (in six of eight cases), the interaction term (time by distance) was not significant (in three of four cases) (Engås et al. 1993). Within the investigated area the change in fish distribution happened so rapidly after the shooting started that the sampling frequency used with trawls and longlines could not reveal real changes in the horizontal distribution of fish with time. The main reason for a nonsignificant interaction term, however, is that the study area was too small to see the effects diminish with distance, and that the duration of the experiment was insufficient to see catch rebound with time.

The most pronounced indicators of the effects of seismic shooting are therefore the rapid drop in catches immediately after seismic shooting started (Figs. 8A, 8B) and the local drop in fish density across the central area, as measured on some of the acoustic transects during seismic shooting (Fig. 5). It is unlikely that a natural rapid shift in horizontal distribution coincided with the seismic shooting, and the results are thus most likely explained by the hypothesis that fish are scared by the sound generated by the air guns and migrate out of the area.

Fishing effort within the experimental area could have had only a minimal effect on the observed catch reductions. The largest effort was made within the shooting area, where total catches were about 20 t of cod and 4.5 t of haddock. The total quantity available within the shooting area, determined acoustically, was about 834 t. Fishing therefore removed only 3% of the initial stock. A fish-out effect would also have caused a gradual change in abundance and catch rates, as opposed to the sudden reductions observed immediately following the start of seismic shooting.

Reductions in catch rates caused by seismic activity have also been demonstrated in other studies. Løkkeborg and Soldal (1993) investigated catch data obtained from commercial vessels that happened to be operating on fishing grounds where seismic explorations were being conducted and found a 55–80% reduction in longline catches of cod and a reduction of 80–85% in the by-catch of cod in shrimp trawling. For fishing with vertical lines, catches of various redfish species declined by 50% during discharges of a single air gun (Skalski et al. 1992).

In this study, differences were found between trawls and longlines in terms of the degree of reduction in catches of cod and its spatial and temporal extent. During seismic shooting, the masses of cod taken by trawl fell by 69% within the area where the seismic vessel was operating, and a total catch reduction of about 45% was observed throughout the survey area. For longline fishing, however, the catch rates for cod fell by 44% in the seismic shooting area, but the influence on catch rate gradually diminished towards the border of the survey area, where no significant change in the catch rates was observed after shooting started. After shooting ended, there was a tendency for the longline catches of cod to increase.

The differences in the results for trawl and longline catches of cod may be due to the different catch mechanisms of these gears. Longlines have a definite point of gear saturation limited by the number of baited hooks (Skud 1978), and a linear relationship between catch rate and fish abundance cannot be assumed. If a nonlinear relationship applies, the consequence of estimating fish abundance from longline catch rates is that changes in fish abundance are consistently underestimated, especially when abundance is high (Siegler 1993). The decrease in fish abundance owing to seismic activity may therefore have been more pronounced than was reflected in the longline catch rates. However, in our study only about 20% of the hooks had caught a fish, and gear saturation alone can hardly explain why the longline catches did not reflect a 50% reduction in cod abundance at the border of the survey area, as measured by trawl and acoustics.

Catch per unit effort in longline fishing may be affected by competition between species (Skud 1978; Siegler 1993). In the period after shooting, the catch rates for haddock were much lower than in the preshooting period, and the longline may have become more efficient in catching cod. Furthermore, the seismic shooting caused the fish to migrate out of the area, and the movement of fish may have increased the rate of encounters with the baited hooks.

On the other hand, if we assume that the longline catch per unit effort data on cod in this experiment correctly reflect real changes in abundance, the trawl and acoustic measures must have been biased. The trawl itself and the trawling operation both generate noise (MacLennan and Hawkins 1977). Fish that have been subjected to sound from air guns may be more sensitive to sound and show a stronger avoidance reaction to trawling than unaffected fish, causing trawl catchability to decrease in areas already affected by seismic activity. The observed decrease in abundance, as reflected by the trawl catches, may thus have been overestimated. However, the trawl data were in agreement with the acoustic density estimates, and the changes in abundance seem therefore to be more accurately reflected by the trawl data than the longline data. The longline catch per unit effort, particularly for cod, may be biased through a combination of the effects of gear saturation, changes in interspecific competition for bait, and increases in fish movement induced by sound emission.

Our study was also designed to investigate the spatial and temporal range of the effects of seismic explorations. The size of the experimental area was chosen to include distances beyond those within which fish reactions and catch reductions were expected to be demonstrated. On the basis of our knowledge of fish hearing and reaction thresholds, it was assumed that fish would be able to detect the sounds emitted by the air-gun array at the border of the experimental area, but no reaction was expected further out than 5–6 nmi from the shooting area. However, catch reductions beyond this distance were demonstrated for both trawls and longlines. In our calculations we assumed that the reaction threshold exceeded the detection threshold by about 20 dB, but the results indicated a smaller difference between the detection and reaction thresholds for air-gun noise. Alternatively, the threshold of detection of air-gun noise may be lower than the auditory thresholds reported in the literature (see Chapman and Hawkins 1973; Hawkins 1993).

The catch rates did not return to preshooting levels during the 5-day period after shooting ended. Trawl catches of cod and haddock and longline catches of haddock showed no increase after shooting ended. The longline catches of cod approached the preshooting level during this 5-day period, but the catch rates in the shooting area and at the border of the experimental area were still below preshooting levels. The length–frequency distribution in the area also approached, but did not return to, its initial pattern. The results thus indicated that trawl catches do not normalize during the first 5 days after seismic shooting ends, whereas there is a tendency for longline catches to approach preshooting levels. The investigation therefore demonstrated that the effects of seismic shooting lasted for at least 5 days.

Effects on small and large fish

We found that the reductions in the acoustic estimates and in the longline and trawl catches were more pronounced for large than for small fish. An increase in longline catches of small cod was even observed after seismic shooting started (see Engås et al. 1993). The higher catch rate of small cod by longline may be due to less competition for available bait at lower fish density (Løkkeborg and Bjordal 1992). Small individuals may be more successful in taking the bait available when the larger individuals have avoided the area.

The stronger response of larger fish to air-gun discharges may be explained by size-dependent swimming capacity. Assuming that fish within the shooting area responded to the sound emissions by swimming at their maximum sustained speed, then a 30-cm cod (maximum sustained swimming speed = 0.6 $m \cdot s^{-1}$ (Wardle 1977)) would have been able to swim 28 nmi and reach the border of the survey area during the first 24 h after shooting started. However, as the fish were responding to continuously discharging air guns and swimming through a gradient of exponentially decreasing sound levels, habituation may have occurred. Thus, fish may have terminated their avoidance reaction at different distances from the central area depending on their size and swimming speed. Alternatively, the fish may have responded to the air-gun discharges by increasing their swimming speed beyond the sustained speeds, leading to exhaustion. Avoiding the sound source by prolonged swimming speeds (He 1993) may thus have produced a response pattern of alternating intervals of swimming and resting until habituation terminated the response at different distances for fish of different sizes.

Another explanation for this difference may be based on improved hearing ability with increasing size for species with a swim bladder owing to reradiation of sound from the swim bladder, although such a relationship has not been documented. Larger fish also have lower resonance frequencies than small fish, and may therefore be more sensitive to sound of lower frequencies. However, this is not a likely explanation for a stronger response to air-gun discharges in larger fish because the resonance frequency for a 1 m long cod is about 600 Hz (Hawkins 1977; Løvik and Hovem 1979), while most of the energy spectrum of the air gun is below 150 Hz. At frequencies above 600 Hz, the energy is significantly lower, and there is little reason to believe that resonance phenomena can cause the differences in behaviour we observed between large and small fish.

Acknowledgements

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peak source level for a large air-gun array is 250–255 dB re 1 μPa (Greene 1985), which corresponds to 210 dB re 1 $\mu Pa \cdot Hz^{-1}$ at the spectral level. The source level of the array is specified in its most powerful direction, i.e., downwards at its acoustic axis, and less energy, about 200 dB re 1 $\mu Pa \cdot Hz^{-1}$, is transmitted in the horizontal direction. Assuming a reaction threshold of 110–120 dB re 1 $\mu Pa \cdot Hz^{-1}$, the expected distance at which fish may react to this sound would be 3–10 km. The distance at which fish are capable of detecting the seismic sound, however, is about 10 times greater, i.e., 30–100 km. These rough estimates of detection and reaction distances are based on available literature on hearing in fish, together with a simple sound propagation model.

There is little documentation on how seismic shooting affects fish behaviour and catch rates. Acoustic mapping and catch trials in the North Sea indicated that fish distribution changed under the influence of seismic shooting (Dalen and Raknes 1985). Trials off the coast of California showed that hook and line catch rates for various redfish species were reduced by 50% under the influence of a single air gun (Pearson et al. 1992; Skalski et al. 1992). Analyses of catch data from longliners and trawlers before, during, and after seismic shooting in Norwegian waters showed that longline and trawl catches of cod were reduced by 55–85% during seismic shooting (Løkkeborg and Soldal 1993). However, these studies were not designed to investigate the spatial and temporal extent of the effects of seismic explorations. A controlled, full-scale experiment was therefore carried out to answer the following questions: (*i*) Does seismic shooting affect local abundance and catch rates of cod and haddock (*Melanogrammus aeglefinus*)? (*ii*) How far from the seismic shooting area can effects be demonstrated? (*iii*) For how long after seismic shooting can effects be demonstrated?

To investigate these effects, fishing trials with trawl and longline as well as acoustic mapping of fish abundance and distribution were carried out before, during, and after seismic shooting. Longlines and trawls were chosen because they are two of the most important types of gear used in the Norwegian fisheries for cod and haddock, and because of the contrast in their capture mechanisms.

Materials and methods

Study area, period, and seismic shooting

The fishing experiment and acoustic mapping were conducted from 1 to 17 May 1992, on the North Cape Bank (water depth 250–280 m) in the Barents Sea (Fig. 1). On the basis of the expected sound level from the air-gun array, absorption of sound in water, and our knowledge of fish hearing and reaction thresholds, we decided to perform fishing and acoustic mapping about 18 nautical miles (1 nautical mile (nmi) = 1.852 km) to each side of the shooting area of 3 × 10 nmi. The study area was thus about 40 × 40 nmi, with the shooting area in the centre. The trial was divided into three periods: before (7 days), during (5 days), and after (5 days) shooting.

Seismic shooting was conducted from 8 May 1992 at 00:09 (GMT) until 12 May at 17:58 (GMT) from a chartered seismic vessel. The air guns were towed at a depth of 6 m. Rigging of the air-gun array (3 × 6 guns, 13 784 kPa (2000 psi), total volume 82 132 cm^3) and practical execution of the shooting assignment were performed according to normal procedures used in ordinary three-dimensional surveys for the oil industry, i.e., a shot was fired every 10 s, or every 25 m. A total of 36 seismic transects were shot, each 10 nmi long, with a distance of 125 m between adjacent transects.

Acoustic mapping

Acoustic mapping of the fish distribution was carried out with a trawler equipped with a hull-mounted 38-kHz split-beam transducer (ES38–29) and a Simrad EK500, connected to the Bergen Echo Integrator System (Knudsen 1990; Foote et al. 1991). The instruments were calibrated in accordance with standard practices (Foote et al. 1987; Nes 1991).

To obtain higher coverage in the shooting area, this area was crossed systematically to a radius of 20 nmi from the centre, with the central crossing point varied from transect to transect. In addition, the shooting area was mapped more densely by means of shorter north–south transects before and during shooting (Fig. 2A). For the data analysis, the study area was divided into five parts: the shooting area and four circular belts of 5 nmi width, with the midpoint of the shooting area as the centre. The measured acoustic quantity was the area backscattering coefficient, s_A:

$$(1)\qquad s_A = 4\pi(1852^2)\int_{z_1}^{z_2} s_v \, dz$$

which is the depth-integrated volume backscattering coefficient, s_v (Urick 1975), normalized to the absolute unit ($m^2 \cdot nmi^{-2}$). The average area backscattering coefficient was computed for the pelagic region (from 10 m above the bottom to the surface) and for the bottom region (from the bottom to 10 m) and totals were calculated for all areas and for each time period (before, during, and after seismic shooting), subsequently referred to as acoustic density.

To identify species and length compositions of the acoustically recorded fish, trawling was carried out at random positions with the standard bottom sampling trawl (cod-end mesh size of 40 mm) (Engås and Godø 1989). Altogether, 94 hauls were conducted (Fig. 2A). Each trawl haul lasted for 30 min at a speed of 1.5 $m \cdot s^{-1}$. The measured door spread was 54 m, and the average head-line height was 3.8 m.

On the basis of the trawl catches and echograms, the acoustic registration was interpreted in accordance with the standard methods used by the Institute of Marine Research (Dalen and Nakken 1983) and split between cod–haddock and other species. The acoustic measures of area density for cod and haddock were further converted to number and mass in 5-cm groups, by computing the average target strength from the trawl catches.

Geostatistic was used to compute the variance ($\sigma_E 2$) of the acoustic abundance estimates (Petitgas and Poulard 1989; Simmonds et al. 1991; Petitgas 1993). This was expressed through the standard deviation, σ_E, normalized to the average value, $\bar{z}$:

$$(2)\qquad s_{geo} = \frac{\sigma_E}{\bar{z}}$$

Fishing trials

The stern trawler used a typical bottom fishing trawl (Alfredo No. 3), with cod-end mesh sizes of 139 and 140 mm (twin bags). Each haul lasted for 30 min at a towing speed of 1.8 $m \cdot s^{-1}$. The door spread was measured at about 150 m, and the vertical opening of the trawl was 4.2 m. The total number of hauls was 60, 65, and 60 for the periods before, during, and after seismic shooting, respectively (Fig. 2B). The trawl hauls were made at four distances from the seismic shooting area: within the shooting area, and 1–3, 7–9, and 16–18 nmi from the shooting area. The directions of the hauls were varied randomly every day, and trawling was conducted day and night.

The longliner was equipped with an autoline system and Mustad Quick Snap line (7 mm) rigged with Mustad EZ-hooks (quality 39975, No. 12/0). Each longline fleet (one fleet = 15 connected longlines) consisted of about 3000 hooks and the hook spacing was

Changes to fishing practices around the UK as a result of the development of offshore windfarms – Phase I (Revised)

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Marine Research Report

Appendix III – STATEMENTS OF INDIVIDUAL FISHERMEN IN BEHALF OF THEMSELVES AND THE ASSOCIATIONS

The following emails were prepared by individual fishermen with extensive knowledge, experience and expertise in the Morro Bay Lease Areas and intervening coastal, tidelands, and submerged lands areas within State jurisdiction.

The collective experience and knowledge of the two Associations and their memberships concerning commercial fishing in the areas affected by the commercial wind developments exceeds any comparable knowledge base of the regulatory and trustee agencies, and most other experts because of the depth, spatial extent, duration and continuous presence required of commercial fishermen over the course of their individual and collective careers.

Impacts to Commercial Fishing

From Site Survey Activity

My name is Alan Alward. I am a commercial fisherman whose main fishery is albacore which I fish off the three west coast states of Washington, Oregon and California during the summer months into October. During the rest of the year I fish ground fish from my home port of Morro Bay, CA. I have missed the last few years of ground fishing because of important boat improvement projects during the off season and because of market difficulties in Morro Bay. I have a bachelor's degree in Civil Engineering from Cal Poly, SLO. My primary income has been from commercial fishing for most of my life.

I am deeply concerned by the impacts from Offshore Wind development to commercial fisheries and all other aspects of the environment in our nation's coastal waters. I can see that the Federal and State governments are aggressively moving forward with a program of Offshore Wind development with only a cursory appreciation for the impacts their actions will have on the waters off our coasts, and especially on the commercial fishing industry. It may be that I will be retired from commercial fishing before the first floating offshore turbine begins turning off the coast of California. However, I am confident that if I attempt to fish the winter fisheries available to me out of my home port of Morro Bay I am likely to have significant impacts from the Site Survey Activity which is anticipated to begin in the coming year.

Most disturbing to me is the fact that this Site Survey Activity is going to go forward with very little understanding of the impacts it will have on our fisheries. The Federal agency responsible for and driving OSW development, The Bureau of Ocean Energy Management, or BOEM, has stated in its Environmental Assessment that the impacts on fisheries from Site Survey will be 'minimal'. This is only a hypothesis because it has never been studied. The collective experience of fishermen is that this is not true. Based on past experience we are convinced that there will be significant reductions to our catch over prolonged periods of time over large areas during and possibly after Site Survey. On one hand we have government telling us impacts will be minimal, without ever having studied the issue, and on the other hand we have a small, relatively defenseless minority asserting they expect SIGNIFICANT impacts.

Clearly, if justice is to be served, now is the time to clear up this issue with a comprehensive study of the impacts of Site Survey on commercially fished stocks. This will be the first major Site Survey for a floating offshore wind project off the West Coast. California has strict law protecting its fishing industry. We intend to see that these protections do, in fact protect us. Therefore, now is the time to begin documenting the impacts on fisheries from OSW related

Site Survey activity. It seems to us that BOEM is more interested in marketing Offshore Wind to the public then really examining the complaints of stakeholders. It appears that BOEM is all set to move forward with Site Survey while deferring a study of the impacts and deferring mitigation for those impacts until after the damage is done. A blank dismissal of our concerns is not going to cut it!

A comprehensive study would be one that determines changes in catch rates before, during and after sonic testing in such a way that the effects can be sampled inside the lease areas and transmission cable routes and outside to distances where the effects become negligible. Control sampling at a site far removed would help to inform the study as well as visual submarine investigation to check the bottom for mass kills of fish and larvae. This has never been done and it needs to be done. To achieve this goal Site Survey will have to be postponed until a satisfactory research plan is prepared and 'before' and initial 'control' studies are completed.

If this path is not followed BOEM will not have followed through on its supposed mission of truly listening to stakeholder claims. It will further be concluded that BOEM is not interested in finding out if it is impacting commercial fish stocks. Climate change concerns or lack of 'policy' do not entitle BOEM to sidestep the issue. In lieu of satisfactory mitigation of a subjective nature such as that prescribed in the existing MBCFO/Castle Wind mitigation agreement for events leading up to and including Site Survey, Site Survey will have to be postponed until the Coastal Commission's 7.C working group can come up with a satisfactory mitigation plan. If both BOEM and the State are unwilling to recognize the existing authentic subjective mitigation plan, then the science will have to be done to quantitatively determine impacts. To go forward without studying the problem or identifying mitigation satisfactory to the local fishing industry would be intentional neglect.

TO: BOEM c/o douglas.boren@boem.gov; jennifer.miller@boem.gov

California Coastal Commission c/o kate.Huckelbridge@coastal.ca.gov; holly.wyer@coastal.ca.gov

California State Lands Commission c/o Jennifer.Mattox@slc.ca.gov and Jennifer.Lucchesi@slc.ca.gov.

Cc: Haas, Greg greg.haas@mail.house.gov

Nov. 8,2023

Re: BOEM Final Environmental Assessment for the Morro Bay Wind Energy Area, California

I fished commercially out of Port San Luis and then Morro Bay for over 45 years. I retired in 2021. I started fishing in 1974 after graduating from Cal Poly San Luis Obispo with a degree in chemistry. While attending Cal Poly, I spent many hours sport diving in the ocean from Santa Barbara to Fort Bragg, CA for fish, abalone, scallops, and clams. Competing in spear fishing contests, before our events, I spent many hours scouting and observing fish behavior. I have a good practical knowledge on fish behavior and their actions when disturbed or threatened. I have listed a few of my concerns below.

In reading BOEM's EA, the first thing that caught my attention was the use of "most likely" in describing what actions/work the leasees would "most likely" conduct. Then farther on in the document is the "assumptions" or also known as best guesses. The commercial fisheries of the United States are highly regulated by the National Marine Fishery Service and are based on the precautionary principle. If there's any doubt or not supported by concrete science, then a precautionary approach is taken. Why would this be any different since the NMFS has to sign off on this activity?

The EA also mentions the vessel traffic in the WEA and what AIS data shows. AIS isn't used by the majority of fishing vessels, both commercial and recreational, and therefore this data is flawed. And the data used came from 2019 or earlier which is 4 years or more old.

The use of High Resolution Geographic surveys will definitely have a negative effect on the fish and marine mammals in the area. For leases issued in early 2023, site assessment activities could continue through early 2028. Though they are not expected to take this long, they could and/or sporadically over 5 years. The EA keeps stating that there will be no risk from these activities, based on their spreadsheet and geometric spreading models. But they will/can be using 228db, which is very high. Fishermen have seen computer modeling and it's at best a poor predictor in the real marine world. Fishermen have seen their catches drop off whenever HRG surveying has been done. Do we really know how much damage that is done to the fisheries by these surveys?

Also in the EA is the statement: "With the requirements for qualified Protected Species Observers (PSOs) to monitor a 1,000 m (3,280 ft) monitoring zone, for vessels to maintain 500 m (1,640 ft) from marine mammals, as well as the shutdown requirements when ESA-listed marine mammal species are sighted within 500 m, BOEM believes that the risk of PTS occurring in any protected marine mammal species from HRG surveys is discountable." So, with the survey vessels operating on a cost/day, will they shut down during heavy fog, at night, or when it's blowing, and the seas are such that visibility to spot animals is difficult to impossible? I see no such mention in the EA, only when they see a certain animal are they required to take action.

The EA claims that the data collection buoys will only have a minor impact to fishermen and only be in the water for approximately one year. Most fishermen fishing in the area use either traps or longlines. And because of the depth, the gear takes time to reach the bottom. Depending on the current and wind, fishermen need plenty of searoom to not only set, but to retrieve their gear, and that maybe miles from the collection buoys. If these buoys are set on or near a hot fishing area, it could impose serious financial hardship on the fisherman. The EA claims that the area the collection buoys is comparatively small in size when compared to the full extent of available fishing grounds. What an uneducated statement. Obviously, they think you can catch fish just anywhere! That is called a theory in the scientific community and can easily be proven wrong.

It is obvious that the EA contains many errors and false assumptions, and I request that BOEM do a full rewrite of the EA to correct the errors.

Respectfully,
Wayne Moody
10990 Bobcat Lane
Arroyo Grande, CA 93420

Regarding: BOEM Oct. 2022 Commercial Wind Lease and Grant Issuance and Site Characterization Activities of the Morro Bay lease area.

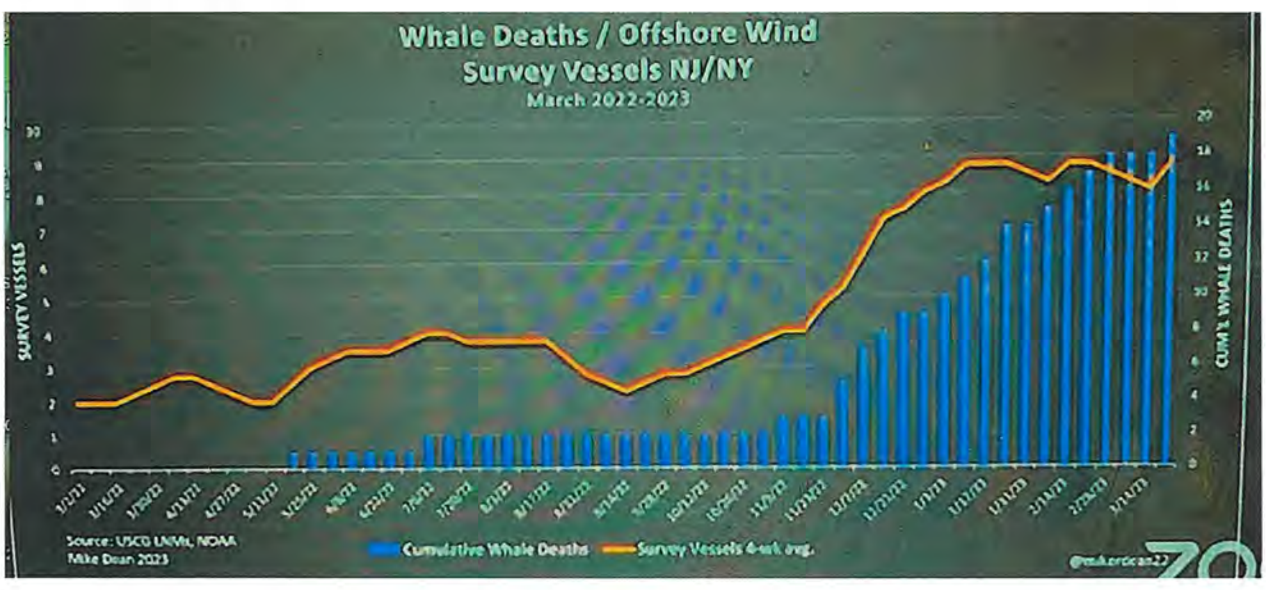
To whom it concerns,

I have been fishing for over 50 years along the Pacific Coast. I chased albacore from Baja to Canada out of San Diego for 12 years then trapped lobster out of San Diego another 8 years before moving to the Central Coast of California. I have mainly been trapping spot prawns and nearshore live fish but have also fished Deepwater groundfish (black cod) for the last 30 years out of Morro Bay up to Big Sur.

The central coast has a history of oil rig and fiber optic cable installation. Both required geological surveys that impacted fishing. I wasn't personally involved with the oil rig installation but was told it caused the rockfish landings to go down for over 5 years! I was fishing near the cable installation. It impacted the nearshore fish landings for at least 1 year. The surveying and the installation took about 6 months, and our catch was less at least another 6 months however some species seem to take longer to recover.

The biggest personal impact from geological studies I have had is from USGS EXPRESS https://www.usgs.gov/centers/pcmsc/science/express-expanding-pacific-research-and-exploration-submerged-systems. They have been doing high resolution geographic (HRG) studies off the central coast from Big Sur to Morro Bay in 2017, 2018, 2019, and 2020 with most of it in 2018 and 2019. As a result, there has been a dramatic reduction in spot prawns' landings. I did a custom search from the CDFW landings records and found that from 2014 - 2017 there were 77,141 lbs. of spot prawns landing in Morro Bay. From 2018 to 2021 there were 28,688 lbs. A 63% decline during the period of the EXPRESS surveys. I know that you will want to blame it on everything else but HRG surveys, but it is coincidental enough to suspect they were part of the cause. Especially, since they have stopped testing, the spot prawns' landings have finally gone back up.

What has happened on the East Coast is suspicious as well. 73+ whales have died (that we know about) at the same time they began doing HRG surveys. And if whales are dying, fish are dying.



The most recent studies BOEM sites regarding HRG survey impacts were done in 2017. The studies sited mainly focus on impacts to mammals and turtles and not fish. There are newer studies done in 2018 regarding the impacts of HRG surveys to fish. "An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes" by Arthur N. Popper/ Anthony D. Hawkins. The data shows "mortality and potential mortal injury" to fish with > 207 -219 dB. We have been told by the Coastal Commission that the wind developers will be using up to 228 dBs.

So, based on the above evidence, BOEM's conclusion regarding impacts to commercial fishing from site surveys as being "minor and temporary" and mainly from "spatial conflicts" are false. There will be changes in fish behavior, mortality, migration patterns, mating, and feeding patterns from the HRG surveys in the lease area and along the cable routes. This activity will lower our catches. Impacts to commercial fishermen are legally protected by city, county, state, and federal laws. **There must be mitigation in place to mitigate the loss of fishing opportunity before the site surveys begin! BOEM must open another review of the EA and change their conclusion to protect the rights of commercial fishermen that rely on sustainable fishing near the wind energy lease area and cable routes to support themselves, their families, and their community.**

Tom Hafer
President Morro Bay Commercial Fishermen's Organization

To whom it concerns,

The following actual statements (in black) contained in BOEM's EA for Site Surveys for the Morro Bay Lease Area for Offshore Wind completed Oct. 22 are incorrect and contain significant errors (in red).

HRG Survey Impacts

Geophysical survey equipment that will be used for site characterization of renewable energy leases emits lower energy levels than the airgun surveys used in the past to define petroleum reserves, which required deep penetration of acoustic signals into the seabed. For site characterization, there is either no acoustic penetration into the seabed (e.g., side-scan sonar) or shallow penetration (e.g, sparkers, boomers). There is no evidence that tissue trauma occurs to fishes or invertebrates from the energy levels emitted from foreseeable geophysical survey methods described in this EA.

Describing the survey as "low energy" is incorrect. True the High Resolution Geographic (HRG) survey will be using lower decibels than with oil exploration but will still be using considerably high energy decibels of 228dB. This is high enough to impact fish behavior and mortality. The review paper "An Overview of Fish Bioacoustics and the impacts of anthropogenic sounds on Fishes" by A. Popper/ A. Hawkins, 2018, has a table of impacts on fish from anthropogenic sounds. It shows fish behavior changes

Type of Animal	Mortality and potential mortal injury	Impairment			Behaviour
		Recoverable injury	TTS	Masking	
Fish: no swim bladder (particle motion detection)	> 219 dB SEL_{cum} or > 213 dB peak	> 216 dB SEL_{cum} or > 213 dB peak	>>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	> 186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	186 dB SEL_{cum}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Sea turtles	210 dB SEL_{cum} or > 207 dB peak	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) Moderate (F) Low
Eggs and larvae	> 210 dB SEL_{cum} or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak and rms sound pressure levels dB re 1 μPa; SEL dB re 1 $\mu Pa^2 s^{-1}$.

and impacts from masking at 186 dBs and mortality at 207-219 dBs for some species.

The HRG surveys will need to penetrate at least 10-20' into hard bottom to test for installing substations, burying multiple cables and placing giant anchors. This is not as deep as oil wells but not shallow either.

Compared to marine mammals, fish and invertebrate species use different sensory systems and primarily perceive particle motion rather than sound pressure levels.

Behavioral response to anthropogenic noise is expected to be less for fish and invertebrate species than for marine mammals. Recent evidence suggests that noise generated by fishing activity (e.g., seal bombs, bottom trawling, echo-sounders, vessel noise, etc.) may have a greater acoustic impact to the environment than the expected noise levels generated by site characterization activities described in this EA (Daly and White 2021; Wiggins et al. 2020). BOEM anticipates further investigation to all these anthropogenic noise sources in preparation for future environmental review of a COP.

It is not true that all species perceive only particle motion rather than sound pressure noise. According to "An Overview of Fish Bioacoustics and the impacts of anthropogenic sounds on Fishes", there are some species of fish that don't have a fish bladder like flat fish that are less sensitive to sound pressure and use mainly particle motion to hear but ALL OTHER SPECIES WITH SWIM BLADDERS such as rock fish, salmon, bait fish are highly sensitive to sound pressure and will hear the HRG sound. Bait fish (sardine, anchovies) are the most sensitive since their swim bladders are incorporated in their hearing. The behavior of bait fish have significant impacts on many of the fisheries.

It is ridiculous to state that seal bombs, echo-sounders, and vessel noise create more noise than the anticipate Site Survey HRG surveys which will be using up to 228dBs over 2000 hours over 400 square miles of Wind Energy Area and over 400 miles of cable route for 3-5 years. Sound travels several miles in the ocean. The cumulative impact will most certainly have an impact on several of our important fisheries including groundfish, salmon, spot prawns, hagfish, rockfish, crab, albacore, swordfish, squid, and others.

The last sentence admits that more investigation needs to be done of the impacts of anthropogenic noise but only for the Construction Operation Plan which occurs after the Site Survey. This means BOEM has no intention of investigating impacts to our fisheries from the Site Survey anthropogenic noise. They also have no intentions of requiring a monitoring system to ensure there are no impacts.

Conclusion of Impacts on Commercial Fishing

The impact analysis for ascertaining space-use conflicts with commercial fishing considered marine shipping, marine protected areas, and the IPFs associated with the Proposed Action. Potential impacts to commercial fishing from the Proposed Action are expected to be minor and temporary in duration (5 years or less, meaning that although lessees have 5 years to complete their surveys, the surveys themselves will not take 5 years), and primarily associated with a spatial incompatibility around the data collection buoy(s) and interactions with project vessels, which is comparatively small in size when compared to the full extent of available fishing grounds. BOEM recommends lessees to incorporate Best Management Practices that will aim to minimize adverse effects to commercial fishing from their site assessment and site characterization activities.

BOEM is incorrect concluding that the only impacts from HRG surveys for 3-5 years are minor and temporary spatial conflicts. They deny any changes in our fishing opportunities, changes in fish behavior or mortality, and/or trickle down socioeconomic impacts on the entire fishing community from the Site Surveys. The Central Coast has had experience with the installation of fiber-optic cables. The fish were off the bite for years afterwards and that survey covered a much smaller area.

They also only discuss impacts to the Lease Area but do not address the substations or cable routes. There will be at least 3 large substations and 10-15 cables, each 30 miles long to shore several feet apart. This area will need to be surveyed as well and contains many important fisheries. It should be included in their review.

Based on the above inaccuracies, we request that BOEM reopen the Environmental Assessment of the Site Survey of the Morro Bay lease area for offshore wind and more accurately describe the impacts of HRG surveys on our fisheries.

Tom and Sheri Hafer
Owner/Operator f/v Kathryn H
President Morro Bay Commercial Fishermen's Organization

"To Whom it Concerns, Regarding the Morro Bay Lease Area"

My name is Jeff Dyerly and I am a commercial fisherman with both South Central Nearshore and Deeper Nearshore Limited Entry permits. I have been fishing in this area for 15 years and commercially since 2019. I have previously been a high school science teacher with advanced degrees in both liberal studies and education. I would like to address some Major Concerns I have with the way in which fishermen are not being recognized as a major stakeholder in the Wind Projects being considered in our area. As a person who is makes his living from the ocean resources of our area, I believe that our concerns should be taken into consideration BEFORE any work begins, including SITE SURVEYS!

It has been my experience that there are many different human activities that can disrupt fishing. Here are a few recent examples. Just a few weeks ago, a project to repair the jetty at Port San Luis was completed that involved placing tons and tons of huge boulders on top of the existing jetty that protects the harbor. This project used several large barges, a huge crane and several tug boats to meticulously place additional boulders along the jetty. Before the project began last spring, I was routinely be able to catch 75-100 lbs of rockfish a day within a few miles from the port. While this project was in progress, I couldn't even fish locally because I could not catch enough to even pay for fuel and bait. With the weather always dictating when and where I can fish, having access to an abundance of local fish to catch is extremely important so that I can make money in a more consistent manner to support my family. If the Wind project were to become a reality, the traffic from large vessels, similar to the large crane and barge from this recent jetty project, into and out of Port San Luis would increase to a point that it would make fishing locally on bad weather days a futile option for me. The net result would be a severe reduction in income.

Another example of a human caused activity that has already severely reduced my ability to catch sufficient quantities of fish is the expanded launch schedule at Vandenberg Space Force base. With the building out of the Starlink satellite network and the increase usage of other various satellite technologies, the amount of rocket launches and exploded! One source has stated that they expect the launches to increase to 3 a week! Every time a launch occurs, the ground fish that I target do not seem to feed again for several days. With this kind of intense activity, it is only a matter of time until that section of reef will be devoid of life. Fish won't stay in the area if the conditions they need to survive are lacking.

To highlight the drastic change, back when very few launches occurred, the shallow water rockfish fishery off of Vandenberg was exceptional. I have had many days in the past where the total landing of fish was in excess of 500 lbs! However, since the increase of launches, most days are averaging less than 150-200 lbs with some of the trips down there have been downright dismal. The one common denominator on these bad days are the length of time since the last launch. It seems to take about three days for the fish to fully recover and feed again. On one of those bad days recently, I only caught 16 lbs of fish! When my boat burn 50 gallons of fuel to travel down there and back, that was not even enough to pay for bait, let alone the fuel.

Yet another example of human construction and activity that has affected my ability to catch fish occurred several years ago when utility company laid down cables from Pismo Beach to Morro Bay. At first I didn't think that it would affect the rockfish that I target, since the work was to occur over sandy areas of the ocean floor. However, within a day of the start of the project, the rockfish bite completely shut off. I couldn't catch a fish within ten miles to save my soul. Now I am more familiar with the sonar technology that they use to located the cables and how they not only can affect fish behavior but also literally kill them if the exposure is great enough. In that instance, the work lasted for months and it took many more for the fishing to recover in that area.

Each time one of these human caused actives affects an area that I fish, I have to go looking for someplace to make my catch. I will be honest. Its getting to the point where I don't have any more viable options to travel to. The market sector that I sell my fish in requires me to keep my fish alive. For rockfish, this means that I have to fish at depths less than 120' in order to prevent barotrauma from killing the fish I catch. In addition, I can only catch rockfish in areas where there is rock. These two factors severely limit the amount of ocean where I can fish. At present there are three main areas left to fish out of Port San Luis. Purisma, (off Vandenberg), Point Sal/Mussel point and the reef in front of Port San Luis. If the Wind Project were to come to fruition, Purisma and Port San Luis would be ruined and if all the fishing pressure were directed to Pt. Sal, it wouldn't take long to overfish that area.

I beg and plead with you to consider not continuing moving forward with the Wind Project. Everything that I have researched has indicated that there is little energy to gain from such a large loss to our precious ocean resources that I depend on to provide for me and my family.

Respectfully,

Jeff Dyerly

F/V Grizzly Bear

williamswalterpc@gmail.com

rom:	mbcfo member <mbcfo1972@gmail.com>
Sent:	Thursday, October 26, 2023 8:18 AM
To:	Bill Walter
Subject:	Letter from fisherman re: site survey concerns - Wayne Moody

Begin forwarded message:

From: Wayne Moody <fvcapriccio@yahoo.com>
Subject: Offshore Wind
Date: October 25, 2023 at 10:33:05 AM PDT
To: "mbcfo1972@gmail.com" <mbcfo1972@gmail.com>
Reply-To: Wayne Moody <fvcapriccio@yahoo.com>

Oct. 25, 2023

To whom it concerns regarding the Morro Bay Lease Area

We have been involved in the commercial fishing industry for over 45 years and just sold our boat and retired 2 years ago. We are deeply concerned with the development of the offshore wind farms in the Pacific Ocean and especially here off Morro Bay. Even though we're retired and won't directly experience the financial impact from the offshore wind development, we know it will have devastating impacts on the fishing industry, not to mention among other areas.

The 3 offshore wind companies are gearing up to start their site survey work in the Morro Bay call area. They will be submitting plans to the California state and federal agencies for the necessary permits to do this work. I want to encourage the agencies to carefully review the plans AND TO DENY issuing any permit until they have signed an agreement with the Morro Bay Lease Areas Mutual Benefits Corporation (MBLA MBC). The MBLA MBC has been developed and approved by the fishermen from the Morro Bay Commercial Fishermen's Organization and the Port San Luis Commercial Fishermen's Association after years of meetings with one of the unsuccessful wind company bidders. It was considered a fair and equitable agreement by both parties, fishermen and a prospective wind developer, to the damage that the industrialization of the ocean that the offshore wind development will cause.

Fishermen knew that the government was "hell bent" on developing offshore wind, no matter the damage, and fishermen weren't going to be able to easily stop it. The government was/has throwing out the precautionary principle and it was full speed ahead. (Remember the bullet train!) That is why the MBLA MBC was formed! And now, after the "latest train" is on the way, California has come up with a 7c working group that will supposedly provide "guidelines" to address the damage to the fishing industry. The working group is not required to have this done until 2026. Will the permits be held up until the 7c working group's recommendations are decided? I doubt it. Will those recommendations be included in the permits? We don't even know what, if anything substantial, will come out of the working group and how it will be administered. The wind companies do have seats on the group and what will they agree on. Will the compensation be like the Diablo Canyon compensation for fish larva kill and not even come close to benefitting the marine environment or industry?

As soon as the offshore wind companies get their site survey permits and start work, the fishing industry will start having problems. The geophysical surveys will cause fish to alter their behavior and some/many will possibly be killed. Fish and marine mammals are very sensitive to the high energy used and this will alter their behavior. How much and to what extent is the big question? We can't take the attitude that we'll wait and see the damage AFTER the work is done. It is a fact the fishermen have see their catches decrease during this type of testing. It will probably even drive some out of the industry. Saying that's

O.K. is a dam poor attitude. That is why the wind developers have to sign onto the MBLA MBC BEFORE site surveys begin, and not wait until after 2026.

Wayne & Diane Moody
10990 Bobcat Lane
Arroyo Grande, CA 93420

/om:	mbcfo member <mbcfo1972@gmail.com>
Sent:	Thursday, October 26, 2023 8:17 AM
To:	Bill Walter
Subject:	Letter from fisherman re: Site Survey concerns - Owen Hackleman

Begin forwarded message

From: Owen Hackleman <ohackleman@gmail.com>
Subject: Coastal Comission and staff
Date: October 25, 2023 at 11:09:47 AM PDT
To: Tom Hafer <somethingsfishy@charter.net>

Dear Coastal Commision and staff,
I am writing to voice my concern about the impacts on fishing from upcoming site surveys for Morro Bay OSW leases. I have been supporting my family and 2-3 crew as a commercial fisherman out of Morro Bay for fourteen years. We fish for sablefish and other groundfish within the lease areas year round. We are concerned about loss of income from being displaced from our fishing grounds for a long period of time due to the site survey vessel traffic and eventually displaced indefinitely due to construction and long term operation of the wind farms. We also are very concerned about the effects of the seismic surveys which, based on previous experiences of our local fishermen, have devastating effects on catch per unit effort. It appears that the effects on fishing from the types of acoustic equipment that will be used have not been adequately studied. There is potential that seismic surveys could cause migratory fish like sablefish to leave the area, change their feeding patterns or even injure fish and fish larvae in close proximity to the testing. My family and crew cannot financially survive long term periods of poor fishing or being displaced from our fishing grounds by traffic from site survey activities. We have had repeated meetings with the wind companies, and they overwhelmingly refuse to acknowledge potential impacts on fishermen due to the site surveys. They have been condescending and dismissive of our concerns and have implied that there cannot be impacts unless they acknowledge them.

I ask that the Commission require potential impacts to the fishing community from the site survey activities be mitigated before the site survey begins. If this is not done, my business and others face a real possibility of going under before OSW construction even begins. Of course, this may be what the wind companies are hoping for.

Thank you for your consideration,
Owen Hackleman
F/V Provision

To whom it concerns regarding the Morro Bay Lease Area:

I am an active commercial nearshore and deeper nearshore 'live-fish' fisherman out of Morro Bay writing to you because I have numerous concerns about the negative effects that wind farms off the California coastline will have on my livelihood.

Since I graduated with a degree in oceanography from UC Santa Barbara in 2010, I have been commercial fishing in multiple fisheries and hold permits to fish sea urchins, sea cucumbers, groundfish, nearshore rockfish, and deeper nearshore rockfish. Since I bought into the latter fishery in 2018, I have landed tens of thousands of nearshore fish out of Morro Bay. As someone with a background in science and a desire to keep the fisheries I love sustainable, I have also taken on collaborative research roles in these fisheries as past chairman of the California Sea Urchin Commission (CSUC), founder and president of the California Sea Cucumber Divers' Association (CSCDA), and active member of the Morro Bay Commercial Fisherman's Organization (MBCFO). In these roles, I have worked collaboratively with CA DFW scientists and regulators to help keep these fisheries healthy and sustainable.

I mention these facts because I want you to know I am not a staunchly 'anti-development' type of person or fisherman. I believe in progress, science, and collaboration. I am not unequivocally against the creation of oceanic wind farms / sustainable energy. But I am very much against a process in which these wind companies can make unprecedented changes to the ocean waters from which I earn a living, and expect commercial fishermen like myself to 'just deal with it' and cope with the new reality of turbines on the ocean. I am thinking about my fisheries, my future, my family, including my 2 year old son – and I am deeply worried about the environmental ramifications these wind farms will have on fisheries. I've invested everything I have into fishing. I have spent the past decade building a successful fishing business—a career that I hope to stick with for the rest of my life, and then ultimately pass on to my children. These wind farms threaten that.

I would like to touch on just a few examples of why I believe oceanic wind farms will damage commercial fishing on the California coast. Not only do the wind farms take potential fishing area away from fishermen, but they also bring potentially damaging unknowns that are difficult to quantify. No one knows what kind of effects these wind farms will have on fish in the long term. We KNOW that acoustic surveys will negatively impact fish stocks and fishing in the short-term, but how will they effect upwelling and larval recruitment? Will the wind and waves that are displaced by the wind farms alter the settlement patterns and distribution of fish larvae? It seems highly likely that our nearshore fish stocks (near the WEA, yet close to the coast) will be adversely effected by this large-scale change in ocean dynamics. Put simply, fishermen stand to lose big time.

Here's another example. I own a 'west coast ground fish permit' - a limited entry permit which is good for fishing off the coastlines of CA, OR, and WA - a regulator might think that a wind farm in Central or Northern CA won't have an effect on a fisherman in Southern California, or vice versa. This is not the case. We are dealing with coast-wide stocks that don't spend their entire life cycle in one specific locale. By introducing wind farms, you have the potential to alter complex patterns of larval settlement and distribution over a very wide range. If the recruitment of fish is negatively affected in one area, that could negatively affect the fishing over a much larger area.

Additionally, when fishing area is taken away, you displace fishermen. The fishermen that were displaced now have to fish elsewhere. When they do, it creates more competition wherever they move to. Predicting how fishermen will respond and where they will shift effort to is a guessing game. A deep-water ground fish fisherman that gets displaced by a wind farm may instead shift his/her focus to target nearshore rockfish. Well, now you created more competition amongst the fishermen targeting nearshore rockfish. Here is another example: you fish in Central CA, then the Morro Bay wind farm comes. So you move your whole operation to San Diego, or Port Orford, or wherever. That upsets a delicate balance as you have shifted effort to a new port. This displacement of effort still effects your fishery even if there are no wind farms close to your port and perhaps never will be. Regulators say you won't be effected. Wrong.

You might not even fish your permit yourself, but you lease it out to other fishermen, much like a landlord rents to tenants. When wind farms get created, guess what, even if the closed area is not near you, the value of your permit is less because the fishing grounds have shrunk and the amount someone is willing to pay to lease that permit decreases. It's simple. Less area to fish, less potential money to make in the fishery = less price paid for the harvest rights. This last example hits particularly close to home for me since in 2022 I purchased a west coast groundfish permit to build and diversify my business. The total cost represents a large portion of the savings I have worked for years to grow. Because this federal permit is leasable, I planned to lease my permit to another fisherman while I am in the process of building a larger boat to fish it myself in a few years. (The boat I use for my other fisheries is too small and does not have the equipment necessary for this fishery) In this way, I considered it a good investment since by buying the permit prior to being actually ready to use it, I would be able to recoup some of the cost through the lease of it. My leasee also benefits by not having to outlay such a large sum of money to get started in the fishery. Win-win I thought. However, the loss of fishing grounds caused by OSW will almost certainly decrease the total and lease-able value of my groundfish permit as well as negatively affect my future catch when I do begin fishing it myself. And what is worse, even if a financial agreement is struck to mitigate fishing losses, since I will have had no landings in this fishery yet, I stand to lose out on this money if it is allocated only to those with prior landings. Because of this, I believe compensation should not be based on landings alone.

To summarize, the proposals I have heard about for mitigation to commercial fishermen thus far in this process are sorely lacking, do not take into account the many different ways in which wind farms will damage commercial fishing, and it feels like us commercial fishermen are being shoved to the side and dismissed from this process. Fishermen should and need to be compensated for the loss of ocean space. And not just the fishermen with catch history in a certain area, but any fishermen holding a permit or having landings in any commercial fishery that could conceivably be impacted by wind farms off our coast. Furthermore, fishermen should be compensated not only once upfront, prior to development, but also ongoing.

Between the limited entry permits, fishing boats, and fishing equipment I have purchased in the past decade, I have invested over $300,000 dollars into my fishing business that will experience severe negative consequences due to the building of OSW. Such wind farms will forever limit the ability of commercial fishing businesses like mine to grow and expand. Therefore, I believe that each year or every several years, for as long as these wind farms are in existence, the wind farms should have to confer with NOAA, etc. and compensate fishermen with a stake in the business based off the best available science as the effects of these wind farms are better studied and understood over time. There is precedence for this. The offshore oil companies and undersea cable entities have similar programs in place. I don't think it is much to ask when you think of the size and scale of these farms and the amount of money they will generate in power. The mitigation process should also be agreed upon and in place BEFORE any work (including survey work) is started by the wind companies. This would foster a relationship of mutual respect rather than resentment between wind companies and commercial fishermen. The government should create an established procedure for the compensation of commercial fishermen (in advance), instead of leaving it open-ended so that fishermen have to spend time and money fighting each wind company separately for mitigation. And to be clear, I am not against the creation of wind farms, but I am against them if COMMERCIAL FISHERMEN ARE NOT TREATED FAIRLY.

Thank you very much for your consideration.

Nathan Rosser
L49456
8776 Nye Road
Ventura, CA 93001
paradisecoveseafood@gmail.com
(310) 227-3644

From:	mbcfo member <mbcfo1972@gmail.com>
Sent:	Monday, October 30, 2023 3:53 PM
To:	jennifer.miller@boem.gov; douglas.boren@boem.gov; Jennifer@SLC Mattox; Jennifer.Lucchesi@slc.ca.gov; Kate.Huckelbridge@coastal.ca.gov; Holly@Coastal Wyer
Cc:	Justin Franklin; Chris Pavone; Gerald Sato; Tom Hafer; Owen Hackleman; Wayne Moody; Garrett Rose; Matt Newman; Jeremiah O'Brien; Bill Ward; Bill Blue; Mark Tognazzini; Bob Maharry; Alan Alward; Bill Barrow; Ted Schiafone; Bill Walter
Subject:	Sustainability of California Commercial Fishing during Offshore Wind Development:Impacts to fisheries from Site Surveys not recognized in EA

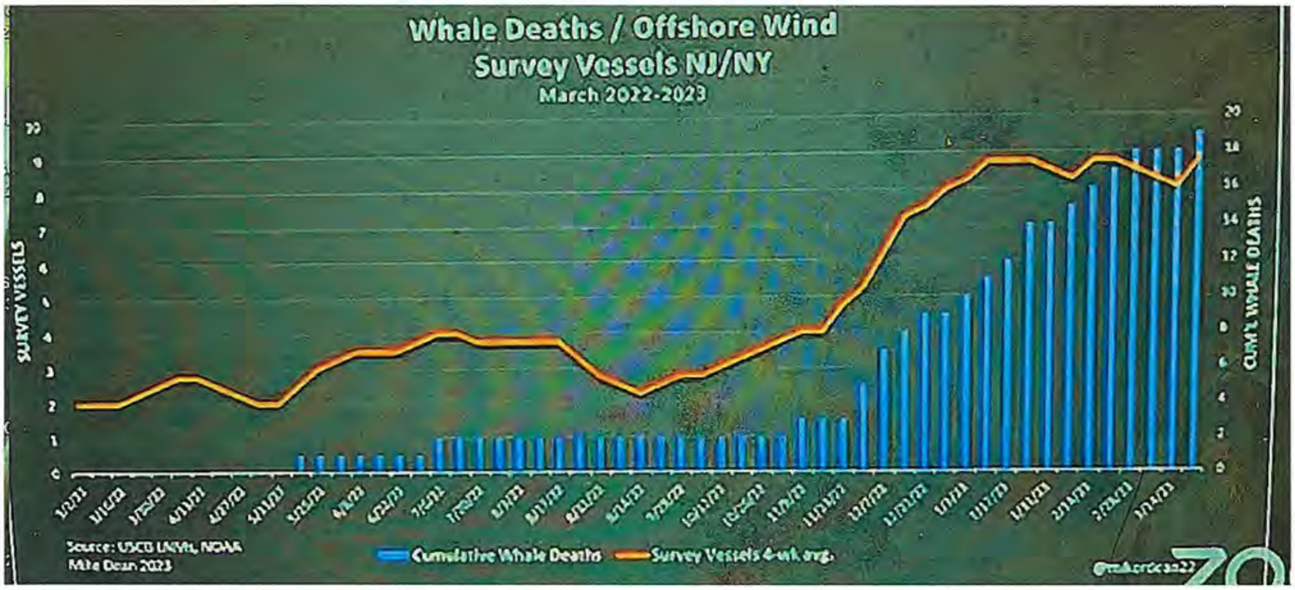
BOEM, SLC, CCC,

I want to let you know the other huge frustration for the Morro Bay and Port San Luis fishermen. The MBLA wind developers (Ocean Wind, Equinor, Invenergy) are set to begin their Site Surveys next year without a mitigation plan for all impacts to commercial fishing. The site surveys will require High Resolution Geophysical (HRG) surveys. The BOEM EA states they will be allowed to use up to 228 dB. This is less than the 250dB from seismic surveys but still loud! However, **BOEM has concluded there will be only "minor spatial conflicts" to commercial fishing and denies any impacts to our fisheries. We of course disagree.** We know from our experience with oil rig and fiber optic HRG surveys, that our catch rates will decline for years. If it goes like it has on the East Coast, the MBLA and the cable routes will require over 2000 hours of exposure to loud HRG surveys over a several month time period. This noise pollution results in masking of sounds needed to hear their predators or prey, it alters their migration patterns, their feeding patterns, mating, and larvae production for years. There is an article on fish bioacoustics: "An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes" by Arthur N. Popper and Anthony D. Hawkins, 2018, that found fish die at > 207. Here is a table from that study:

Type of Animal	Mortality and potential mortal injury	Impairment			
		Recoverable injury	TTS	Masking	Behaviour
Fish: no swim bladder (particle motion detection)	> 219 dB SEL_{cum} or > 213 dB peak	> 216 dB SEL_{cum} or > 213 dB peak	>>186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder is not involved in hearing (particle motion detection)	210 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	> 186 dB SEL_{cum}	(N) Moderate (I) Low (F) Low	(N) High (I) Moderate (F) Low
Fish: swim bladder involved in hearing (primarily pressure detection)	207 dB SEL_{cum} or > 207 dB peak	203 dB SEL_{cum} or > 207 dB peak	186 dB SEL_{cum}	(N) High (I) High (F) Moderate	(N) High (I) High (F) Moderate
Sea turtles	210 dB SEL_{cum} or > 207 dB peak	(N) High (I) Low (F) Low	(N) High (I) Low (F) Low	(N) High (I) Moderate (F) Low	(N) High (I) Moderate (F) Low
Eggs and larvae	> 210 dB SEL_{cum} or >207 dB peak	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low	(N) Moderate (I) Low (F) Low

Peak and rms sound pressure levels dB re 1 μPa; SEL dB re 1 $\mu Pa^2 s^{-1}$.

We should take notice of what has happened on the East Coast. To date there has been 73 whales and over 300 other cetaceans die during the HRG surveys. A 164% increase from the prior year. The Atlantic Marine Conservation Society Board of Directors doing the analysis of whale deaths is made up of over 50% directors which are coincidentally tied to the success of wind farms. They have come up with every excuse for the whales dying except HRG surveys. **If whales, dolphins, and sea lions are dying, fish are dying too!**



The BOEM EA doesn't even address impacts from HRG to fish! They only reference impacts and mitigation for whales, cetaceans, sea lions, and turtles. Because BOEM shows no concern for the impact on our fisheries, the wind developers think they have a green light to move forward with only mitigation for "spatial conflicts". Their "Fisheries Communication Plan"(FCP). They absolutely refuse to mitigate for the impacts to our catch rates quoting the conclusions from the BOEM EA.

As you know, we have been preparing for OSW since 2015. We have spent thousands of meetings with fishermen and wind companies (Castle Wind/ EnBw/Total) and over $170K in legal costs to come up with a fair mitigation plan: the MBLA MBC. Thankfully, Governor Newsom signed AB286 that includes recognition of locally negotiated industry to industry agreements to mitigate commercial fishing. It would save all of us a lot of time, frustration, non-cooperation of fishermen, legal action, and money if the MBLA wind developers would just join the MBC. It is set up to not duplicate whatever the CCC 7c working group comes up with in 2026. It will ensure we get some kind of mitigation for our lost fishing opportunity over the next 2-3 years or more. Unavoidable impacts to commercial fishing are required to be mitigated under the California Coastal Act. We had 4 meetings with the 3 MBLA lessees trying to get their cooperation to join the MBC. They refuse. They are hoping for a State managed fund with no local control and have no intentions of compensating any fishermen for their activities. Just as they have got away with before. Despite being the most impacted stakeholder in this entire process, we will likely get nothing but possibly "scout boat" duty.

Due to new evidence from fish bioacoustics studies and East Coast HRG surveys correlating with an unusual whale and other species mortality event, **BOEM needs to open up a new review of the impacts from HRG surveys on fish** and therefore to commercial fishing. This will then require the Wind developers to mitigate for all the unavoidable impacts to commercial fishing opportunity in and around the MBLA, substations and cable routes from the HRG surveys. Sound travels several miles in the ocean, so many fisheries are involved. The fiberoptic companies were required to do so, not sure why the wind companies, whom are surveying a much larger area, are not. There should be **a mitigation plan for all impacts to commercial fishing required before the Site Surveys begin.**

Thank you for your consideration of the sustainability of commercial fishing off California's coast during the anticipated offshore wind development.

Tom Hafer
President Morro Bay Commercial Fishermen's Organization
(805) 610-2072

Cc - MBCFO and MBC directors

Link to BOEM final EA for MBLA Site Survey

https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/2022-MorroBay-FinalEA.pdf

To whom it may concern,

My name is Harold Morris i have been an active fisherman for 18 years with fishing being my primary source of income during that time. I am a single father and fishing is the only job that gives me the flexibility to support my son and provide for us. I primarily do live nearshore rockfish but have been involved one way or another in almost every fishery throughout my career. In the world of commercial fishing, I'm relatively new and young to the industry. There are lots of fisherman that have way more experience than I have that I have had the pleasure of working and speaking too. All though I don't have any direct experience with negative effects to fishing from industrial operations in the ocean I have learned and heard a lot through my time and conversations with the more experienced fisherman.

I have learned there are a couple more or less recent industrial events that have negatively impacted fishing here just on the central coast of California. When the oil rigs were installed off the coast of Santa Barbara and Vandenburg the rockfish landings were negatively affected for five years. When the cables were installed the fishing was negatively impacted for more than a year. When the usgs did their high resolution geographic (HRG)studies off the central coast from Big Sur to Morro Bay around 2019 there was a 63% decrease in spot prawn landings when compared to before the study started not to mention a decrease of landings in other species.

Despite the obvious negative impacts to fishing from the construction, the existence and displacement from offshore wind, one of the most urgent matters that need to be addressed is the upcoming site survey. During these surveys they intend to use high powered acoustics to map the ocean floor. I don't think anyone would argue that hearing is not an important part of survival for any animal that has the ability to do so. This is especially true for fish as sound and hearing overcome the limitations of other senses such as vision, touch, taste and smell. Sound is a critical part of mating, detection of prey, migration and habitat selection. Depending on the severity of the noise disturbance it can result in hearing impairment, stress effects, changes in behavior and even death.

Although the effects of these acoustics site surveys have not yet been studied enough to have a concrete conclusion of the effects they will have there are other real-world situations that could be used to help draw conclusions. On the east coast where they are currently performing these site surveys and there has been a 164% increase in whale deaths that correlates exactly with site surveys. In 1996 there was a study done on the effects of acoustic surveys and the effects of fishing. During 5 days of acoustic testing fisherman in the area experienced a 50-70% in there catch rates. The 5 days after the testing the catch did not come back to pre-survey levels. (Can. J. Fish. Aquat. Sci. Vol. 53, 1996)

With all the information that I have provided and with any amount of your own research I believe it would ignorant and/or naive to say that these site surveys will be minor and not impact catch rates or the overall fishing community on the central coast in a negative way. It's easy to see that the effects are far from just spatial conflicts. These surveys will most definitely result in loss of jobs, loss of fishing opportunity, loss of fishing grounds, damage to fishing infrastructure and parts suppliers. This damage must be mitigated according to a plethora of local, state, and federal laws. BOEM must open another review of the EA and change their conclusion to protect the rights of commercial fishermen that rely on sustainable fishing near the wind energy lease area and cable routes to support themselves, their families, and their community.

williamswalterpc@gmail.com

From:	Tom and Sheri Hafer <somethingsfishy@charter.net>
Sent:	Sunday, August 27, 2023 7:49 AM
To:	Jeremiah & Trudy O'Brien
Cc:	Matt Newman; Bill Blue; Alan Alward; Bob Maharry; Garrett Rose; Owen Hackleman; Mark Tognazzini; Chris Pavone; Ted Schiafone; Bill Ward; Bill Diller; Gerald Sato; Bill Barrow; Justin Franklin; Wayne Moody; williamswalterpc@gmail.com
Subject:	Re: ATTORNEY CLIENT COMMUNICATION -- CURRENTLY THERE ARE NO ENFORCEABLE MITIGATIONS FOR COMMERCIAL FISHING IMPACTS WHICH ARE REQUIRED BEFORE THE PROJECTS PROCEED FURTHER

More "dirt"

There will be an increase in large ship traffic. Here are examples of SOV's used for OSW installation and maintenance -

VINEYARDWIND.COM
SCOUR PROTECTION — Vineyard Wind
OFFSHORE WIND MARINER UPDATE NO. 76

On Aug 26, 2023, at 10:38 AM, Jeremiah O'Brien <aguerofish@gmail.com> wrote:

Tom, one of the issues that is of great concern is the build out plan. What we see now is going to grow to 4500 sq. mi. in Cal. alone
that would cripple any fishing of any consequence in the state. That is a food security issue that the CCC are supposed to protect???
Jeremiah

Appendix IV – MISCELANEOUS EMAILS AND FISHERMEN SUGGESTED AGENDA FOR FINAL MEETING WITH DEVELOPERS REFERENCED IN THIS CORRESPONDENCE.

williamswalterpc@gmail.com

From: williamswalterpc@gmail.com
Sent: Monday, October 2, 2023 2:30 PM
To: 'Tyler Studds'; khislop@invenergy.com; 'Casali, Laura'; 'Kelly Boyd Momoh'; 'Elizabeth Marchetti'
Cc: 'Tom and Sheri Hafer'; 'Chris Pavone'
Subject: AGENDA FOR OCTOBER MEETING
Attachments: AGENDA FOR OW DEVELOPERS FISHING MITIGATION MEETING 10-2-2023 Final.docx

Hi Tyler,

Here is the Agenda for the meeting on October 9, 2023 which I thought could give us a discussion structure or checklist so that by the end of the meeting the fishing organizations will know the position of the OW developers. Perhaps you can check and see if there are any others persons who should be on this list and forward it to them with a copy to me so my email can populate their contact information for future reference. (My email chains are mostly copies with very few direct emails from each of the companies or at this point who the appropriate focus contacts will be.) You indicated that you had mentioned to Kate Hucklebridge at CCC that the prior meetings had been "acrimonious" (a strong word, "angry" and "bitter") which I attribute to fishermen frustration with the lack of focus on specifics at each of the prior meetings. I think this agenda can facilitate the focus on specifics and avoid acrimony or frustration from a sense of lack of progress.

A major area of concern is the impacts of the site surveys, timing, environmental review, and whether any enforceable commercial fishing mitigations are in effect prior to commencement of any phase of the project. That is a very important issue, but I thought it was pre-mature before we see whether there will be any progress on commercial fishing mitigations.

Thank you.

Bill Walter

A. MEETING PURPOSE: DISCUSSION OF BYLAWS OF THE MORRO BAY LEASE AREAS MUTUAL BENEFITS CORPORATION, ADOPTED OCTOBER 14, 2022

1. CHOICE CALIFORNIA MUTUAL BENEFIT CORPORATIONS CODE SECTION 7110 etc. FOR CREATION OF NON-PROFIT CORPORATION FOR COMMERCIAL FISHING MITIGATION IN THE MORRO BAY LEASE AREAS
    - Widely Used Type Of Corporation; Established Legal Procedures, Fiduciary Duties, Achieves Non-Profit Purposes; Stable And Perpetual Management until projects decommissioned
    - Reliable And Effective Supervision Provided By The California Department Of Justice, Charitable Trusts Section, detailed In *"Attorney General's Guide For Charities, Best Practices For Nonprofits That Operate Or Fundraise In California,"*
    - Successful Experience For Twenty Years With The *Central California Coast Joint Cable/Fisheries Liaison Committee, A California Nonprofit Mutual Benefit Corporation.*
    - In response to documented commercial fishing impacts from offshore wind development, the Crown Estate of The United Kingdon has utilized a not-for-profit company structure to administer donations to the "direct benefit to the fishing industry operating in within the vicinity" of the wind farms by the owners of UK offshore windfarms "in line with their corporate social responsibility objectives." Gray, M., Stromberg, POL., Rodmell, D. 2016 'Changes to fishing practices around the UK as a result of the development of offshore windfarms – Phase 1 (Revised). The Crown Estate, 121 pages. ISBN: 978-1-9064 10-63-3, pg. 121.

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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2. APPENDIX III, FISHERMEN LETTER:
   - Avoids protracted disagreements and potential claims and litigation because each fisherman consenting to the project; and agreeing to be bound by COP requirements and restrictions, including the project area and cable route
   - Written agreement by each fisherman that they accept the measures in Exhibit A (to Appendix III) "as providing acceptable mitigation measures."
   - Written agreement by each fisherman to communicate to the Project Developer any observed non-conformity with the BOEM lease terms and BOEM-approved COP.
   - Fishermen agree to operate commercial fishing vessel according to the safety requirements and restrictions in the Construction and Operation Plan; go first to the Project Developer with any concerns; "agree to not oppose the Project Developer's Project in the Morro Bay lease Area".
   - Fishermen waive any claims for monetary compensation whatsoever which is not included explicitly in the Bylaws; that any appeal of compensation accepts the decision of Trustees' Committee is "final and not subject to further review or challenge: waives fishermen claims against Trustees' Committee and all Project Developer s and their agents "arising out of "any decision about individual fishermen compensation.

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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3. MORRO BAY LEASE AREAS COMMERCIAL FISHING MITIGATION FUND, Article IX, pp. 12-13.

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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4. TRUSTEES' COMMITTEE, Article X, p. 13-14

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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5. MAKE-UP OF THE BOARD OF DIRECTORS AS WRITTEN W/O CASTLE WIND: Section 3.2, p. 5:
   - (2) President and Vice President of MBCFO
   - (2) President and Vice President of PSLCFA
   - (1) the Harbor Master for City of Morro Bay or Port San Luis
   - (1) From each Project Developer awarded Lease and Executed Agreement, Appendix I, for a total of 3 as currently written.

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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6. APPENDIX I, Project Developer Accession Letter

Section I. Upfront Payments to Individuals, p. 1-2

Section II. Preconstruction Payments, pp. 2-3

Section III. Payments During Construction

Section IV. Post-COD Funding

Section V. Government Mitigation Offset

Section VI. Additional Obligations

A. Consultation
B. Right of First Offer
C. Request for Proposal:
   Response to the RFP
   Right to Contract with Non-Members
   Training
D. 24-Hour Telephone Hotline
E. Safety Management System
F. Grear Replacement
G. Fish Stock Surveys and Biological Assessments
H. Future Unforeseen Impact Mitigation
I. Project Termination

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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7. APPENDIX II CRITERIA FOR QUALIFICAITON FOR INDIVIDUAL PAYMENTS TO MITIGATE MORRO BAY AND PORT SAN LUIS COMMERCIAL FISHERMEN FOR THE MORRO BAY LEASE AREAS

   This was the result of extensive meetings and nearly 20 drafts between representatives of both Organizations and represents a broad consensus related to fairness, discouraging "moral hazard" (claims without any history of fishing in the affected areas), related to economic impacts; addresses uncertainty in impacts commencing with site surveys.

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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8. AMENDMENTS TO BYLAWS: Article XV, p. 20.

Acceptable to Developers: ____________

Reasons Developers Disagree:

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Developers' Alternative Proposal:

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9. BOILER PLATE PROVISIONS:

Article III: Board of Directors, sections 3.1 through 3.8.

Article IV: Meeting of Board of Directors

Article V. Fees Compensation, and Reimbursement of Expenses

Article VI. Officers of the Corporation

Article V. Responsibilities of Officers

Article VI. Executive Director

Article XI. Committees

Article XII. Dealings with Directors and Officers

Article XIII. Standards of Conduct for Officers and Directors

Article IV. Records and Inspection Rights

Article XV. Amendments [to Bylaws]

Acceptable to Developers: ____________

Reasons Developers Disagree:

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____

____

Developers' Alternative Proposal:

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____

____

From:	Tyler Studds <Tyler.Studds@oceanwinds.com>
Sent:	Saturday, October 7, 2023 4:10 PM
To:	williamswalterpc@gmail.com; 'Tom and Sheri Hafer'
Cc:	'Kristen Hislop'; Laura.Casali@stantec.com; 'Kelly Boyd Momoh'; 'Elizabeth Marchetti'; 'Chris Pavone'
Subject:	RE: AGENDA FOR OCTOBER MEETING

Hi Bill,

Thanks for your message and apologies for not more clearly calling out the agenda in my email. It is:

- Introductions
- Review agenda and ground rules
- Morro Bay Leaseholder feedback on the MBC
  - Points of agreement in concept
  - Some areas of concern
  - Clarifying questions
- Potential survey mitigation approaches

Thank you for the suggestion to add to the ground rules listening to the concerns of the commercial fishing industry by the developers and happy to include it.

Best,
Tyler

From: williamswalterpc@gmail.com <williamswalterpc@gmail.com>
Sent: Saturday, October 7, 2023 3:19 PM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>; 'Tom and Sheri Hafer' <somethingsfishy@charter.net>
Cc: 'Kristen Hislop' <khislop@invenergy.com>; Laura.Casali@stantec.com; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>; 'Chris Pavone' <pavonefish@gmail.com>
Subject: RE: AGENDA FOR OCTOBER MEETING

Hello Tyler,

- Can you provide the agenda ahead of time – the same courtesy I showed the developers by providing an agenda which has been unilaterally "tabled" in advance of the meeting?
- Please recognize the frustration of four meetings – collectively costing individual fishermen hundreds of thousands of dollars in lost fishing time. After those meetings, we know no more about an enforceable mitigation regime than before the meetings. That's sort of astonishing to me and I am sure many others.
- Please recognize that after these four meetings, there has been not a single suggestion or feedback from any of the developers.
- My fear is that the frustration is being stoked, perhaps unintentionally, to make the fishing industry look unreasonable, "threatening", "name calling," and "intimidating" – to then report those items ex parte to Coastal Staff without an opportunity to balance the picture. It forces us to "tell the other side of this story" to Commission staff so that there is some "balance."

- The value of most fishing businesses had decreased by a substantial factor (some estimate 50% or more) due to the risk and uncertainty of the proposed industrial scale development in traditional fishing areas for hundreds of years. On land, we call that "unreasonable pre-condemnation activity" which has been unconstitutional in California for decades; that is, the implementation of the project which depresses the value of the business interests subject to injuries for alternative "winners'" purposes.
- I agree with staying "on topic" – but when the developers control to "topics" without providing an agenda – it seems condescending and disrespectful of the existential threat of these projects to the survival of the fishing industry over the next decade and beyond.
- Let me add -- "listening" to the concerns of the commercial fishing industry by the developers. I think the tone will improve if the developers show that they are listening and can point to any example where they have in the past provided meaningful compensation to affected fishing interests.
- There is currently no enforceable mitigation for commercial fishing or any hint of what the developers think that looks like and is viable. These projects affect people's lives, businesses, and the foundations of the coastal visitor serving economies – which the broader local community is beginning to learn about. It creates fear and distrust when proposed by for-profit businesses permanently changing the coastal environment without first committing to written mitigation.

In any event, I think it's worth the effort if the developers show some responsiveness and awareness of the need to make sure that commercial fishing off the California coast must be capable of surviving the industrialization of the ocean through well considered mitigation regimes.

Sincerely,

Bill Walter

P.S. – To show the success of commercial fishing mitigation, the Cable Committee recently granted $100,000 for harbor improvements to the City of Morro Bay. This track record should be acknowledged by the developers in recommending or opposing mitigation regimes when none of you have a history of local success, knowledge and experience.

William S. Walter,
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Counselor at Law
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805-541-6640 (fax)
805-215-9069 (cell)
https://william-s-walter-a-professional-corporation.business.site/

From: Tyler Studds <Tyler.Studds@oceanwinds.com>
Sent: Saturday, October 7, 2023 11:39 AM
To: williamswalterpc@gmail.com; 'Tom and Sheri Hafer' <somethingsfishy@charter.net>
Cc: 'Kristen Hislop' <khislop@invenergy.com>; Laura.Casali@stantec.com; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>; 'Chris Pavone' <pavonefish@gmail.com>
Subject: RE: AGENDA FOR OCTOBER MEETING

Hi Tom and Bill,

It was good to speak with you earlier today about our upcoming meeting this Monday. As discussed, the purpose of the meeting is for Morro Bay Leaseholders to provide feedback on the MBC including points of agreement, some areas of concern, and to ask some clarifying questions. As I noted o the call, we are interested to work together and to having an open, mutually respectful, and productive dialogue. To that end, I am sharing the following meeting ground rules which we discussed on today's call:

- Respect different views: Show others the respect you want people to show you.
- Do not threaten, intimidate, or name call others. Should this happen, the meeting will end immediately
- Share the floor
- Stay on topic

I will open the meeting, review the agenda and ground rules, and then turn it over to my colleagues to share points on the MBC. We are also interested to discuss surveys including potential mitigation approaches and overall expectations.

Enjoy the rest of your weekends and look forward to speaking Monday.

Best,
Tyler

From: williamswalterpc@gmail.com <williamswalterpc@gmail.com>
Sent: Friday, October 6, 2023 9:07 AM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>; 'Tom and Sheri Hafer' <somethingsfishy@charter.net>
Cc: 'Kristen Hislop' <khislop@invenergy.com>; Laura.Casali@stantec.com; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>; 'Chris Pavone' <pavonefish@gmail.com>
Subject: RE: AGENDA FOR OCTOBER MEETING

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Call my cell phone 805 215 9069.

Thank you.

William S. Walter,
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805-215-9069 (cell)
https://william-s-walter-a-professional-corporation.business.site/

From: Tyler Studds <Tyler.Studds@oceanwinds.com>
Sent: Thursday, October 5, 2023 7:41 AM
To: Tom and Sheri Hafer <somethingsfishy@charter.net>
Cc: williamswalterpc@gmail.com; Kristen Hislop <khislop@invenergy.com>; Laura.Casali@stantec.com; Kelly Boyd Momoh <KMOM@equinor.com>; Elizabeth Marchetti <EMARC@equinor.com>; Chris Pavone <pavonefish@gmail.com>
Subject: Re: AGENDA FOR OCTOBER MEETING

Thank you

From: Tom and Sheri Hafer <somethingsfishy@charter.net>
Sent: Thursday, October 5, 2023 10:09:18 AM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>
Cc: williamswalterpc@gmail.com <williamswalterpc@gmail.com>; Kristen Hislop <khislop@invenergy.com>; Laura.Casali@stantec.com <Laura.Casali@stantec.com>; Kelly Boyd Momoh <KMOM@equinor.com>; Elizabeth Marchetti <EMARC@equinor.com>; Chris Pavone <pavonefish@gmail.com>
Subject: Re: AGENDA FOR OCTOBER MEETING

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Tom's cell: 805-610-2072

> On Oct 5, 2023, at 2:33 AM, Tyler Studds <Tyler.Studds@oceanwinds.com> wrote:
>
> Thanks and will give a call at 9:15. What is the best number to reach you? Thanks and look forward to speaking.
>
> Tyler
>
> ---
>
> **From:** Tom and Sheri Hafer <somethingsfishy@charter.net>
> **Sent:** Wednesday, October 4, 2023 8:54:43 PM
> **To:** williamswalterpc@gmail.com <williamswalterpc@gmail.com>
> **Cc:** Tyler Studds <Tyler.Studds@oceanwinds.com>; Kristen Hislop <khislop@invenergy.com>; Laura.Casali@stantec.com <Laura.Casali@stantec.com>; Kelly Boyd Momoh <KMOM@equinor.com>; Elizabeth Marchetti <EMARC@equinor.com>; Chris Pavone <pavonefish@gmail.com>
> **Subject:** Re: AGENDA FOR OCTOBER MEETING
>
> ***Caution!! External email.*** *Do not open attachments or click links, unless this email comes from a known sender and you are sure the content is safe.*
>
> Saturday morning 9 to 10 should be ok for Tom.
>
>> On Oct 4, 2023, at 4:45 PM, <williamswalterpc@gmail.com> <williamswalterpc@gmail.com> wrote:
>>
>> Hello Tyler,
>>
>> Let's see when Tom is available.
>>
>> Best wishes,
>>
>> Bill W.
>>
>> **William S. Walter,**
>> **A Professional Corporation**
>> **Counselor at Law**
>> **677 Monterey St.**
>> **San Luis Obispo, CA 93401**

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Cc: williamswalterpc@gmail.com; Kristen Hislop <khislop@invenergy.com>; Laura.Casali@stantec.com; Kelly Boyd Momoh <KMOM@equinor.com>; Elizabeth Marchetti <EMARC@equinor.com>; Chris Pavone <pavonefish@gmail.com>
Subject: Re: AGENDA FOR OCTOBER MEETING

Tom is "gone fishing" until late Friday. Sheri

On Oct 4, 2023, at 3:54 AM, Tyler Studds <Tyler.Studds@oceanwinds.com> wrote:

Hi Bill,

Thanks and confirming receipt. Are you and Tom available for a quick call this week to discuss? I am free:

- Thu: after 1
- Fri: 8:30-11, after 1

Thanks and look forward to speaking

Best,
Tyler

From: williamswalterpc@gmail.com <williamswalterpc@gmail.com>
Sent: Monday, October 2, 2023 2:30 PM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>; khislop@invenergy.com; 'Casali, Laura' <Laura.Casali@stantec.com>; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>
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Thank you.

Bill Walter

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- Respect different views: Show others the respect you want people to show you.
- Do not threaten, intimidate, or name call others. Should this happen, the meeting will end immediately
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Enjoy the rest of your weekends and look forward to speaking Monday.

Best,
Tyler

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Call my cell phone 805 215 9069.

Thank you.

William S. Walter,
A Professional Corporation
Counselor at Law
677 Monterey St.
San Luis Obispo, CA 93401
805-541-6601 (office)
805-541-6640 (fax)
805-215-9069 (cell)
https://william-s-walter-a-professional-corporation.business.site/

From: Tyler Studds <Tyler.Studds@oceanwinds.com>
Sent: Thursday, October 5, 2023 7:41 AM
To: Tom and Sheri Hafer <somethingsfishy@charter.net>
Cc: williamswalterpc@gmail.com; Kristen Hislop <khislop@invenergy.com>; Laura.Casali@stantec.com; Kelly Boyd Momoh <KMOM@equinor.com>; Elizabeth Marchetti <EMARC@equinor.com>; Chris Pavone <pavonefish@gmail.com>
Subject: Re: AGENDA FOR OCTOBER MEETING

Thank you

From: Tom and Sheri Hafer <somethingsfishy@charter.net>
Sent: Thursday, October 5, 2023 10:09:18 AM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>
Cc: williamswalterpc@gmail.com <williamswalterpc@gmail.com>; Kristen Hislop <khislop@invenergy.com>; Laura.Casali@stantec.com <Laura.Casali@stantec.com>; Kelly Boyd Momoh <KMOM@equinor.com>; Elizabeth Marchetti <EMARC@equinor.com>; Chris Pavone <pavonefish@gmail.com>
Subject: Re: AGENDA FOR OCTOBER MEETING

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Tom's cell: 805-610-2072

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> Tyler
>
> ---
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Saturday morning 9 to 10 should be ok for Tom.

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> Hello Tyler,
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> Let's see when Tom is available.
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> Best wishes,
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> Bill W.
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> **Counselor at Law**
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>> Thanks and confirming receipt. Are you and Tom available for a quick call this week to discuss? I am free:
>>
>> - Thu: after 1

- Fri: 8:30-11, after 1

Thanks and look forward to speaking

Best,
Tyler

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Sent: Monday, October 2, 2023 2:30 PM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>; khislop@invenergy.com; 'Casali, Laura' <Laura.Casali@stantec.com>; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>
Cc: 'Tom and Sheri Hafer' <somethingsfishy@charter.net>; 'Chris Pavone' <pavonefish@gmail.com>
Subject: AGENDA FOR OCTOBER MEETING

You don't often get email from williamswalterpc@gmail.com. Learn why this is important

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Hi Tyler,

Here is the Agenda for the meeting on October 9, 2023 which I thought could give us a discussion structure or checklist so that by the end of the meeting the fishing organizations will know the position of the OW developers. Perhaps you can check and see if there are any others persons who should be on this list and forward it to them with a copy to me so my email can populate their contact information for future reference. (My email chains are mostly copies with very few direct emails from each of the companies or at this point who the appropriate focus contacts will be.) You indicated that you had mentioned to Kate Hucklebridge at CCC that the prior meetings had been "acrimonious" (a strong word, "angry" and "bitter") which I attribute to fishermen frustration with the lack of focus on specifics at each of the prior meetings. I think this agenda can facilitate the focus on specifics and avoid acrimony or frustration from a sense of lack of progress.

A major area of concern is the impacts of the site surveys, timing, environmental review, and whether any enforceable commercial fishing mitigations are in effect prior to commencement of any phase of the project. That is a very important issue, but I thought it was pre-mature before we see whether there will be any progress on commercial fishing mitigations.

Thank you.

Bill Walter

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williamswalterpc@gmail.com

From: williamswalterpc@gmail.com
Sent: Sunday, October 8, 2023 5:24 PM
To: 'Tyler Studds'; 'Tom and Sheri Hafer'
Cc: 'Kristen Hislop'; Laura.Casali@stantec.com; 'Kelly Boyd Momoh'; 'Elizabeth Marchetti'; 'Chris Pavone'
Subject: RE: AGENDA FOR OCTOBER MEETING

Hello Tyler,

Can we add:

- Respect the fishermen's suggestions concerning the agenda topics they proposed
- Respect the time and expense (lost income) of the individual fishermen participants in the meeting
- Acknowledge the frustration throughout the fishing community of not getting any substantive suggestion on mitigation during the first four meetings and the lack of commitments to commercial fishing mitigations which has stoked strong resentments and distrust towards the project developers' intentions
- Acknowledge that the project phases will impact commercial fishing and that the uncertainty the proposed projects pose for the fishing industry, the willingness to buy and sell businesses, invest further in businesses, value of business assets, etc.
- Do not presume or imply that fishermen collectively engage in threatening, intimidating or name calling behavior
- Agree that any communications about the meeting to any government agencies (e.g., Coastal Commission) will be in writing and copied to the participants to avoid undocumented oral ex parte communications which could prejudice either party with those agencies.

Can we add to the agenda a brief discussion of the permitting and environmental review processes for the site surveys.

Thank you for raising the issue of "ground rules" since it is obviously a great concern to both sides.

I look forward to tomorrow's Microsoft Teams meeting.

Bill Walter

William S. Walter,
A Professional Corporation
Counselor at Law
677 Monterey St.
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https://william-s-walter-a-professional-corporation.business.site/

From: Tyler Studds <Tyler.Studds@oceanwinds.com>
Sent: Saturday, October 7, 2023 11:39 AM
To: williamswalterpc@gmail.com; 'Tom and Sheri Hafer' <somethingsfishy@charter.net>
Cc: 'Kristen Hislop' <khislop@invenergy.com>; Laura.Casali@stantec.com; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>; 'Chris Pavone' <pavonefish@gmail.com>
Subject: RE: AGENDA FOR OCTOBER MEETING

Hi Tom and Bill,

It was good to speak with you earlier today about our upcoming meeting this Monday. As discussed, the purpose of the meeting is for Morro Bay Leaseholders to provide feedback on the MBC including points of agreement, some areas of concern, and to ask some clarifying questions. As I noted o the call, we are interested to work together and to having an open, mutually respectful, and productive dialogue. To that end, I am sharing the following meeting ground rules which we discussed on today's call:

- Respect different views: Show others the respect you want people to show you.
- Do not threaten, intimidate, or name call others. Should this happen, the meeting will end immediately
- Share the floor
- Stay on topic

I will open the meeting, review the agenda and ground rules, and then turn it over to my colleagues to share points on the MBC. We are also interested to discuss surveys including potential mitigation approaches and overall expectations.

Enjoy the rest of your weekends and look forward to speaking Monday.

Best,
Tyler

From: williamswalterpc@gmail.com <williamswalterpc@gmail.com>
Sent: Friday, October 6, 2023 9:07 AM
To: Tyler Studds <Tyler.Studds@oceanwinds.com>; 'Tom and Sheri Hafer' <somethingsfishy@charter.net>
Cc: 'Kristen Hislop' <khislop@invenergy.com>; Laura.Casali@stantec.com; 'Kelly Boyd Momoh' <KMOM@equinor.com>; 'Elizabeth Marchetti' <EMARC@equinor.com>; 'Chris Pavone' <pavonefish@gmail.com>
Subject: RE: AGENDA FOR OCTOBER MEETING

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Thank you.

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Bill Walter

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Sent: Monday, October 9, 2023 10:22 AM
To: 'Tyler Studds'; 'Tom and Sheri Hafer'
Cc: 'Kristen Hislop'; Laura.Casali@stantec.com; 'Kelly Boyd Momoh'; 'Elizabeth Marchetti'; 'Chris Pavone'
Subject: RE: AGENDA FOR OCTOBER MEETING

Tyler, Laura Kelly, Elizabeth, Kristen,

As part of my due diligence, would you all be kind enough to provide me copies of the California Secretary of State filings for each of the three developers.

Thank you.

Bill Walter

William S. Walter,
A Professional Corporation
Counselor at Law
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San Luis Obispo, CA 93401
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Subject: RE: AGENDA FOR OCTOBER MEETING

Hi Bill,

Thanks for your message and apologies for not more clearly calling out the agenda in my email. It is:

- Introductions
- Review agenda and ground rules
- Morro Bay Leaseholder feedback on the MBC
    - Points of agreement in concept
    - Some areas of concern
    - Clarifying questions
- Potential survey mitigation approaches

Holly Wyer
California Coastal Commission
Senior Environmental Scientist
Energy, Ocean Resources, and Federal Consistency
455 Market Street, Suite 300
San Francisco, California 94105
holly.wyer@coastal.ca.gov
(she/her/hers)
Value coastal protection? Value Scientists.

-----Original Message-----
From: mbcfo member <mbcfo1972@gmail.com>
Sent: Monday, September 25, 2023 4:08 PM
To: Huckelbridge, Kate@Coastal <Kate.Huckelbridge@coastal.ca.gov>; Wyer, Holly@Coastal <holly.wyer@coastal.ca.gov>
Subject: Morro Bay Lease Area (MBLA) Site Surveys

Hello Kate and Holly,

We would just like to clarify if the California Coastal Commission plans on giving permission to the Offshore Wind Lease companies to begin Site Surveys next year - we heard possibly in May in the MBLA? And that these Site Surveys will include geological studies of the bottom with high resolution sonic equipment (as an OSW developer told us it would)? And if that is so, how many decibels do you anticipate they will be using in depths up to 3600 ft. ? On the East Coast, they required 205 decibels for 300 ft. And required 610 hrs of sounding for ~100 square miles. Do you anticipate these geological studies will have an impact on our fisheries?

Morro Bay Commercial Fishermen's Organization

LAW
OFFICES
WILLIAM S. WALTER
A PROFESSIONAL CORPORATION

TELEPHONE (8OS) 541-6601
FACSIMILE (805) 541-6640

THE BELLO COTTAGE
677 MONTEREY STREET
SAN LUIS OBISPO, CALIFORNIA 93401

EMAIL
williamswalterpc@gmail.com

CONCERNS AND SUGGESTIONS OF THE MORRO BAY COMMERCIAL FISHERMEN'S ORGANIZATION (MBCFO) AND PORT SAN LUIS COMMERCIAL FISHERMAN ASSOCIATION (PSLCFA) REGARDING IRREVERSIBLE IMPACTS TO COMMERCIAL FISHING FROM OFFSHORE WIND SITE SURVEYS WITHIN THE BOEM MORRO BAY LEASE AREAS Submittal # 2

December 8, 2023

Holly Wyer, Senior Environmental Scientist
California Coastal Commission
Energy, Ocean Resources and Federal Consistency
455 Market Street, Suite 300
San Francisco, CA 94105-2421 (Via Email; Facsimile 415-904-5400)

VIA EMAIL TO: **BOEM** c/o
douglas.boren@boem.gov;enjennifer.miller@boem.gov;
California Coastal Commission c/o
kate.Huckelbridge@coastal.ca.gov; holly.wyer@coastal.ca.gov
California State Lands Commission c/o Jennifer.Mattox@slc.ca.gov
and Jennifer.Lucchesi@slc.ca.gov;
CSLC.CommissionMeetings@slc.ca.gov
Cc: Haas, Greg greg.haas@mail.house.gov

RE: Response to Holly Wyer Correspondence DTD 11-28-2023

Dear Holly Wyer:

The Morro Bay Commercial Fishermen's Organization (MBCFO) and Port San Luis Commercial Fisherman Association (SLCFA) appreciate your email and letter of November 28, 2023 responding to an email dated October 18, 2023 from MBCFO. This office sent correspondence and emails to the regulatory and trustee agencies dated November 12, 2023, (40 pages) followed by separate emails with documents, studies, records, testimony, etc., organized in four Appendices.

Additional materials have been sent by MBCFO in subsequent emails containing related evidential materials.

Without repeating what has already been communicated to the regulatory and trustee agencies, and in a good faith spirit of collaboration and cooperation, here's a short version of why the Organizations believe that the points and conclusions in your letter are factually and legally incorrect:

1. The Coastal Commission's Consistency Determination, adopted June 8, 2022, expressly made the following finding concerning immediate impacts on commercial fishing from the Consistency Determination allowing BOEM leasing and provisionally authorizing developer site surveys of the Morro Bay Lease Areas. Finding "immediate effects on fishing communities" triggers the mandatory legal duty for enforceable mitigation and monitoring of commercial fishing impacts before any further project activities (such as site surveys) commence:

"However, issuance of leases will have immediate effects on fishing communities even before any lease development activities occur, as the leases and overall BOEM process injects uncertainty into an occupation that is already heavily regulated and uncertain." (CD-0004-22 (BOEM) p. 24.

The Organizations could not agree more with this short but compelling finding by the Commission which BOEM accepted when it did not challenge any portion of the Consistency Determination.[1] The mitigation and monitoring of these "immediate effects" on commercial fishing expressly protected by California's Coastal Management Program and State Constitution[2] cannot be deferred and unenforceable while *any* portion of the BOEM projects proceed. This prohibition literally and unambiguously includes "issuance of leases," "any lease development activities" which includes site surveys, and "the whole of the action." Impacts must be mitigated when they occur and the impacts to commercial fishing have been

[1] (See July 1, 2022 correspondence from the Commission by Holley Wyer to Doug Boren, Director, BOEM Regional Director; "Consistency Determination CD-114-22 (Morro Bay Wind Energy Area)".

[2] See Walter Correspondence, November 14, 2023, pp. 10-20.

found to be occurring *now* in direct conflict with various policies identified at length in our prior submits.

2. Your letter presents the opinion that the "concept of deferred mitigation under CEQA" does not "apply to the Commission's action. The reason suggested for this conclusion is "CEQA does not generally extend to the Commission's CZMA" authority "on federal land" and the "outer continental shelf."

The Consistency Findings of the Commission do not support these straight-jacket characterizations which would prevent achieving CCMP consistency because of (a) "spillover effects" into the Coastal Zone from federal activities, (b) easements through State waters (and tidelands) to the shoreline for energy transmission. and (c) findings of the Commission's "authority to review activities" within "federal waters." The only methodology available to the Commission in this process must be the "functional equivalent" of CEQA, which is why the Commission formulated both findings and "conditions" for BOEM to accept or reject under its own procedures:

(a) Spillover effects: **"Thus, in its evaluation of this proposed lease sale's consistency with the Coastal Act, this Commission analyzes spillover effects on coastal resources beyond federal waters." (CCC Consistency Determination CD-0004-22, p. 19.)**

These "spillover effects" include the immediate impacts of leasing on the commercial fishing industry identified above (#1) in the Commission's findings. Also, spillover effects to the coastal zone expressly include sound used in geophysical surveys which will last for five years:

"In this instance, the Commission's review of activities in federal waters focuses on spillover effects on coastal resources within the coastal zone. This review may include effects that activities in federal waters may have on resources within the coastal zone, or effects that activities in federal waters may have on species in federal waters that travel in and out of the coastal zone. For example, the sound used to conduct geophysical surveys may travel from where the survey is

being conducted in federal waters to the coastal zone and affect marine life within the coastal zone. Similarly, geophysical surveys could impact marine species that travel large distances and are known to move between the coastal zone and federal waters, such as marine mammals." (pp. 18-19, see 25.)

The spill-over effects from site surveys have been found to extend for a lengthy time period:

"BOEM expects that lessees would survey their entire proposed lease area during the 5-year site assessment term…." (p. 29.)

The spill-over effects from site surveys directly impacts the Morro Bay Harbor and commercial fishing:

"…BOEM expects that lessees would stage their lease exploration activities from the Port of Morro Bay." (p. 29.)

(b) There are also easements which extend through State waters contemplated by the approval, including site survey, construction and eventual decommissioning activities through State waters:

"These easements would all be located within the Central California OCS, extending from the WEA through to federal and state waters and to the onshore energy grid." (p. 24.)

(c) The Commission findings assert discretion and review authority over federal waters:

"Although numerous other state agencies have been involved and have an interest in the offshore wind leasing and development process, the Coastal Commission is the only state agency with authority to review activities that occur more than 3 nautical miles offshore in federal waters." (p. 3.)

3. The Commission's Consistency Findings also reject the analytical premises of that portion of BOEM's Consistency Determination submittal

to the Commission, and the Environmental Assessment deferring the identification of impacts, including commercial fishing, as not "reasonably foreseeable." BOEM acknowledges that:

"The analysis found here and found in the EA does not consider construction and operation of any commercial wind power facilities…. based on several factors…

"First, the issuance of a lease only grants the lessee the exclusive right to submit to BOEM a Site Assessment Plan (SAP) and Construction and Operations Plan (COP) proposing development of the leasehold; the lease does not, by itself, authorize any activity within the lease area. …"

"Second, BOEM does not consider the impacts resulting from the development of a commercial wind power faciality within the WEA to be reasonably foreseeable." (BOEM, "Consistency Determination," April 15, 2022, pp. 11-12)):

The Commission's Consistency Determination recognized BOEM's approach and disagreed in two regards to which BOEM lodged no objections under the CZMA and therefore accepted:

First: the Commission found: **"However [identifies impacts of leasing on commercial fishing quoted above and then] …Based on past BOEM leases and authorizations for wind development on the east coast, it is also reasonably foreseeable that the leases will lead to construction and operation of at least some offshore wind facilities, and it is feasible to describe, at least at a high level, the types of impacts that such facilities could have on coastal resources." (CD-0004-22, p. 24.)**

Second: the Commission identifies ten pages of potential impacts on commercial fishing, noting that, **"These concerns were brought forth by the fishing community during interagency outreach meetings, as well as derived from a list of concerns submitted by numerous fishing organizations in a public comment letter."** (CD-0004-22 (BOEM), p. 88, note 2.)

> The reasonably foreseeable impacts on commercial fishing were summarized by the Commission as "**common potential impacts that have already been identified and articulated by the industry. These include:**
>
> **"I. Exclusion. The ocean is a shared space. Fishing and other uses must coexist and work through complex management and regulatory requirements. It is anticipated that offshore wind development areas will become exclusionary zones and will restrict already limited ocean space.**
> **"II. Displacement. Related to Exclusion, fishers that are excluded from the WEA may be forced to relocate into other, already limited fishing grounds, placing additional environmental pressure on the remaining habitat, and potentially increasing conflicts between user groups.**
> **"III. Increased costs and time at sea to avoid wind development. Placement of wind facilities can delay direct access to fishing grounds and force fishers to fish or drift far outside of lease boundaries due to movement of gear and vessels on the open ocean.**
> **"IV. Loss of future fishing grounds. Fishing grounds are highly variable. Continuous and often rapid changes in ocean conditions cause changes to fish populations which in turn result in changes to fishing behavior year over year. Large-scale wind development would eliminate a huge portion of potentially viable fishing area, limiting fishermen's ability to adapt to changes in fishing grounds.**
> **"V. Loss or disruption of harbor space and fishing infrastructure at ports due to increased presence of wind related facilities." (CD-0004-22 (BOEM), p. 88.)**

See also the impacts on commercial fishing explained in more detail, including the site survey phase, on pp. 84-98 of the Commission's Consistency Determination findings, many of which occur commencing with site surveys, attached as Appendix V.[3]

[3] To create a coordinated record, the Appendixes are consecutively numbered starting with the prior correspondence submitted to the regulatory and trustee agencies.

BOEM did not object to these commercial impact findings according to its own procedures and is now bound to accept "reasonable foreseeable impacts on commercial fishing" now existing which triggers immediate requirements for complete, enforceable, mitigation and monitoring before the commencement of site surveys.[4] Later, of course, mitigation can be expanded with flexible procedures similar to the MBLA MBC and Trustees' Mitigation Fund Committee, when the specificity of project designs and placement call for more and different mitigation and during a further Certification or Permitting by the State Agencies. Having **no** enforceable mitigation based on this Consistency Determination, however, is not an option under either CEQA, NEPA, or CZMA.

4. Without citation to statutes, regulations, findings, judicial authority or a balanced consideration of opposing perspectives, the Commission would dismiss some of the most fundamental principles of modern land use and environmental law: the broad consensus and undisputed principles against deferred mitigation, unenforceable mitigation before any part of the "whole of the action" (or "project") commences, no minimal or unsubstantial mitigation, a completely public and transparent process with an opportunity of the "concerned citizenry" to be heard, and consideration of "new information" through additional analysis and public review. When agencies' action and procedures drift away from keystone principles, there is cause for all involved to take a critical look at the "drift" before irreparable damage occurs to either the environment or commercial fishing protected by the State's Coastal Management Program, the California Constitution, etc. Substance controls form when findings of existing impacts to commercial fishing merely from leasing have been adopted.

5. The Consistency Determination contains an omission in the consistency findings related to the Certified Local Coastal Program of the City of Morro Bay – where, of course, the largest commercial fishing fleet is harbored, closest to the Morro Bay Lease Areas, and most likely to be highly impacted from leasing, surveys, construction, operation through

[4] See July 1, 2022 Consistency Determination correspondence from Holly Wyer to Doug Boren, BOEM Regional Director, confirming the conditions and findings of the Commission.

de-commissioning. (See CD-0004-22, p. 17, only references Commission certification of "LCPs for portions of San Luis Obispo County that are relevant to this CD".) Morro Bay is an incorporated city with its own Certified Local Coastal Program. This material omission should be remedied through further NEPA/CEQA compliance and identification of enforceable mitigation and monitoring of existing and reasonably foreseeable commercial fishing impacts from offshore wind projects.

6. We appreciate your references to the Work Group process, the recommendations of which are not enforceable without further action, adoption and ratification through a public hearing process and related environmental review. More to the immediate point, however, and identified in prior correspondence, no site surveys can occur or be permitted by either BOEM, State Lands Commission or the Coastal Commission until review, adoption, and completion of the protocols and best practices for site surveys. The site surveys cannot be commenced before the complete compliance, prior to the issuance of any permits or commencement of site survey activities, with Public Resources Code Section 30616 (c) (b) "statewide strategy …shall include best practices for addressing impacts to the commercial…fishing industries…associated with offshore wind energy projects, including, but not limited to, the following: … (3) Best practices for offshore surveys and data collection to assess impacts." It would be a futile exercise for the Legislature to have required best practices for site surveys to be developed *after* site surveys lasting up to five years have occurred.

7. All of the agencies have to follow the procedures required when "new information" about impacts have been presented whether under NEPA, the Commission's functional equivalent process for impacts to State submerged and tidelands, and/or the State Lands Commission permitting of site surveys and CEQA compliance requirements.

Please appreciate that emails and correspondence from this office and from the MBCFO and PSLCFA are intended to raise legitimate concerns, present substantial evidence, to clarify processes, and to foster confidence in the process of assuring the highest, transparent, and complete compliance with both NEPA and CEQA.

As we explained in prior correspondence, the solution we have proposed for these and the many other deficiencies have been described by the joint work of the President's Council on Environmental Quality (CEA) and the California Governor's Office of Planning and Research quoted at length in at pp. 5-6 of my prior correspondence dated November 14, 2023, to which no regulatory or trustee agency has responded. The obvious gravitas of these two agencies at the pinnacle of authority for both the U.S. Government and the State of California is clearly described in *"NEPA and CEQA: Integrating Federal and State Environmental Reviews" (2014).*

The current status of these projects seems to be the exact situation of single projects crossing Federal and State jurisdictions where NEPA and CEQA integration would be appropriate and mandatory based on the joint recommendations of the CEQ and OPR. The new information submitted cannot be dealt with via email evaluations at the staff level or other non-statutory procedures which do not involve complete public transparency and compliance with established CEQA and NEPA procedures with which no one can reasonably disagree given the combined gravitas of CEQ and OPR.

We constructively urge the Coastal Commission, State Lands Commission, all other State agencies with jurisdiction, and BOEM (and other federal agencies) to follow the procedures identified for "*Integrating Federal and State Environmental Reviews*" under CEQA and NEPA. The process can not only address new information regarding site survey impacts which mandate a further NEPA/CEQA review, but also provide an opportunity to enact enforceable mitigation and monitoring of commercial fishing impacts from the projects *before* further project actions such as site surveys commence, and reconcile omissions and inconsistencies in the Consistency Determination identified above.

Respectfully yours,

WILLIAM S. WALTER

https://william-s-walter-a-professional-corporation.business.site/

APPENDIX V

COASTAL COMMISSION CONSISTENCY DETERMINATION FINDINGS DISCUSSING PRESENTLY KNOWN IMPACTS FROM THE BOEM MORRO BAY LEASE AREAS OFF SHORE WIND PROJECTS

STATE OF CALIFORNIA - NATURAL RESOURCES AGENCY GAVIN NEWSOM, *GOVERNOR*

CALIFORNIA COASTAL COMMISSION
ENERGY, OCEAN RESOURCES AND FEDERAL CONSISTENCY
455 MARKET STREET, SUITE 300
SAN FRANCISCO, CA 94105-2421
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W7a

CD Filed:	4/15/2022
60th Day:	6/14/2022
Staff:	HW-SF
Staff Report:	5/20/2022
Hearing Date:	6/8/2022
Vote:	8-0

ADOPTED FINDINGS

Consistency Determination No.:	**CD-0004-22**
Applicant:	**Bureau of Ocean Energy Management**
Location:	In federal waters offshore of San Luis Obispo County, approximately 20 miles off Cambria
Project Description:	Conduct a lease sale for up to 240,898 acres of federal waters for the future development of offshore wind energy facilities. Permit lessees to conduct site characterization and assessment activities and submit a construction and operations plan for development of offshore wind energy on their leases.
Commission Action:	Conditional Concurrence

SUMMARY OF COMMISSION ACTION

The Bureau of Ocean Energy Management (BOEM) seeks the Commission's concurrence that proposed leasing and lease activities within the Morro Bay Wind Energy Area (Morro Bay WEA, or WEA), located approximately 20 miles off Cambria, is consistent with California's Coastal Management Program (CCMP). The CCMP consists of the enforceable policies of Chapter 3 of the Coastal Act (Cal. Pub. Res. Code §§ 30200-30265.5). BOEM anticipates issuing up to three leases, covering up to 240,898 acres, as part of the Morro Bay WEA lease sale. BOEM's leases would allow lessees to perform geophysical, geotechnical, and biological surveys and would permit site assessment activities, including the temporary placement of up to three metocean buoys and oceanographic devices. After BOEM's lessees complete surveys and site assessment activities, the lessees would submit a construction and operations plan (COP) to develop a lease. The submission of a COP starts the federal environmental review process for specific wind development projects and would require BOEM's lessees to receive consistency certifications from the Commission prior to any further development being approved by BOEM.

The proposed lease sale is the culmination of many years of work by BOEM, as well as other federal and state agencies, to develop offshore wind resources in California. The state of California has set aggressive goals to reduce greenhouse gas emissions, move to clean energy sources, and achieve carbon neutrality as soon as possible, but no later than 2045. California will need to roughly triple its current electric power capacity to meet the 2045 target for clean energy, and the California Energy Commission has modeled scenarios that involve producing up to 10 gigawatts of energy from offshore wind. Likewise, the federal government has set a goal to deploy 30 gigawatts of offshore wind in the United States by 2030 and has been working hard to develop those wind resources quickly, while still protecting coastal uses and resources. On the U.S. east coast, there are currently two operating offshore wind farms, one more that is fully permitted, and fifteen additional projects that have reached the permitting phase. This is the first proposed lease sale of offshore WEAs on the west coast.

The federal Energy Policy Act of 2005 set up the legal framework under which BOEM analyzes potential WEAs, conducts planning, leases sites, and oversees the site assessment and construction and operation of commercial wind facilities. Pursuant to its authority under that law, in 2016 BOEM established a Renewable Energy Task Force with California to facilitate coordination among federal agencies and affected state, local, and tribal governments throughout the offshore wind leasing process. Following the first Task Force meeting, BOEM and the state, led by the California Energy Commission, engaged in a collaborative, data-based offshore wind energy planning process to foster coordinated and informed decisions about California's ocean resources. In addition to participating with the Task Force, Commission staff also participate in a state interagency working group to coordinate the state's regulatory, research, and planning work on offshore wind. Other agencies participating in the working group include the California Energy Commission, Ocean Protection Council, Department of Fish & Wildlife, Public Utilities Commission, State Lands Commission, Governor's Office of Planning and Research, and Department of Parks & Recreation. This working group provided joint comments to BOEM on that agency's environmental targeted by fishers on the West Coast were rockfishes[22], albacore tuna, lingcod, halibut and salmon.

Pacific coast-wide in 2019, marine recreational anglers took an estimated 3.8 million trips and caught a total of more than 11 million fish. Almost 90 percent of these trips were made in California, followed by approximately 6 percent in Oregon, and 4 percent in Washington. The most commonly caught (as opposed to targeted) non-bait species (in numbers of fish) across all trips were Pacific (chub) mackerel, kelp bass, black rockfish, California scorpionfish, and vermilion rockfish. The largest harvests by weight across all trips were albacore, lingcod, black rockfish, Chinook salmon, vermilion rockfish, and coho salmon. Approximately 71% of trips occurred in state waters, 17% in federal waters, and 12% in inland waters. Of those trips that fished primarily in federally managed waters, the non-bait species most commonly caught (in numbers of fish) were California scorpionfish, ocean whitefish, vermilion rockfish, squarespot rockfish, and bocaccio. Other popular recreational catch, particularly on CPFV vessels, are salmon and halibut (NMFS, 2019).

Recreational fishing typically uses smaller scale fishing methods, such as hook and line, trolling, hand nets, or occasionally harpoon. With limited exceptions, recreational fishing is generally a nearshore activity due to the limited trip lengths, smaller size of vessels, weather conditions, and cost. One recreational fishery that does operate farther offshore in the Central Coast region is the HMS fishery, although there is limited overlap with the boundary of the WEA. As can be seen in **Exhibit 3-13,** which shows CPFV activity (recreational for hire fishing), fishing intensity is higher closer to shore, but still present in the WEA.

Social and Cultural importance of Fisheries

Aside from the economic importance of fisheries described above, fishing activity is also interwoven into the societal and cultural fabric of communities up and down the coast. Modern fishing has been a part of the Central Coast community economy since modern cities were founded but has been an integral part of the indigenous coastal communities since time immemorial. Monterey, in particular, invokes a historical connection to Cannery Row, and the abundance of sardines and other CPS that supported much of the region's early economy. Liu et al (2019) describe how current Central Coast fishing communities provide a vital link to the past, especially in Morro Bay, which once supported a prominent abalone fishery that is quintessentially tied to the seafood identity of coastal California. Fishing communities and the infrastructure associated with them provide jobs and amenities to the surrounding community, as well as promote a broader connection with the public to the ocean. For Tribes and other entities that rely on fisheries for subsistence, access to even a small quantity of fish is important for food security and to the continuance of cultural traditions. Thus, even those fisheries that make up a smaller component of the overall economic value in the Central Coast may still be critical to the existence and identity of an area, even when value or poundage of

[22] Fishing for certain types of rockfish on the Central Coast is currently depth limited but is proposed to be moved outside of the 50 fathom depth contour for recreational fishing of certain species in order to reduce nearshore fishing impacts to copper and quillback rockfish.

landings itself conveys a less substantial role.

Lease Exploration Impacts

During the leasing period, a lessee may conduct lease exploration activities within the WEA including shallow hazards assessments, geological, geotechnical, archaeological, and biological surveys, and installation, operation, and decommissioning of data collection buoys. These activities have the potential to interfere with commercial and recreational fishing in and offshore of Cambria primarily through impacts to important fishery species and space-use conflicts within staging locations and offshore.

Data collection buoys may exclude fishing operations that frequent deeper water, in particular mobile gear fisheries. Mobile fishing is typically defined as any operation with active gear such as nets or dredges that are set out and hauled back with winches or drums while the vessel and gear are underway, typically on a cycle measured in minutes or hours. Using this type of gear significantly hinders a fisher's ability to maneuver their vessel during operations, including around structures that are affixed to the seafloor, such as buoys. Fishermen could also suffer decreased efficiency (such as spending more time on fishing by setting and hauling gear) when trying to avoid buoys during their operations. Decreased efficiency can result in increased time at sea, fuel expenses, and additional wear on equipment. The spatial extent of de facto exclusion from fishing grounds may be estimated (as a proxy) using US Coast Guard (USCG) safety zone considerations for OCS facilities where 500-meter (1,640 feet) safety zones were established to promote the safety of life and property.[23] Using this approach estimates a 0.785 km^2 (0.303 mi^2) circular exclusion zone per buoy. Although the exclusion area itself is not very large, avoiding this area could mean that fishermen have to modify fishing activity or transits to continue fishing and navigating safely. If fishermen fail to avoid buoys, subsequent entanglement may result in damage to or loss of fishing gear for which they could be held financially liable. Mobile gear types appear to have limited operations in the Morro Bay WEA, however, other fisheries operating within the WEA may also be affected by buoy placement, but the impact is expected to be minimal: deployment and retrieval of other gears may have more maneuverability compared to mobile bottom gear such as trawls.

As described above in more detail in section E, sampling or site assessment activities may result in adverse impacts to fish and other marine species that could lead to an indirect impact on commercial or recreational fishing. Geophysical surveys that use acoustic methods may negatively impact fish in the larval stage as well as have negative impacts on the ability of fish to hear within the water column. To address this concern, BOEM has clarified that high-energy acoustic surveys are not assessed in the EA and will not be authorized as part of a lease, and as such, impacts to fish species are not expected to be significant. Furthermore, **Condition 1(c-e)** requires geophysical surveys to be conducted using low-energy equipment, including subbottom profilers, echosounders, and side-scan sonars, and requires BOEM to encourage lessees to collaborate on their survey plans to increase efficiency and minimize impacts to coastal

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[23] 33 CFR §147.1109

resources associated with the surveys. In addition, survey vessels could disturb important seafloor habitats or accidentally release oil or other hazardous materials into the ocean. As described in more detail in section E, Conditions 1(f) and 2 require BOEM to ensure lessees avoid hard substrate habitat and submit a variety of plans, including an Anchoring Plan, a project-specific Spill Prevention and Response Plan and a Critical Operations and Curtailment Plan to ensure that vessels operate safely and avoid impacts to the marine environment. In addition to data collection buoys, site characterization and assessment activities may result in conflicts to the marine operations and fishing vessels located near offshore of the Central Coast and in the WEA. Proposed lease exploration activities involve survey vessels mobilizing and transiting from port (it is unknown which port at the present time) to the WEA. The number of round trips for project-related vessels over a 3-year period will range from 188–274 for 24-hour operations or 566–598 for 10-hour daily operations. An additional 21–30 round trips will be conducted over a five-year period for the deployment, maintenance, and decommissioning of up to three metocean buoys. The addition of more vessels into the area may reduce efficiency of fishing operations due to time delays associated with congestion. In addition, vessels associated with the leasing activities may accidentally damage fishing gear (e.g., by cutting trap floats) or release marine debris which could cause entanglement or interfere with other fishing operations. Nearshore fishing activities may be further impacted due to the presence of survey vessels conducting site analysis or fish surveys[24] (for example) along potential cable routes. It should be noted, however, that both lease exploration activities and placement of buoys are a temporary impact, which will conclude after approximately 5 years and result in the removal of any installed metocean buoys and their associated gear that may have been anchored to the ocean floor, per BOEM regulations.

Typical mitigation measures to reduce the previously described space-use conflicts focus on avoidance and procedures to increase navigation safety. For example, vessel operators are required to comply with regulations regarding pollution/discharge at sea such as those under the Federal Water Pollution Act which regulates the release of oil at sea, and those under the Clean Water Act, which regulates the discharge of pollution at sea, and the Marine Pollution Convention (Annex V) which regulates discharge of trash at sea. These requirements reduce the likelihood of discharges into the marine environment and ensure that if any accidental releases of trash and debris do occur, the operator is responsible for reporting spills as appropriate, recording authorized discharges, and held accountable through violations and fines if found not in compliance.

Furthermore, at the end of the approximately 5-year lease exploration term, data collection instrumentation will be decommissioned, and large marine objects removed so any existing de facto exclusion zones will be eliminated. To enhance navigational safety, lessees will develop survey plans and SAPs that will include site-specific

[24] Although specific fish surveys have not been proposed, NOAA (NMFS) has indicated that it may be necessary to obtain an Exempted Fishing Permit or Letter of Authorization for the take species. CDFW also has indicated that it may be necessary to obtain a scientific collection permit (dependent on survey activities and locations).

measures to mitigate navigational concerns. Such measures may include a local notice to mariners, designation of vessel traffic corridors, lighting specifications, incident contingency plans, or other appropriate measures. According to BOEM, survey development is an ongoing process, and each survey plan will be carefully evaluated, not only for scientific rigor, but also incorporation of best management practices to ensure measures are taken to minimize impacts to fish species, mammals, and to promote save navigation.

In authorizing similar marine survey or infrastructure projects, the Commission has typically required a series of mitigation measures to reduce or eliminate impacts to fishermen and fisheries resources. Many of these measures are similar if not identical to those required by BOEM.[25] For example, communication with the maritime industry, updating nautical charts and providing notice to mariners are commonly incorporated measures. However, the Commission has also typically included a few additional measures that are not currently included in BOEM's proposed activities. These include specific prohibitions on contact with hard substrate, a submission of several emergency response plans such as spill, anchoring, and critical operations and curtailment (**Conditions 1(f) and 2**).

To ensure these measures are implemented, **Condition 1(a-b)** states that BOEM will encourage continuous and open communication and dialogue between BOEM, the lessees, the Coastal Commission, and other relevant state agency staff during review of survey plans and site assessment plans; BOEM will also coordinate with the Coastal Commission and other relevant state agencies to provide access to the lessees' survey plan submissions. Additionally, **Condition 7** will require continued close coordination with members of the fishing industry, primarily through a fishing liaison, to ensure that timing of surveys is considered (i.e.; in relation to fishing seasons) as well as ensuring proper channels of communication are in place to minimize potential on-water conflict. With these measures included and as described above, the proposed lease activities will be implemented in a manner that recognizes and protects the economic importance of marine resources and commercial/recreational fishing and are therefore consistent with Sections 30230, 30234, and 30234.5 of the Coastal Act.

Future Lease Development Impacts

As described in section B, the purpose of this section is to identify and assess reasonably foreseeable impacts associated with potential future development of offshore wind leases. At this stage, there is not enough information to conduct the type of comprehensive and cumulative socioeconomic analysis for potentially impacted fisheries that will be necessary to evaluate specific projects. However, there is sufficient information to conduct a siting-level analysis that incorporates information on the size of the wind area and the maximum potential build-out capacity, development and infrastructure likely needed to support offshore wind development, the types of fisheries

[25] BOEM guidance for providing information on fisheries social and economic conditions for renewable energy development on the Atlantic OCS is available here: https://www.boem.gov/sites/default/files/documents/about-boem/Social%20%26amp%3B%20Econ%20Fishing%20Guidelines.pdf

present that have a potential to be impacted, and different strategies that have or could be employed to ensure that impacted fishing communities remain protected, viable and resilient.

As described earlier in this section, the waters offshore California support numerous types of fishing, and there is a high cultural and economic significance associated with these activities. In its EA, BOEM identified the fishing grounds for sablefish, thorny heads, chinook salmon, and swordfish as overlapping with the WEA. These fisheries are an important part of the overall landings value in the Central Coast region, and BOEM's finding is consistent with CDFW data presented in the first section. Other fisheries present within or near the WEA include coastal pelagic species, shrimp and prawn, market squid, and Dungeness crab. Market squid, the highest value fishery in the region, is generally fished nearer to shore (Exhibit 3-8) and does not have an identified overlap with the WEA, although could be impacted by cable routes and other lease development activities that would occur closer to the coast. Impacts to fishing from potential wind development are complex and will vary on a fishery by fishery, and even individual basis. However, there are common potential impacts that have already been identified and articulated by the industry.[26] These include:

I. Exclusion. The ocean is a shared space. Fishing and other uses must coexist and work through complex management and regulatory requirements. It is anticipated that offshore wind development areas will become exclusionary zones and will restrict already limited ocean space.

II. Displacement. Related to Exclusion, fishers that are excluded from the WEA may be forced to relocate into other, already limited fishing grounds, placing additional environmental pressure on the remaining habitat, and potentially increasing conflicts between user groups.

III. Increased costs and time at sea to avoid wind development. Placement of wind facilities can delay direct access to fishing grounds and force fishers to fish or drift far outside of lease boundaries due to movement of gear and vessels on the open ocean.

IV. Loss of future fishing grounds. Fishing grounds are highly variable. Continuous and often rapid changes in ocean conditions cause changes to fish populations which in turn result in changes to fishing behavior year over year. Large-scale wind development would eliminate a huge portion of potentially viable fishing area, limiting fishermen's ability to adapt to changes in fishing grounds.

V. Loss or disruption of harbor space and fishing infrastructure at ports due to increased presence of wind related facilities.

Each of these impacts will be explored further below.

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[26] These concerns were brought forth by the fishing community during interagency outreach meetings, as well as derived from a list of concerns submitted by numerous fishing organizations in a public comment letter. The impacts have been summarized in this document, but the full list of concerns/potential impacts can and should be considered in the scope of future project development.

(1) Exclusion

There are currently a multitude of protected and/or conservation areas in both state and federal waters that specifically impact when and where fishing can take place. These areas, which include Essential Fish Habitat (EFH), HAPCs, Marine Protected Areas (MPAs) and National Marine Sanctuaries, also affected the siting of the WEA itself. EFH designates areas important for fish spawning, breeding, feeding or growth, and can include full or partial fishing closures, especially for groundfish. EFH areas near the WEA include Monterey Bay/Canyon, West of Sobrantes Point, Point Sur Deep, Big Sur Coast/Point San Luis, La Cruz Canyon, West of Piedras Blancas State Marine Conservation Area, East San Lucia Bank, and Point Conception (Exhibit 3-14). Northwest of the Morro Bay WEA is the Davidson Seamount, an area which fishing below 500 fathoms is prohibited.

A HAPC is a discrete subset of EFH, which designates areas that provide extremely important ecological functions or are especially vulnerable to degradation. On the western portion of the WEA, there is a large overlap with HAPC (most likely hard bottom habitat), shown in Exhibit 2-1b. MPAs designate important marine habitat areas and may include fishing closures. There are 29 state protected areas in this region between Pigeon Point and Point Conception that cover approximately 204 square miles (three are north of Monterey County): approximately half allow some amount of commercial and recreational fishing (CDFW, 2019b). The Monterrey Bay National Marine Sanctuary is adjacent to a northeast portion of the WEA in federal waters, and the proposed Chumash Heritage National Marine Sanctuary (which is still in process of pursuing designation) shares its southern border.

The protected area exclusions described above are just one example of fishing exclusion. Certain types of fishing areas are also limited by seasonal closures, depth limitations, gear restrictions, and quota limits, which affect the amount of allowable catch. These limitations result in much smaller areas in which fishermen are able to continue to harvest catch. Although not yet completed, this is expected to be illustrated through a story map created by Central Coast fishermen that is similar to the North Coast Fisheries Mapping Project.[27]

On top of the exclusions described above, offshore wind development within the WEA would likely result in an additional up to 376 square miles closed to fishing for at least the next three decades and likely longer. Based on a review of current fisheries data, several different fisheries could be affected by exclusion from the WEA. These include salmon, hagfish, groundfish, and HMS (including recreational). While fishing for salmon could potentially occur in the WEA, based on the expansive range of the species, most documented fishing activities for the species occur in closer proximity to the coast. The dominant form of groundfishing in the WEA is pot (typically for sablefish) which would be impacted by leasing and future development projects. Trolling gear and some gear used with HMS and fishing techniques are slightly more flexible, it is not certain that salmon trolling or all HMS fishing would be wholly excluded from the WEA. With respect

27 (North Coast Fisheries Mapping Project (arcgis.com))

to HMS, it is anticipated that this fishery (both commercial and recreational) may be impacted by the execution of leasing activities and wind development because it will inhibit direct access to some fishing grounds such as those used by the swordfish fishery. Additionally, given the variability of the temperature margins that HMS species follow, it is possible that the species distribution could overlap at higher (or lower) levels with a physical location of future development. Like salmon, hagfish activity is also generally reported closer to shore, although the depth range of the species overlaps with the WEA. With respect to shrimp fishing, the pink shrimp and spot prawn fishery range is shallower than the current boundary of the WEA, and are not likely to experience significant impacts from the leasing activities (Exhibit 3-15). CPS also occur closer to shore and are not likely to experience significant overlap with survey activities.

(2) Displacement

Displacement occurs when fishermen can no longer access historic grounds and instead seek fishing opportunities elsewhere, which can overlap and lead to conflicts with other fisheries. The impacts associated with displacement can be difficult to quantify in areas such as the Central Coast where fishing activity that takes place in and around the WEA may not be landed at one of the Central Coast ports (i.e., Moss Landing, Monterey, Morro Bay or Port San Luis/Avil), but in more distant ports, such as Santa Cruz, San Francisco or farther south in Santa Barbara or LA/LB. Or, even if fish are caught and landed in the Central Coast, it is often the case that a significant portion of the fishing vessels are homeported outside the region, making it difficult to track impacts associated with displacement.

For offshore fisheries such as groundfish, salmon, and HMS, development within the WEA could result in the need to relocate to other fishing grounds that are less valuable, farther away or already in use by other fishermen, if adequate fishing grounds are available under current environmental and regulatory conditions. Displacing fishermen into fishing grounds that are farther away could result in increased costs related to time and fuel, and safety risks resulting from fishing farther away from port, or close to wind facilities.

Nearshore fisheries, such as CA halibut, market squid, CPS and Dungeness crab, that are caught in waters primarily inshore of the WEA, are not expected to experience direct impacts from offshore wind turbines in the WEA but may be displaced by related development. Offshore wind development will require power cables and other infrastructure to bring the power onshore. Construction and operation of these cables can adversely affect fishermen through temporary displacement or interference during construction, and as an ongoing hazard especially for fishermen using bottom contact gear. For example, fishermen using trawls or other gear that has bottom contact run an increased risk of snagging on the cable and losing or damaging gear. For some previous fiber optic cable projects, fishermen and cable companies have agreed to a "no fishing" buffer around the fiber optics cables in order to minimize potential interaction and snags. In addition, nearshore fisheries are likely to be competing for space with other fisheries that have been displaced. For example, the nearshore area directly offshore of the Central Coast supports high, episodic squid fishing activity, and this is certainly a concern for this and other nearshore fisheries.

For the recreational sector, the presence of fishing within the WEA is somewhat limited. It is possible, however, that development within the WEA could inhibit access to fishing grounds for highly migratory species, such as albacore tuna or swordfish, or other species that may occur farther offshore such as rockfish. There is significant variation with the location of fishing for HMS activity due to the variability of temporal habitat. However, the general trends of the fishery appear to be to the north (in their highest density) of the WEA, which suggests that the recreational (as well as commercial HMS fishery) is not likely to be significantly displaced from its fishing grounds (**Exhibit 3-13**). As future conditions shift, conflicts could occur.

(3) Increased costs and time at sea

The potential development of wind facilities offshore of the Central Coast could result in increased time (and therefore cost) of being at sea for many fishermen. Displaced fishermen may need to travel farther away to achieve the same catch. This could mean much longer trips in and out of ports, which increases fuel costs, vessel wear and tear, and potentially the number of overall trips a vessel could take due to time on the water. The simplest way to describe this is through an example. As shown in **Exhibit 3-10** the albacore tuna fishery is active primarily on the north side of the WEA. Currently, fishing that takes place from the ports south of the WEA would access fishing grounds through a direct route.

According to the data generated by Coastal Commission staff (and inspired by the North Coast fishermen's mapping study) (**Exhibit 3-16**) it currently takes approximately 7 hours to access the center of the WEA. If fishermen are no longer able to take a direct route through the WEA, but instead have to go around, that can add at least one or more hours to the trip depending on the wind facility layout. That additional transit time adds fuel costs, and reduces the amount of time the fishermen spend actually fishing (depending on the fishery). More time to access fishing grounds can ultimately result in an overall reduction of trips that a vessel is able to take. Less trips generally equate to less overall harvest, or in the case of recreational/CPFV fishing, less business. Vessels also report that in circumstances where the vessels remain at sea overnight, a vessel can drift as far as 10 nautical miles. This would mean that fishermen in this situation would need to leave a 2-hour buffer from a wind farm to ensure that they were not placing their vessels or persons at risk of collision.

Finally, many fishermen have brought up the fact that fishing around wind development will require additional space beyond the boundary of the WEA. Certain types of fishing gear, such as a sablefish pot, drift horizontally in the water column before it reaches the bottom. The horizontal distance travelled varies with ocean conditions, but can drift up to a mile from where it was set. If fishing in or around a wind facility, this would add a mile buffer around the entire perimeter of the lease area that would also be considered unfishable (subject to an individual fishermen's assumption of risk).

(4) Loss of future fishing grounds.

Fishing is a highly variable vocation, and as such, the construction and operation of a stationary offshore wind facility and its associated infrastructure have a high probability of impacting the ability of fisheries to adapt to the changing spatial-temporal conditions that define fishing. This makes predicting the exact potential for loss of future fisheries as a result of wind development extraordinarily difficult. Fishing activity, especially for HMS fisheries which vary seasonally in relation to water temperature, are already difficult to predict year to year with precision. When coupled with broad scale predictions and uncertainty related to climate change, including expectations that species will shift north with warming water trends, it's nearly impossible to say with precision what fisheries will look like in the future. However, given the realities of a warming ocean and climate change, it is highly likely that future fishing grounds will be different than they are today.

A potential loss of future fishing grounds could apply to multiple fisheries, whether or not they have occurred in the WEA in the past. This includes the HMS fishery, ocean salmon, groundfish, and hagfish (an open access fishery). Specifically described with the groundfish trawl industry was the recent return of permits to the industry in 2019, which allow the activity to resume after nearly two decades of cessation.[28] While activity of this type is not currently occurring in great volume, the construction of offshore wind facilities would substantially lessen the area where it could.

Currently under development is a comparable study to the North Coast Fishermen's Mapping Project,[29] which mapped potential future fishing grounds in the North Coast (see **CD-0001-22 exhibits**), which is expected to show fishing potential on the Central Coast, which may (or may not) overlap with the Morro Bay WEA. Regardless, a loss of area to use for future fishing operations makes it more difficult to adapt fishing operations over time, and as such, business planning for successful years of operations takes on a higher level of uncertainty. This uncertainty can also expand to related fishing businesses such as processors and wholesale retailers. As aptly explained in a public comment letter on the Morro Bay Draft EA from Alliance of Communities for Sustainable Fisheries:

> *...ex-vessel values translate into waterfront economic activities. As stated in a 2017 report prepared for the Morro Bay Commercial Fishermen's Organization (MBCFO), ex-vessel values from commercial fishing are: "...directly responsible for approximately 200 jobs for skippers, deckhands, dock workers and local seafood processors, and represents a success story in attracting and retaining businesses and supporting local business ownership and employment. The commercial fishing industry and the activity driven by the working waterfront make up the backbone of Morro Bay's Robust and Diverse economy."*

This sentiment echoes concerns raised by fishermen and processors on the North Coast: that even a small loss of fishing grounds and activity can have much more

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[28] Another example of future fisheries that may be limited by development is Box Crab (Coates, 2018). The species is currently authorized for limited/exploratory harvest under an experimental fishing permit overseen by State fish and wildlife regulators. Three EFPs were authorized for fishing in state waters north of Pt. Conception (and 5 south of Pt. Conception).

[29] North Coast Fisheries Mapping Project (arcgis.com): A similar exercise is occurring for Central Coast fisheries.: A similar exercise is occurring for Central Coast fisheries.

expansive impacts to associated businesses.

(5) Loss or disruption of harbor space and fishing infrastructure at ports due to increased presence of wind related activities and facilities.

Offshore wind development in the Morro Bay WEA may require substantial port and harbor space to support assembly and staging of turbines and other equipment. There are a few existing and ongoing studies examining feasibility of various ports the state, to serve as a support base for the offshore wind industry. However, ports such as Los Angeles/Long Beach, Port Hueneme, Diablo Canyon, Morro Bay, and even ports farther north such as Oakland could serve to support OSW in a future development capacity. As these studies and decisions are ongoing, the scope and scale of upgrades needed to support offshore wind infrastructure on the north and Central Coasts, and thus any coastal resource impacts that would result from those upgrades, is uncertain. However, examples from the east coast can provide some information that can assist in describing potential impacts.

As noted above, staging for offshore wind and the associated pier/berth facilities can take up a significant amount of space. In the Port of New Bedford, which is an urban port in Southeastern, MA being developed as a staging area for (currently) two offshore wind projects, a 29-acre site is being developed on an existing waterfront site. Features of the New Bedford OSW marine terminal include:

- Co-location with more than 200 maritime businesses
- 29-acre facility, including 21-acres of heavy-lift capacity: uniform loading up to 4,100 pounds/square foot and crane loads of up to 20,485 pounds/square foot
- 1,200 feet of bulkhead, including 800 feet of deep draft berthing and 400 feet of barge berthing space
- Within the most protected port in the U.S., with the U.S. Army Corps Hurricane Barrier that guards against storms up to Category 3 hurricanes
- No height restrictions on site, and no overhead restrictions from the Terminal to open water
- Easy roadway connections to interstate highway system via I-95 or I-495 (via connections through New Bedford Route 18 and MA Route 140 and/or Route I-195)
- No Harbor Maintenance Tax

In terms of fishing, New Bedford is considered one of the most economically valuable fishing ports in the country supporting more than 100 (homeported) vessels and landing more than a million pounds of seafood a day (Commercial Fishing, 2018). It is home to vessels, processors, wholesalers and restaurants that all rely on the industry. The incorporation of the offshore wind site in New Bedford is on an existing developed parcel, and part of the design includes expanded seafood offloading facilities. An important distinction between the two coasts is that the wind turbines on the West Coast have the potential to be much larger than those used on the east coast, and thus, the space needed to stage them (and the vessels needed to transport them) will likely have to be larger.

For the fishing industry, expanded development within the many of the aforementioned ports could result in additional concerns related to traffic, loss of port and harbor space and facilities. For example, large vessels, such as those needed to transport turbine structures could prevent other vessels from transiting in designated channels and delay in and outbound transits when they are operating. It could also force vessels to operate outside of main channels, which may harm sensitive natural resources such eelgrass. However, as noted in the industry letter received on February 9th, 2022, there can also be some benefits of co-location such as decreased fuel prices and even general harbor space improvements/repairs. Keeping this siting information in mind, it will be important to consider the location of offshore wind staging within the harbor, overall spatial requirements, and the additional impact minimization measures that can be incorporated into the design that could lessen impacts to the fishing industry and thus be consistent with Coastal Act Section 30234.

Coastal Act Analysis and Approaches to Avoidance, Minimization and Mitigation

As described in detail in the previous sections, activities related to offshore wind leasing and foreseeable future development within the Morro Bay WEA will result in impacts to the fishermen and fisheries of California's Central Coast. Several fisheries: pot: (sablefish) drift gillnet (thresher shark/swordfish), and trolling (albacore tuna) currently overlap with portions of the WEA and would likely be excluded from these areas if offshore wind development is authorized. To varying degrees, all Central Coast fisheries would likely be affected by temporary or permanent displacement, increased cost and time at sea, traffic, loss or disruption of harbor space and fishing infrastructure within the port and potential loss of future fishing grounds. As described above, some of these effects would be felt directly and immediately with lease exploration activities. Other effects would be felt later in time—likely in the context of lease development activities—but are still reasonably foreseeable and need to be analyzed and addressed, at least at a broad scale, at this point in time. In addition, the leasing action itself will have immediate effects on fishing because it creates uncertainty for fishermen about where they will be able to fish in the future, which affects their ability to conduct longer term financial planning, such as deciding whether to take on debt to purchase new equipment. Communications with the fishing industry during outreach activities and through comments on the BOEM Draft EA reiterate this concern.

Although the exact impacts of future wind development are not known at this time, there are immediate and reasonably foreseeable future effects that need to be addressed in order to protect the economic and commercial importance of fishing activities, as required by Coastal Act Sections 30234.5 and 30230. The Central Coast landings averaged $19.6 million annually (2010-2020 average), accounting for approximately 12% of commercial landings statewide[30]. This value does not fully address the economic value of fishing crews, fish processors, gear manufacturers, ship supply and

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[30] The Fisheries of the U.S. report, page 38, states $164,327,000 of annual landings in 2019 for the state of California.

repair businesses, seafood retailers and restaurants in the Central Coast and beyond. As such, the high-value fishing grounds in the Central Coast and the species that are fished there can be considered areas and species of special economic significance that garner specific protection under Section 30230. For example, the pot fishery for sablefish, which contributes a significant portion of the overall catch landed in the Central Coast, is likely to experience direct impacts (i.e.; economic loss) given the overlap in fishing activity with the WEA boundaries.

The Coastal Act requires the protection of commercial and recreational fishing activities, and there are a variety of actions that could be taken to ensure that California's Central Coast fishermen are protected and recognized. These could include disallowing offshore wind development in portions of the WEA that correspond to the highest value fishing grounds for the affected fisheries, creating buffers within the boundaries of the WEA to allow for fishing activity to safely operate around the perimeter, developing a program that helps affected fisheries adjust to changes in fishing grounds, gear transitional programs, or developing a comprehensive mitigation package that adequately compensates fishermen for the loss of these fishing grounds, and many options in between.

It is possible, if not likely, that the ultimate solution will include elements of all these options. At this time, it is not necessary to decide exactly how all of these impacts need to be addressed. It is critical, however, that discussions about how to address impacts to specific fisheries, and to the Central Coast fishing industry as a whole, include affected fishermen and representatives of the fishing industry. It is also necessary at this point in time to have BOEM, in concert with the Coastal Commission, other state and federal agencies, Tribes, and fishing interests, begin setting forth a framework for how the entire wind development process- from leasing decisions through actual wind development-will address the effects that the process will have on fishing activities. If this framework is not set up until later stages of the offshore wind development process, such as during BOEM review of a COP, it will force the fishing industry to operate for the next several years with significant uncertainty about potential future development. In addition, if BOEM waited until lessees submitted COPs to analyze and address impacts to fishing, it would likely be too late to gather the necessary information about the scale and location of fishing activities as well as potential avoidance, minimization and mitigation measures that are needed to adequately evaluate and address impacts. This could significantly delay future project approvals.

In recognition of the importance of direct engagement, and in an effort to begin the discussion with fishermen about how best to address the impacts described above, representatives from State agencies, including Commission staff, and BOEM held a series of meetings with representatives of the fishing community in Crescent City, Eureka, Fort Bragg, Santa Barbara, and Morro Bay.[31] At this stage of the offshore wind process, the goal of the outreach was to meaningfully engage the fishing community about the state and federal processes for OSW development, hear their concerns, answer questions, and determine what the most appropriate avenue for addressing

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[31] Meeting Summaries are available here: Upcoming Projects (ca.gov)

impacts and mitigation would be moving forward. At these meetings, there were several concerns that were echoed coastwide, that have largely been reflected in the impact analysis above. Fishermen had many questions about the scale and type of development that might take place in the coming years, concerns that the exclusions, displacement and spatial conflicts would severely limit their ability be profitable and to ensure the longevity of the industry, and an interest in an approach to mitigation that is fair, equitable, and focuses on resilience of the fisheries and of the fishing industry. These sentiments have also been reflected in follow up conversations with key representatives from the fishing community. Most of the fishermen who attended outreach meetings expressed their desire to continue fishing for years to come and to be able to pass down their knowledge and vocation to the next generation.

To achieve these goals, as well as the special protection required by the Coastal Act, all parties – fishermen, offshore wind developers and state and federal agencies – will need to work collaboratively towards a common strategy to avoid, minimize and mitigate impacts to the fishing industry in a consistent and equitable manner. As the Central Coast is not the only offshore region that is being considered for offshore wind development (see CD-0001-22), it is important that the overall strategy be consistent statewide to ensure fairness. BOEM has acknowledged the need for a comprehensive and fair way to address the impacts that offshore wind has on fishing interests and recently conducted a request for information and public comment period on the strategies to addressing impacts to the fishing industry from offshore wind energy development.[32] BOEM is also working with NMFS to effectively manage potential impacts to fisheries surveys that are a critical component of the fisheries regulatory framework.

Similar to the fishing agreements required by CDPs authorizing fiber optic cable installation and operation, the strategy will need to include communication protocols, best practices for surveys and data collection, specific measures for avoiding and minimizing impacts for various stages of offshore wind development, and a framework for compensatory mitigation to address unavoidable impacts. These goals and strategy components are consistent with verbal and written correspondence the Commission has received from fishermen from across the state. For example, a February 9, 2022 letter from sixteen (statewide) fishing and maritime organizations discusses the need for fishing agreements (page 3):

> *The principals of impact avoidance, minimization, and non-monetary mitigations should be considered for all aspects of an OSW project prior to compensation-mitigation discussions. Make no mistake: fishermen would rather have their areas of opportunity preserved than have financial compensation for the loss.*

Once the strategy is developed, it will need to be applied through fishing agreements between an entity representing fishermen and the developers. These agreements will

[32] Request for Information on Reducing or Avoiding Impacts of Offshore Wind Energy on Fisheries | Bureau of Ocean Energy Management (boem.gov)

need to lay out how mitigation funds will be spent, how decisions will be made, and the process for amending the agreement as needed. It is the Commission's expectation that signed fishing agreements, consistent with the statewide strategy described above, will be completed and submitted as part of any application for a CDP or a consistency certification for an offshore wind project. To ensure progress toward development of the statewide strategy, Condition 7 requires BOEM to work with Commission staff and other state agency staff to facilitate a working group consisting of fishing representatives, offshore wind industry representatives and federal and state agency staff to develop the components of the strategy including a fishing agreement template. Condition 7 also requires that the strategy include specific consideration for those fisheries that are disproportionately and/or directly affected by offshore wind development. Finally, to ensure that potential impacts to commercial and recreational fishing during the lease exploration phase are minimized, Condition 7 requires BOEM to require lessees to have an independent fisheries liaison that is responsible for coordination and communication with affected fishermen and harbor districts. The liaison will work with fishermen to coordinate timing of survey work, which has been a documented source of conflict on the east coast, to and develop a process for reporting and remediating conflicts.

In addition to development of the strategy described above, based on a review of projects developed on the east coast, it can be assumed that at a minimum, the design of future wind farms should incorporate measures that ensure safe navigation through the lease areas, including possible identification of transit corridors. This is needed to ensure continued, safe access to fishing grounds surrounding a potential wind farm, to alleviate lengthy transit times, and to ensure that the economic interests of the fishing industry are protected so that the industry can continue to effectively harvest from the region. BOEM has conveyed that these concerns will likely be addressed through the subsequent stages of its leasing process in which the USCG will be conducting a Navigational Safety Risk Assessment. This process has the goal of promoting navigational safety but is not a unilateral decision. Rather, the USCG makes recommendations based on the best available information to apply transit lanes and/or other safety measures to BOEM that the Bureau may then apply to its lessees. Commercial fishing traffic patterns are a component of this analysis and have been integrated into prior risk assessments, such as those that have been completed on the east coast (U.S. Coast Guard, 2018). Condition 4 ensures that BOEM will work with stakeholders, including the USCG, NOAA, state agencies and the fishing and maritime industries to ensure navigation through the lease areas.

Conclusion

Leasing activities and foreseeable future offshore wind development within the Morro Bay WEA will result in project-specific and cumulative adverse impacts to multiple fisheries of economic and social importance to the state of California. Fisheries and fishing communities are likely to be directly impacted by lease exploration activities, including by having increased vessel traffic in the ports near the area, exclusion areas around metocean buoys, and the economic uncertainties caused by BOEM's leasing process. In addition, the exact scale and location of future wind development is unknown at this time, but it is reasonably foreseeable that there will be future development of at least some OSW projects. Such projects would affect fishing directly due to the presence of wind turbines and related infrastructure (exclusion and displacement) as well as indirectly through increased vessel traffic, potential harbor development and decreases in trip efficiency. Although some of these activities will occur outside of the coastal zone, much of the development activity—such as harbor development and use, as well as cable-laying—will occur within the coastal zone. Also, both the activities in and outside of the coastal zone will have coastal effects, as they will both affect the coastal fishing community, the volume and value of fish landed at ports and harbors, and the coastal economy. As such, it is imperative that BOEM, lessees and developers work with the fishing community to minimize these effects in the planning and development of potential projects to ensure that the seafood industry in the Central Coast remains viable and robust. To achieve this, Condition 7 requires that BOEM require lessees to have an independent fisheries liaison to coordinate with fishermen and that BOEM work with state agencies to facilitate a process to develop a statewide strategy for avoiding, minimizing and mitigating impacts to the fishing industry from offshore wind development. With the measures incorporated by BOEM into its leasing program and the conditions imposed by the Commission, BOEM's proposed activities are consistent with the Coastal Act's mandate to protect commercial and recreational fishing.

G. Oil Spills

Section 30232 of the Coastal Act states:

> *Protection against the spillage of crude oil, gas, petroleum products, or hazardous substances shall be provided in relation to any development or transportation of such materials. Effective containment and cleanup facilities and procedures shall be provided for accidental spills that do occur.*

Lease Exploration

The issuance of leases and subsequent site assessment and characterization activities have the potential to result in oil spills within or outside of the coastal zone, either of which could affect coastal resources. According to the CD, a spill of petroleum product could occur as the result of hull damage from collisions with a metocean buoy, collisions between vessels, accidents during the maintenance or transfer of offshore equipment and/or crew, or due to natural events (i.e., strong waves or storms). As described in previous sections of these findings, vessel traffic is expected to approximately triple as a result of lease exploration activities, increasing the risk of an oil spill incident.

The CD provides general information on potential impacts from an oil spill, concluding that an oil spill would dissipate very rapidly and would then evaporate and biodegrade within a day or two, limiting the potential impacts to a localized area for a short duration. Regarding the potential for a diesel spill to enter ocean waters and affect coastal resources, the CD states:

> *From 2000 to 2009, the average spill size for vessels other than tank ships*

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FACSIMILE TRANSMITTAL SHEET

HOLLY WYER, SENIOR ENV. SCIENTIST CALIFORNIA COASTAL COMMISSION	FROM: WILLIAM S. WALTER, ESQ.
COMPANY:	DATE: 12-8-2023
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NOTES/COMMENTS:

ATTACHED IS CORRESPONDENCE DATED 12-8-2023 IN BEHALF OF MBCFO AND PSLFA IN RESPONSE TO CORRESPONDENCE FROM HOLLY WYER

TOM HAFER EMAIL TO COASTAL COMMISSION, STATE LANDS COMMISSION ON MARCH 13, 2024, SUMMARIZING AND INCLUDING:

RAND ACOUSTICS, LLC
“SONAR VESSEL NOISE SURVEY
“TECHNICAL REPORT”
MAY 8, 2023

RAND ACOUSTICS, LLS
“PILE DRIVING NOISE SURVEY
“TECHNICAL REPORT”
MARCH 28, 2024

Rand Acoustic report sent Feb. 2 to CCC and SLC

mbcfo member <mbcfo1972@gmail.com>
Thu 4/4/2024 6:40 AM
To:Bill Walter <williamswalterpc@gmail.com>

Begin forwarded message:

From: mbcfo member <mbcfo1972@gmail.com>
Subject: Fwd: IHA applications need to account for HRG survey vessel thruster positioning system - Study finds they were not on the East Coast
Date: March 13, 2024 at 8:53:31 AM PDT
To: Bill Walter <williamswalterpc@gmail.com>

Begin forwarded message:

From: mbcfo member <mbcfo1972@gmail.com>
Subject: IHA applications need to account for HRG survey vessel thruster positioning system - Study finds they were not on the East Coast
Date: February 2, 2024 at 8:54:19 AM PST
To: Doug Boren <douglas.boren@boem.gov>, Scott Flint <Scott.Flint@energy.ca.gov>, Greg Haas <greg.haas@mail.house.gov>, Eli Harland <eli.harland@energy.ca.gov>, Kate Huckelbridge <kate.Huckelbridge@coastal.ca.gov>, Jennifer Lucchesi <Jennifer.Lucchesi@slc.ca.gov>, Jennifer Mattox <Jennifer.Mattox@slc.ca.gov>, John Romero <john.romero@boem.gov>, Holly Wyer <holly.wyer@coastal.ca.gov>
Cc: Bill Walter <williamswalterpc@gmail.com>, Alan Alward <7aalward@gmail.com>, Bill Barrow <fvzfrog@charter.net>, Bill Blue <bluefisheries1@gmail.com>, Bill Diller <wdiller911@gmail.com>, Justin Franklin <justin.franklin1270@gmail.com>, Owen Hackleman <ohackleman@gmail.com>, Tom Hafer <somethingsfishy@charter.net>, Bob Maharry <mohay1954@aol.com>, Wayne Moody <fvcapriccio@yahoo.com>, Matt Newman <newmatic4000@gmail.com>, Jeremiah O'Brien <aguerofish@gmail.com>, Chris Pavone <pavonefish@gmail.com>, Ross Rickard <dirtydiego41@gmail.com>, Garrett Rose <garrettrose0@gmail.com>, Gerald Sato <sakanacustard@gmail.com>, Ted Schiafone <tschiafone@morrobayca.gov>, Mark Tognazzini <mbtog@aol.com>, Bill Ward <fvdbear@charter.net>

Dear Federal and State Agencies responsible for Offshore Wind farms coming to the California coast, A very experienced acoustician from Maine, Robert Rand, conducted noise measurements during HRG activity at a wind lease 40 miles off the NJ coast and wrote a report on that work. He details the conditions of the monitoring, the specs of his equipment and the different sonars he recorded and their respective frequencies. His report can be downloaded from this link - https://randacoustics.com/papers He was able to match the frequencies to the devices that the applicant said they'd be using however, **the source noise levels in dB did not account for the sparker (medium penetration sub-bottom profiler) used in the vessel positioning system.**

The survey vessel studied required a "sparker" sub-bottom profiler (SBP) and several mid-frequency (MF) positioning system sonars (USBL) that measured, including two impulsive, intermittent USBLs at 19.5 and 20 KHz, and two FM swept-sine USBLs at 21 to 32 KHz.

His study found that the **vessel continuous noise** included propulsion and dynamic positioning **thruster noise measured 128.5 DB from 9.5 Hz to several kiloHz audible at 4 NM.** NMFS requires continuous noise greater than 120dB to maintain 1 NM (1852 meters) from listed endangered species. The geophysical survey vessels were only maintaining 50 meters - 500 meters from marine species.

He found that the **Wind developers did not analyze or list the USBL positioning system on their IHA Applications**. So the IHA applications were listed 16 dB quieter than expected. This altered the calculations for the required distance for Level B Harassment to be only 141 meters when it should have been actually 820 meters.

This is another example of why there **needs to be a comprehensive monitoring and mitigation plan BEFORE the Site Characterization Surveys begin.**

Tom Hafer
President Morro Bay Commercial Fishermen's Organization

Here is the Executive Summary from Robert Rand's report:

EXECUTIVE SUMMARY

Reports of recent whale and dolphin deaths on and near the New York and New Jersey shores, and public concerns of marine noise impacts from offshore wind development activities, prompted an investigation into the sonar noise levels produced by exploratory survey vessels working in ocean areas leased by the Bureau of Ocean Energy Management (BOEM). This technical report presents the methodology, analysis and results of a brief independent investigation of underwater noise levels from a sonar survey vessel, conducted offshore New Jersey on May 8, 2023. Underwater acoustic recordings were acquired between 8:09 and 9:40 am, approximately 43 nautical miles (NM) east of Barnegat Light, Long Beach Island, NJ, near a mobile geophysical survey vessel, the Miss

Emma McCall (vessel). A "sparker" sub-bottom profiler (SBP) and several mid-frequency (MF) positioning system sonars (USBL) were measured including two impulsive, intermittent USBLs at 19.5 and 20 KHz, and two FM swept-sine USBLs at 21 to 32 KHz. An SBP listed for the vessel operating above 85 KHz was not measured as it was above instrumentation range. Transmission loss (TL) was larger at higher frequencies generally above 3000 Hz due to excess attenuation which is expected for the distances measured and shallow-water acoustic conditions.

Peak sound levels were controlled by the sparker and measured 151.6 dB,peak re 1uPA at 0.5 NM. The sparker source level (SL) was estimated at 224 dB,peak re 1uPa@1m, consistent with the sparker manufacturer's published SL of 2 Bars/m (226 dB,peak re 1uPa). Using NOAA National Marine Fisheries Service (NOAA Fisheries or NMFS) 2020 guidelines based on Crocker and Fratantonio (2016), the sparker RMS level is estimated at 219 dB,rms re 1uPA@1m.

Vessel continuous noise included propulsion and dynamic positioning (DP) thruster noise emissions. Vessel noise was tonal, containing multiple cyclical/rotational tonal noise components from 9.5 Hz to several kilohertz, and was highly audible at 0.5, 1 and 2 NM. Vessel tonal noise was audible and measurable at 4 NM. Vessel continuous noise measured 126.5 dB,rms re 1uPA at 0.5 NM. Total vessel continuous noise with sparker was 128.5 dB,rms re 1uPA at 0.5 NM.

The vessel's Incidental Harassment Application (IHA) was reviewed. The USBLs are impulsive yet were not listed or analyzed in the vessel IHA application. Vessel propulsion and DP thruster noise were also not listed or analyzed in the IHA application. The sparker proxy SL,rms used in the IHA application was cited as 16 dB quieter than expected based on manufacturer published levels harmonized with NMFS guidance for RMS noise levels. The IHA listed a 160 dB,rms Level B Behavioral Harassment threshold of 141 meters for the sparker impulsive noise, whereas the threshold using the NMFS Level B spreadsheet tool for calculating the distance to the Level B threshold with manufacturer data returned a distance of 890 meters.

To meet the NMFS 120 dB,rms behavioral harassment limit for continuous noise, the distance required is approximately 1 nautical mile (1852 meters). However, the vessel was operating with a vessel separation distance of 500 meters for the North American right whale (NARW) and other ESA-listed mammals and 50 or 100 meters for all other marine mammals. The IHA is silent regarding the 120 dB,rms Level B behavioral harassment threshold.

The data acquired during the survey and subsequent review of the IHA application raise concerns of sufficient NOAA review and mitigation distances to protect the critically endangered NARW and other marine species from behavioral harassment and temporary threshold shift (TTS) impacts.

Rand Acoustics, LLC, September 22, 2023

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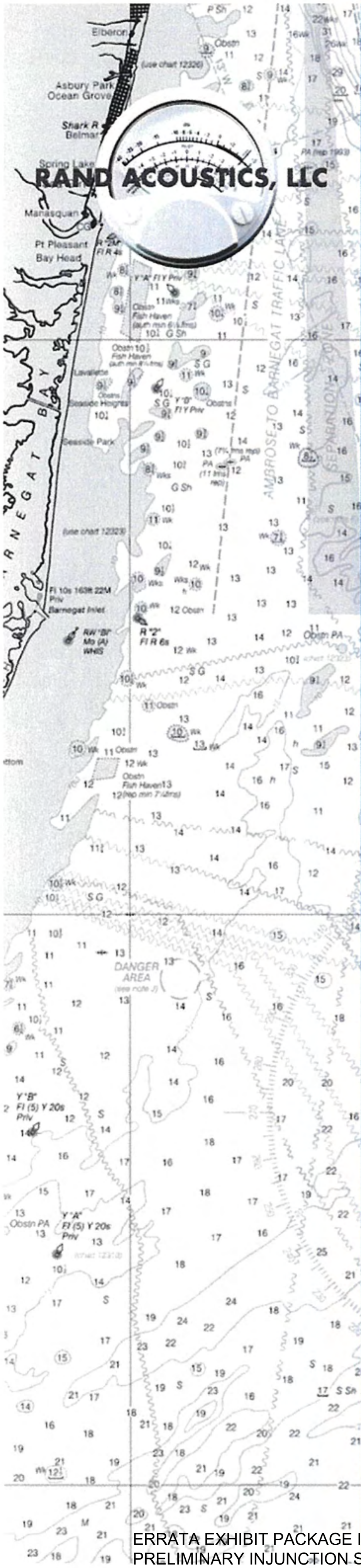

SONAR VESSEL NOISE SURVEY
Technical Report

Survey Date:
May 8, 2023

Report Date:
September 22, 2023

Rand Acoustics, LLC
65 Mere Point Road
Brunswick, ME 04011

Abstract

This technical report presents the methodology, analysis and results of a brief independent investigation of underwater noise levels from a sonar survey vessel, conducted offshore New Jersey on May 8, 2023.

Keywords: noise, offshore, survey, vessel, hydrophone, sonar, sparker, threshold, transmission loss, SEL, thermocline

Foreword

This technical report serves as a comprehensive document intended to provide valuable insights, analysis, and information pertaining to geophysical sonar vessel operational noise. It has been prepared to support understanding of vessel and sonar noise emissions for a diverse audience, including professionals, researchers, policymakers, and interested stakeholders. The primary purpose of this report is to facilitate informed decision-making, foster discussion, contribute to the advancement of knowledge in this field, and improve noise control protections for the critically endangered North Atlantic right whale and other ESA-listed mammals and marine species.

Disclaimer

The information contained in this technical report is presented in good faith and based on the best available data and analysis at the time of publication. However, it is important to note that the content is subject to change as new research, developments, or circumstances emerge. The author makes no representations or warranties, either express or implied, regarding the accuracy, completeness, or suitability of the information provided. Users of this report are encouraged to verify the information independently and consider consulting relevant experts when making decisions based on its content.

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CONTENTS

EXECUTIVE SUMMARY

Reports of recent whale and dolphin deaths on and near the New York and New Jersey shores, and public concerns of marine noise impacts from offshore wind development activities, prompted an investigation into the sonar noise levels produced by exploratory survey vessels working in ocean areas leased by the Bureau of Ocean Energy Management (BOEM). This technical report presents the methodology, analysis and results of a brief independent investigation of underwater noise levels from a sonar survey vessel, conducted offshore New Jersey on May 8, 2023. Underwater acoustic recordings were acquired between 8:09 and 9:40 am, approximately 43 nautical miles (NM) east of Barnegat Light, Long Beach Island, NJ, near a mobile geophysical survey vessel, the Miss Emma McCall (vessel). A "sparker" sub-bottom profiler (SBP) and several mid-frequency (MF) positioning system sonars (USBL) were measured including two impulsive, intermittent USBLs at 19.5 and 20 KHz, and two FM swept-sine USBLs at 21 to 32 KHz. An SBP listed for the vessel operating above 85 KHz was not measured as it was above instrumentation range. Transmission loss (TL) was larger at higher frequencies generally above 3000 Hz due to excess attenuation which is expected for the distances measured and shallow-water acoustic conditions.

Peak sound levels were controlled by the sparker and measured 151.6 dB,peak re 1uPA at 0.5 NM. The sparker source level (SL) was estimated at 224 dB,peak re 1uPa@1m, consistent with the sparker manufacturer's published SL of 2 Bars/m (226 dB,peak re 1uPa). Using NOAA National Marine Fisheries Service (NOAA Fisheries or NMFS) 2020 guidelines based on Crocker and Fratantonio (2016), the sparker RMS level is estimated at 219 dB,rms re 1uPA@1m.

Vessel continuous noise included propulsion and dynamic positioning (DP) thruster noise emissions. Vessel noise was tonal, containing multiple cyclical/rotational tonal noise components from 9.5 Hz to several kilohertz, and was highly audible at 0.5, 1 and 2 NM. Vessel tonal noise was audible and measurable at 4 NM. Vessel continuous noise measured 126.5 dB,rms re 1uPA at 0.5 NM. Total vessel continuous noise with sparker was 128.5 dB,rms re 1uPA at 0.5 NM.

The vessel's Incidental Harassment Application (IHA) was reviewed. The USBLs are impulsive yet were not listed or analyzed in the vessel IHA application. Vessel propulsion and DP thruster noise were also not listed or analyzed in the IHA application. The sparker proxy SL,rms used in the IHA application was cited as 16 dB quieter than expected based on manufacturer published levels harmonized with NMFS guidance for RMS noise levels. The IHA listed a 160 dB,rms Level B Behavioral Harassment threshold of 141 meters for the sparker impulsive noise, whereas the threshold using the NMFS Level B spreadsheet tool for calculating the distance to the Level B threshold with manufacturer data returned a distance of 890 meters.

To meet the NMFS 120 dB,rms behavioral harassment limit for continuous noise, the distance required is approximately 1 nautical mile (1852 meters). However, the vessel was operating with a vessel separation distance of 500 meters for the North American right whale (NARW) and other ESA-listed mammals and 50 or 100 meters for all other marine mammals. The IHA is silent regarding the 120 dB,rms Level B behavioral harassment threshold.

The data acquired during the survey and subsequent review of the IHA application raise concerns of sufficient NOAA review and mitigation distances to protect the critically endangered NARW and other marine species from behavioral harassment and temporary threshold shift (TTS) impacts.

1 Introduction

1.1 Background

Reports of recent whale and dolphin deaths on and near the New York and New Jersey shores, and public concerns of marine noise impacts from offshore wind development activities, prompted an investigation into the sonar noise levels produced by exploratory survey vessels working in ocean areas leased by the Bureau of Ocean Energy Management (BOEM).

In April 2023 the highly mobile exploratory sonar vessel R/V Miss Emma McCall (IMO: 9289659) was identified working off the New Jersey coast within BOEM wind lease area OCS-A 0538. The area is leased to Attentive Energy LLC.

Miss Emma McCall is an offshore tug/supply ship registered and sailing under the U.S. flag (vessel)[1]. It is equipped with 2x CAT 3508TA w/twin disk MG6690-OOSC 3.21 ratio main engines and a CAT 3406, MARPROP 300hp dynamic positioning (DP) bow tunnel thruster. The vessel is understood to have replaced a sister boat (the R/V Brooks McCall) tasked with marine site characterization surveys using high resolution geophysical (HRG) equipment and geotechnical sampling off the coasts of New York and New Jersey in the New York Bight area in the Atlantic Ocean (Attentive IHA Application [2]).

Figure 1. The Miss Emma McCall viewed through binoculars at 0.5 nm distance (May 8, 2023 840 am EDT from investigator boat) while operating approximately 43 nautical miles east of Long Beach Island, New Jersey.

The sonar equipment on board the vessel is generally described in the IHA application as consisting of a multibeam echosounder, side scan sonar, gradiometer, and shallow and deep sub-bottom profiler. A "sparker" is a device that creates an acoustic expansion pulse and possible repetitive or

1 Miss Emma McCall specifications at https://www.tdi-bi.com/wp-content/uploads/2022/03/2021-Miss-Emma-McCall-Flyer_030222.pdf accessed 7/8/23.

2 NOAA.gov https://media.fisheries.noaa.gov/2022-06/AttentiveEnergyNYBight_2022IHA_App_OPR1.pdf.pdf accessed 5/22/23. "To conduct the HRG survey, TOI-Brooks has proposed the use of a purpose-built survey vessel, the R/V Brooks McCall (Figure 1-2) (or equivalent vessel) for the program."

spurious pulses [3]. The IHA application used proxy sparker SL data from Crocker and Fratantonio, 2016 [4], much lower than manufacturer-provided data. A list of the equipment specified in the IHA application is provided in Attachment A of this report. The manufacturer sparker data sheet is included in Attachment B and reviewed in Attachment E.

The IHA application states its requirements to comply with Level B harassment thresholds as follows, "*NMFS has defined the threshold level for Level B harassment at 120 Decibel (dB) Root Mean Square (RMS) referenced to (re) 1 microPascal (µPa) for continuous noise and 160 dB RMS re 1 µPa for impulsive and non-continuous pulsed noise. The Zone of Influence (ZOI) is the area that is ensonified to those levels and constitutes the area in which take of marine mammals could occur.*"

Section 6 of the IHA application reports the marine mammal "take" estimates by species. Therein the application states, "*The only anticipated potential exposures to Level B take for marine mammals is associated with noise and is limited to the use of the Dual Geo-Spark 2000X (400 tip) during HRG surveys*", which utilized the NMFS 160-dB,rms threshold for impulsive sources.

Of concern is that 1) sparker sonar levels listed in the IHA application were much lower than actual, and 2) the IHA application treated the vessel as if it were silent.

As a result it appears the issued IHA permit imposed insufficient noise mitigations. The only protective mitigation imposed by NMFS is covered under the exclusion zones NMFS established, generally defined as 500 meters for the North American right whale (NARW) and other ESA-listed mammals and 50 or 100 meters for all other marine mammals [5].

1.2 Acoustic Terminology

Acoustic waves in water have sound pressure and particle motion components. Mammal hearing is based on sound pressure detection. Sound pressure in water is quantified for level using decibels referenced to 1 microPascal (uPa). Underwater sound pressure levels differ from those in air by 26 dB (the difference in the reference levels of 1 uPA in water versus 20 uPA in air), plus 36 dB (the difference in acoustic impedance between water and air). The differential is roughly 62 dB. For example, a sound pressure level of 160 dB re 1 uPA in water would equate roughly to 98 dB re 20 uPA in air.

Water is compressible like air (although denser) thus longitudinal pressure waves occur in the water fluid medium as they do in air: Particles vibrate in the direction the sound is moving. Sound speed in water is about 1500 m/s, nearly 5 times faster than the sound speed in air (343 m/s). Underwater sound "source level" (SL) is referenced at 1 meter and derived in practice from sound pressure measurements calculated back to 1 meter. Sound pressure level (SPL, dB re 1 uPA) at a distance beyond 1 meter is lower than the SL due to attenuation with distance and is affected by underwater acoustic factors including winter vs summer sound speed gradients and thermocline

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3 Silvano Buogo, Giovanni B. Cannelli; Implosion of an underwater spark-generated bubble and acoustic energy evaluation using the Rayleigh model. J Acoust Soc Am 1 June 2002; 111 (6): 2594–2600. https://doi.org/10.1121/1.1476919, accessed 8/19/23.

4 Crocker, S., Fratantonio, F., Characteristics of Sounds Emitted During High-Resolution Marine Geophysical Surveys, NUWC-NPT Technical Report 12,203 24 March 2016, accessed 8/6/23.

5 Incidental Harassment Authorization, National Marine Fisheries Service, 8/16/2022.

strength. A first-order estimate of SPL using spherical spreading, ignoring absorption in the medium vs frequency, seabed topography and other factors, is:

SPL, dB at r, meters = SL – 20log10(r), dB (spherical)

The drop in sound pressure level with distance using this equation is 20 dB per decade, or 6 dB per doubling of distance. NOAA applies spherical spreading for shallow water conditions. For near-shore conditions, NOAA recommends a "practical spreading" loss model to estimate transmission loss (TL) in the near shore. Using the practical spreading loss model, TL in dB units is defined by,

SPL, dB at r, meters = SL – 15log10(r), dB "practical spreading" (NMFS)

The drop in sound pressure level with distance using this equation is 15 dB per decade or roughly 4.5 dB per doubling of distance.

In a shallow confine, the water surface and sea bottom channel acoustic energy horizontally, with possible cylindrical propagation. Temperature gradients, thermoclines, sea bottom and water surface interactions, shoaling and focusing can lead to deviations from ideal cylindrical spreading. Cylindrical propagation can be estimated ideally using a transmission loss (TL) coefficient α as in αlog10(r) of 10 such as in the equation,

SPL, dB at r, meters = SL – 10log10(r), dB (cylindrical)

The drop in sound pressure level with distance using this equation is 10 dB per decade or roughly 3 dB per doubling of distance.

1.3 Metrics

Underwater sound levels are reported here using peak, peak-to-peak, root-mean-square "RMS" amplitude, and sound exposure level (SEL) metrics to be consistent with NOAA metrics used for regulatory limits of marine sound levels. The relationship of peak, peak-to-peak and RMS is illustrated in Figure 2. SEL is expressed in dB re 1 $\mu Pa^2 s$ as a quantity of exposure over time (the time period must be provided). In the context of this report, NMFS applies cumulative SEL for Level A harassment, e.g. the onset of permanent threshold shift (PTS, hearing loss).

$$SEL = 10 \cdot \log_{10}\left(\frac{1}{T}\sum_{i=1}^{N} p_i^2\right)$$

Where:

- T is the time duration over which the sound levels are integrated (in seconds).
- N is the total number of pressure samples in the given time interval.
- p is the sound pressure value at the i-th sample, usually given in Pascals.

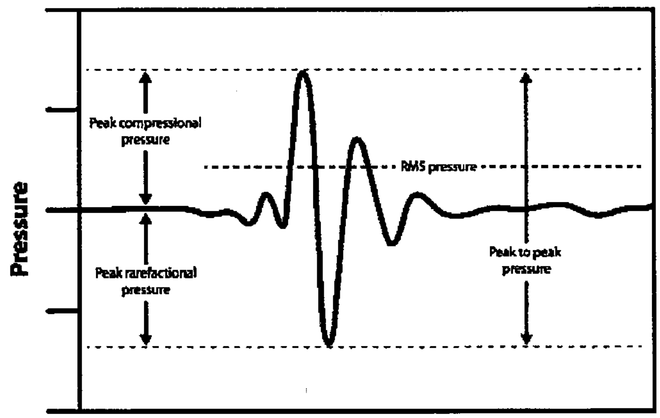

Figure 2. Sound pressure relationship of impulse waveform peak, peak-to-peak, and rms levels.

In Figure 2, the "RMS pressure" is shown as the level integrated over the time period of the pulse, and is always lower than the peak pressure level. The peak sound pressure level is the highest sound pressure measured or "held" by the instrumentation depending on its circuitry. The sound pressure level (defined by ANSI as "rms" pressure) has no restrictions on the RMS integration time period. The integration time period should always be provided with the sound pressure level when it is reported as RMS.

The RMS amplitude value may adequately characterize slow-changing or continuous, non-impulsive noise [6,7]. However, the RMS value of an impulsive sound does not reflect the peak energy in the signal. Peak sound pressure values are preferred over RMS for measuring, characterizing and evaluating the impact of impulse sounds. Depending on the rapidity of the pressure change in impulsive sound, regulation of impulsive sound using RMS values may provide little protection from peak pressures [7].

The disparity between RMS and peak pressures underscores long-standing professional acoustic concerns about the suitability of using RMS levels for protection from impulsive noise sources. The RMS value does not track the impulsivity associated with startle and sudden hearing loss. As Madsen [7] summarized in 2005, "*Current mitigation levels for noise transients impinging on marine mammals are specified by rms pressures. The rms measure critically relies upon choosing the size of averaging window for the squared pressures. Derivation of this window is not standardized, which can lead to 2–12 dB differences in rms sound pressure for the same wave forms. rms pressure does not represent the energy of the noise pulse and it does not prevent exposure to high peak pressures. Safety levels for transients should therefore be given by received peak–peak sound pressure and energy flux density instead of rms sound pressure levels.*" For

6 National Research Council (US) Committ.ee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals. Ocean Noise and Marine Mammals. Washington (DC): National Academies Press (US); 2003. Appendix E, Glossary of Terms. https://www.ncbi.nlm.nih.gov/books/NBK221261/ accessed 6/5/23.

7 Madsen PT (2005), Marine mammals and noise: Problems with root mean square sound pressure levels for transients. The Journal of the Acoustical Society of America (JASA), 117(6), 3952–3957. https://doi.org/10.1121/1.1921508, accessed 6/28/23.

reference, in-air impulsive sound limits for hearing damage are not assessed with RMS but rather with peak and peak-to-peak levels [8].

1.4 Underwater Thresholds for Noise Impact Assessment

NOAA Fisheries or NMFS is an office of the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce. NMFS is charged with protecting marine species and their habitats in the United States. NMFS published guidance related to underwater noise and the potential impacts on marine mammals in a document titled "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing." This document, often referred to as the "NOAA Technical Guidance," was published in 2016, 2018 v 2.0, and again in 2020 v 2.2.

NOAA defines impulsive and non-impulsive (continuous) noise as follows [9]:

> *Continuous sound: A sound whose sound pressure level remains above ambient sound during the observation period (ANSI 2005).*
>
> *Impulsive sound: Sound sources that produce sounds that are typically transient, brief (less than 1 second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (ANSI 1986; NIOSH 1998; ANSI 2005). They can occur in repetition or as a single event. Examples of impulsive sound sources include: explosives, seismic airguns, and impact pile drivers.*
>
> *Non-impulsive sound: Sound sources that produce sounds that can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent) and typically do not have a high peak sound pressure with rapid rise time that impulsive sounds do. Examples of non-impulsive sound sources include: marine vessels, machinery operations/ construction (e.g., drilling), certain active sonar (e.g. tactical), and vibratory pile drivers.*

The NMFS Summary of Marine Mammal Acoustic Thresholds [10] states the following with respect to behavioral harassment,

> "*Marine mammals are considered harassed when exposed to elevated sound levels that may lead to mortality, temporary or permanent hearing impairment (threshold shift), non-auditory physical or physiological effects, and behavioral disturbance. Using the best available science, NMFS has developed acoustic thresholds that identify the received level of underwater sound*

8 Impulse peak limits defined in US law at 140 dB,peak by MSHA standards for mines [30 CFR 56.5050; 30 CFR 57.5050], this exposure limit is enforceable; in the OSHA standards [29 CFR 1910.95; 29 CFR 1926.52], it is nonenforceable. https://www.nonoise.org/hearing/criteria/criteria.htm accessed 7/13/23.

9 National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p. https://www.fisheries.noaa.gov/action/2018-revision-technical-guidance-assessing-effects-anthropogenic-sound-marine-mammal-hearing accessed 6/30/23.

10 NMFS Summary of Marine Mammal Acoustic Thresholds, https://www.fisheries.noaa.gov/s3/2023-02/MMAcousticThresholds_secureFEB2023_OPR1.pdf, 2/24/23, accessed 8/11/23.

from explosive and non-explosive sources above which exposed marine mammals would be expected to:

- *be behaviorally disturbed or incur a temporary threshold shift (TTS), both of which qualify as Level B harassment under the Marine Mammal Protection Act (MMPA), or*
- *incur a permanent threshold shift (PTS) of some degree or lung or gastrointestinal (g.i.) tract injury, both of which qualify as Level A harassment."*

February 2023

Underwater Level B Harassment Acoustic Thresholds (NOAA 2005)

Source type	Threshold
Continuous	$L_{p,\mathrm{RMS,flat}}$: 120 dB re 1 µPa
Non-explosive impulsive or intermittent	$L_{p,\mathrm{RMS,flat}}$: 160 dB re 1 µPa

For in-air sounds, NMFS predicts that harbor seals exposed to RMS received levels ≥90 dB re 20 µPa will be behaviorally harassed, and other pinnipeds will be harassed when exposed to RMS received levels ≥100 dB re 20 µPa.

In-Air Level B Harassment Acoustic Thresholds (Southall et al. 2007; NOAA 2009)

Species/Group	Threshold*
Harbor seal	$L_{p,\mathrm{RMS,flat}}$: 90 dB re 20 µPa
All other pinnipeds	$L_{p,\mathrm{RMS,flat}}$: 100 dB re 20 µPa

* A cumulative sound exposure level threshold of 100 dB re 20 µPa (DoN 2017) has been used for Navy military readiness activities. NMFS is currently in the process of re-evaluating the Navy's threshold.

NMFS defines the threshold level for Level B Behavioral Harassment as follows [2]:

"120 Decibel (dB) Root Mean Square (RMS) referenced to (re) 1 microPascal (µPa) for continuous noise and 160 dB RMS re 1 µPa for impulsive and non-continuous pulsed noise. The Zone of Influence (ZOI) is the area that is ensonified to those levels and constitutes the area in which take of marine mammals could occur".

Sound exposures leading to PTS and TTS may be assessed with the cumulative sound exposure over a period of time ("cSEL" in this report).

1.5 Auditory Weightings for Sound Exposure

Auditory weightings are considered important for assessing marine species *noise exposure* and susceptibility to noise-induced hearing loss [11]. Hearing auditory weighting coefficients for marine mammal species are summarized in the 2018 NMFS guidance document [12].

11 Jakob Tougaard, Michael Dähne; Why is auditory frequency weighting so important in regulation of underwater noise? J Acoust Soc Am 1 October 2017; 142 (4): EL415–EL420. https://doi.org/10.1121/1.5008901 accessed 6/29/23.

12 National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent

Weightings for analysis of this survey's data were selected for the species listed in Tables ES1 and ES2 of the Attentive IHA application, shown below. Highlighting in the table denotes the species evaluated by "Functional Hearing Group" listed in the IHA application [2].

Table ES1: Marine mammal hearing groups.

Hearing Group	Generalized Hearing Range*
Low-frequency (LF) cetaceans (baleen whales)	7 Hz to 35 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kHz
High-frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* & *L. australis*)	275 Hz to 160 kHz
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

* Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for lower limits for LF cetaceans (Southall et al. 2007) and PW pinniped (approximation).

Table ES2: Summary of auditory weighting and exposure function parameters.*

Hearing Group	*a*	*b*	f_1 (kHz)	f_2 (kHz)	*C* (dB)	*K* (dB)
Low-frequency (LF) cetaceans	1.0	2	0.2	19	0.13	179
Mid-frequency (MF) cetaceans	1.6	2	8.8	110	1.20	177
High-frequency (HF) cetaceans	1.8	2	12	140	1.36	152
Phocid pinnipeds (PW) (underwater)	1.0	2	1.9	30	0.75	180
Otariid pinnipeds (OW) (underwater)	2.0	2	0.94	25	0.64	198

* Equations associated with Technical Guidance's auditory weighting ($W_{aud}(f)$) and exposure functions ($E_{aud}(f)$):

$$W_{aud}(f) = C + 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\} \text{ dB}$$

$$E_{aud}(f) = K - 10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f/f_2)^2]^b}\right\} \text{ dB}$$

Hearing auditory weightings consistent with the species evaluated for take estimates in the Attentive Energy application for incidental harassment authorization (IHA) Section 4 are shown in Figure 3. During this survey's post-survey analysis, NMFS 2018 auditory weightings were computed and applied to the unweighted audio recording acquired at 0.5 nautical miles (NM) to obtain weighted overall and one-third octave band sound pressure levels at that distance for the species shown in Figure 3.

and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p. accessed 6/5/23.

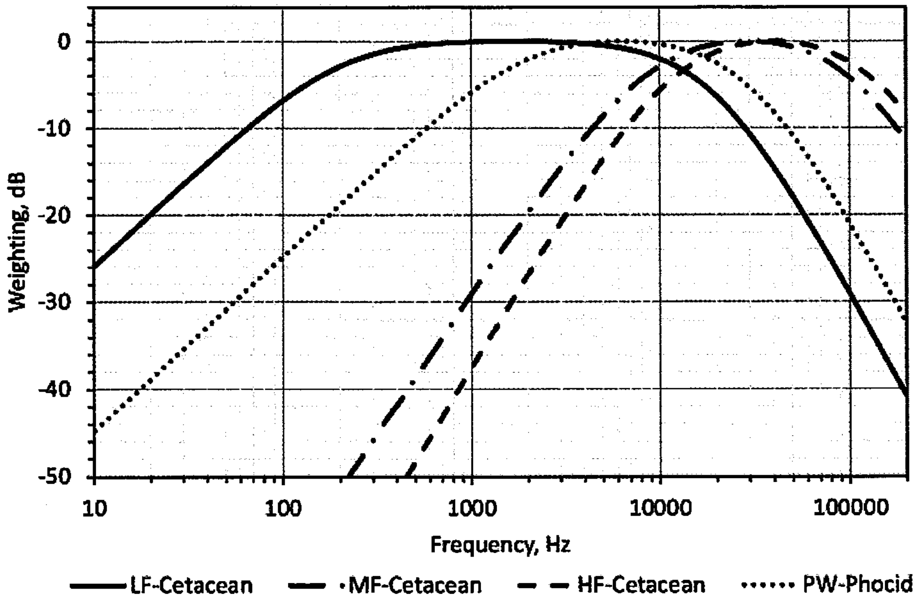

Figure 3. Bode diagram, marine species auditory weightings, NMFS 2018.

While this analysis utilized the 2018 NMFS auditory weightings, it should be noted that Southall et al. 2019 [13] published a set of modifications to the 2018 NMFS auditory weightings for consideration that are less flattened and closer to audiograms. It appears the Southall 2019 weightings are still under consideration.

13 Southall et al., "Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects", Aquatic Mammals 2019, 45(2), 125-232, DOI 10.1578/AM.45.2.2019.125. accessed 6/26/23.

2 Methodology

2.1 Survey location

Underwater acoustic recordings were acquired on May 8, 2023 between 8:09 and 9:40 am, approximately 43 nautical miles east of Barnegat Light, Long Beach Island, NJ (see Figure 4). Passive acoustic monitoring (PAM) was conducted with a hydrophone dipped by hand to a 15m depth from the side of a 32-foot center-console sport-fishing boat ("investigator boat") at 0.5, 1, 2, and 4 NM from the vessel.

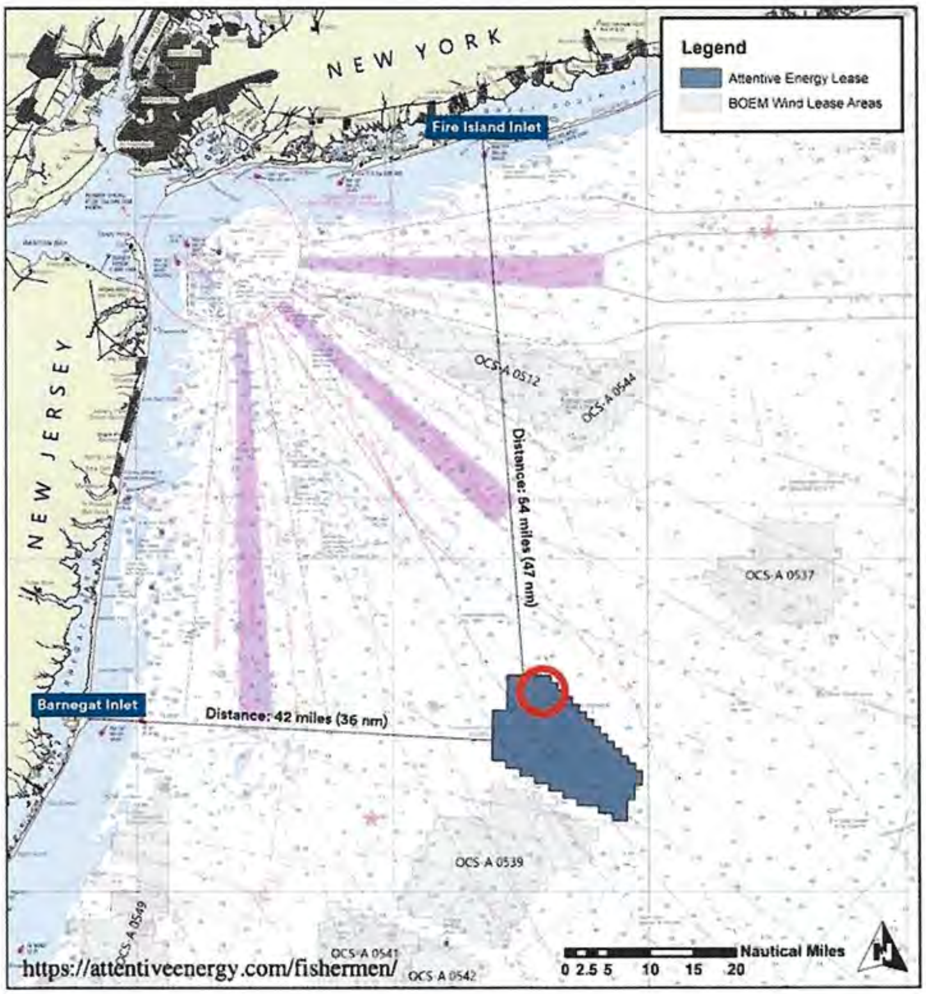

Figure 4. Survey location area marked with red circle, 43 nautical miles from Barnegat Light, NJ.

Distance to the vessel was determined using the investigator boat's onboard Furuno marine radar prior to shutting off systems for acoustic recording. During data recordings, precise source-receiver distances were unavailable. A position uncertainty of ±100 m (+/- 1 dB at 0.5 NM over 120 seconds) is assumed based on a vessel transit speed of 3 knots or less relative to the investigator boat. Sound measurements were acquired forward of the vessel's transit path. No other vessels were within visible range or heard during measurements.

Weather conditions were sunny, with unlimited visibility, thin high clouds, air temperature 63 degrees F (18 C) with very light winds from the NW, and waters at Beaufort sea state 1, water smooth, ~1-foot swells. Water depth at 8:40 am (at 0.5 NM from the vessel) was approximately 45 meters (150 ft) Water temperature at the surface was 55 degrees F (13 C). A seasonal thermocline was visible on the onboard Funuro fishing sonar at 18 to 23 meters (60 to 75 feet). Two sea anchors were deployed during recording which minimized boat drift and successfully prevented hydrophone cable strumming and flow noise.

The survey was conducted in a manner consistent with the NOAA issued guidelines for hydrophone measurements including selection of a "far range" location of at least 20 times the water depth, and hydrophone depth at least 5 meters [14].

The first data acquisition was conducted starting at 8:09 am near the eastern edge of the lease area, in front of and slightly to one side of the vessel transit line at 2 NM (39.79N,73.22W). Upon lowering the hydrophone 15 meters into the water (above the thermocline), vessel and sonar noise was immediately audible on headphones, with repetitive pounding sonar noise and oscillating tonal noise from vessel propulsion, DP thruster and possibly other equipment.

After recording at 2 NM, the investigator boat was steered to a 1 NM distance from the vessel and stopped at 8:30 am (lat/long not recorded). Vessel and sonar noise at the 1 NM distance was notably louder and more prominent. After recording at 1 nm, the investigator boat was then steered to a 0.5 NM distance from the vessel and stopped at 8:40 am, where vessel noise and sonar was dominating the ocean acoustic environment (39.82N,73.20W).

The investigator boat was then steered slowly to a 4 NM distance from the vessel and stopped at 9:30 am (39.79N,73.25W). At 4 NM the vessel propulsion noise was clearly audible but the sparker was not operating. Wind and Beaufort sea state had increased somewhat during transit to the 4 NM distance, resulting in occasional water slap on the investigator boat hull. Two 2-minute recordings were acquired but the sparker remained off except for a few seconds, not enough for sparker analysis. Vessel noise was evaluated in post analysis.

As previously noted, NOAA defines *continuous* sound as a sound whose sound pressure level *remains above ambient* sound during the observation period (ANSI 2005). Sounds observed during this survey were above the ambient during the survey period. In the absence of nearby shipping and marine species noise, ambient ocean noise is primarily a function of wind speed. Winds were light or absent during measurements at 0.5, 1 and 2 NM. Noise from the vessel including sparker pulses, vessel propulsion and DP thrusters dominated the ocean acoustic environment out to 2 NM, clearly above the ambient background. Post analysis confirmed that sparker and MF USBL sonar levels were tens of decibels above ambient levels observed between sonar pulses.

The combined vessel and sonar activity prevented direct measurement of ambient sound levels during the survey, however, a previous survey conducted in similar water depths and distances offshore Ocean City, MD about 105 NM south is informative [15]. Monitoring in that survey found background broadband (1-1000 Hz) ambient sound levels with distant vessel noise were 107

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14 NMFS Northwest Region and Northwest Fisheries Science Center, Guidance Document: Sound Propagation Modeling to Characterize Pile Driving Sounds Relevant to Marine Mammals, January 1, 2012.

15 Marine Acoustics, Inc., Underwater Acoustic Assessment of Pile Driving during Construction at the Maryland Offshore Wind Project, for US Wind, report version 2.3 date 13 May 2022.

dB,rms re 1uPa. Background sound levels were modestly affected by the proximity to shipping lanes into the Philadelphia area. Those results suggest ambient sound levels in the absence of traffic would be lower, in the range of 100 dB re 1uPa, consistent with NOAA determinations in 2019 [16]. These are well below noise levels measured during this survey.

2.2 Instrumentation

Underwater sound pressure levels were acquired with a Cetacean Research C75 research-grade pre-amplified omnidirectional hydrophone. The pre-amplified C75 has an effective sensitivity of -180 dB re 1V/1uPA, an equivalent self-noise of 51 dB re 1uPA/√Hz, and a linear frequency response range of +/-1 dB from 25 Hz to 10 KHz and +/-3 dB from 10 Hz to 170 KHz (see Attachment C). The hydrophone output was routed to a SINUS Messtechnik GmbH Apollo Sound & Vibration Analyzer sn7800 operated with Samurai software Version 2.8.3 running on a Lenovo Windows 10 laptop. Data acquisition was set to 120 seconds, 51.2 KHz, 24-bit resolution, AC coupled, 10 Hz high pass filter. The Sinus Apollo provides digital Class 1 sound level meters meeting Standard IEC 61672-1 and Class 0 octave filtering according to IEC 61260. One-third octaves were stored at a rate of 10 per second. FFT windows were computed with 12800 FFT frame at 0.08 second intervals with Hanning weighting.

The hydrophone signal was split (Y'd) to a Tascam X8 digital audio recorder set to record digital audio files at 96 KHz, 24-bit resolution. The Tascam X8 has a frequency response of 20Hz – 40 kHz at 96 kHz of +0/-0.4dB (JEITA).

The C75 hydrophone, Sinus analyzer and Tascam recorder were calibrated end-to-end with a GRAS 42AG acoustic calibrator at a sound pressure level in air of 114 dB re 20 uPA at 251.2 Hz (equivalent sound pressure in water, 140 dB re 1uPA) using a custom machined hydrophone calibrator adapter Model HADP42AG-C75 from BRC Engineering of Sonoma, CA, with calibration current and certified traceable to NIST (see Attachment D). Recordings were run concurrently on the Tascam X8. Post-survey analysis was conducted with Sinus Samurai software version 2.8.3 and Spectraplus-SC software version 5.3.0.12C (Pioneer Hill Software, LLC). Excel and custom Python scripts were utilized for data and waveform review, analysis and plotting.

The acquired recordings had high signal to noise in the frequency ranges of interest and sufficient headroom to prevent digital signal clipping.

Particle motion was not acquired during this survey.

For sparker RMS computation, Crocker and Fratantonio, 2016 [4] based their RMS time "window" on that part of the acoustic waveform containing 90% of the total radiated energy during the sparker pulse. Their testing was performed close-in within a couple of meters of the devices under test. In contrast, this survey's far-field measurement locations were 0.5 NM (926 meters) and farther, with multipath propagation over distance, reflections, scattering, and distinct sound speeds above and below the ocean thermocline resulting in echo/reflection groups and overlapping recurring peaks especially at the larger distances. The RMS calculation method used in this analysis is the same,

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16 National Oceanic and Atmospheric Administration, 84 FR 52464 October 2, 2019 stating: "Ambient ocean noise levels generally do not exceed 100 dB in the Atlantic waters of the Northeast United States (Haver et al., 2018)." https://www.govinfo.gov/content/pkg/FR-2019-10-02/pdf/2019-21458.pdf accessed 9/10/23.

but the time window is significant, as outlined by Sertlek et al 2012 [17], and importantly, captures the total sound received in the reflective ocean environment during sparker, sonar, and vessel operations.

2.3 Measurement Uncertainty

Uncertainties for the acoustic parameters presented in this report were considered in general accordance with United States and international standards [18,19]. Uncertainty considerations apply to the probability of replicating measured sound pressure levels at the same distances at the same location under the same conditions. Acoustic survey measurements can be affected by acoustic propagation and environmental conditions occurring during the survey. Utmost care was taken to minimize environmental effects by selecting a day with the calmest weather conditions available within the weather forecast, using a standardized depth of the dipped hydrophone, and minimizing handling noise of the dipped hydrophone.

System end-to-end calibration before and after the survey found calibration constant within 0.5 dB. Class 1 digital sound meters have an intrinsic standard uncertainty of +/- 0.5 dB (ISO 1996-2). The remainder of the uncertainty was allocated to the distance to the source being measured, estimated at +/-1 dB. From ANSI 1996-2, the expanded uncertainty (2σ or coverage probability 95%) of effects on short-term measurements with Class 1 instrumentation (the type used during this survey) is +/-1.6 dB. No uncertainty was introduced by residual sound levels as they were well below measured levels. All reported uncertainties are in the category of Type B evaluation or analysis other than a statistical analysis of repeated observations. While a precise total uncertainty for the offshore measurement survey is not known, the expanded uncertainty is unlikely to exceed +/-4 dB.

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17 H. Ozkan Sertlek, Hans Slabbekoorn, Carel J. Ten Cate, Michael A. Ainslie; Insights into the calculation of metrics for transient sounds in shallow water. Proc. Mtgs. Acoust 2 July 2012; 17 (1): 070076. https://doi.org/10.1121/1.4789476 accessed 8/21/23.

18 B.N. Taylor and C. E. Kuyatt, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," National Institute of Standards and Technology, Gaithersburg, MD, NIST Technical Note 1297, 1994. [Online]. Available http://www.nist.gov/pml/pubs/tn1297/ accessed 8/16/23.

19 ISO/FDIS 1996-2 "Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels", ISO/TC 43/SC 1-2017.

3 Results

3.1 Sound pressure data (Pa) versus distance

Time-series sound pressure data are shown in Figures 5, 6 and 7 at 2, 1 and 0.5 NM with 0.005 second linear sampling. The sound pressures in each figure include total vessel propulsion, DP thruster, and other machinery noise (all *continuous*), a sparker and mid frequency (MF) positioning sonar signals firing at different rates and frequencies. The y-axis amplitude scales reflect higher sound levels with closer distance. Of the three measurement distances, the 0.5 NM record provides the highest detail and captured an apparent startup of the sparker. Section 3.2 focuses on the sound pressure levels at 0.5 NM.

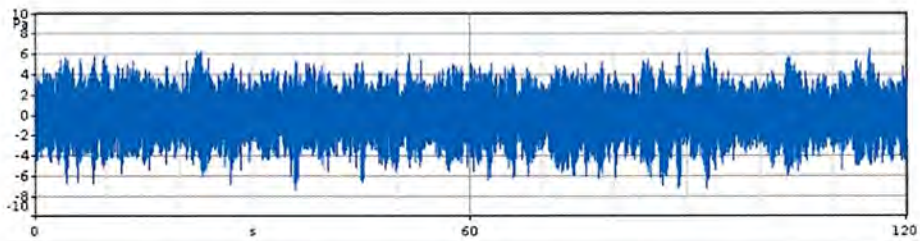

Figure 5. Time series sound pressure, Pa 8:09 am, 2 NM (3704 meters). Vessel continuous noise and sparker and SBP noise were present. Sparker was firing twice per second.

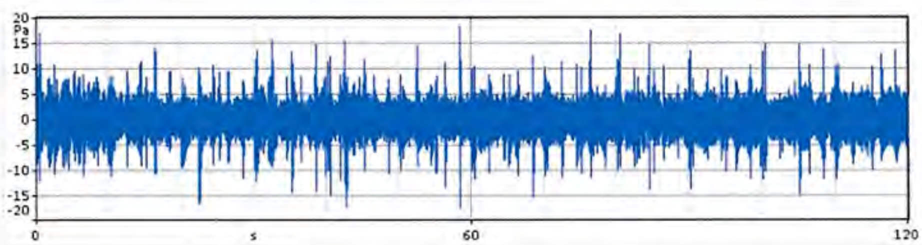

Figure 6. Time series sound pressure, Pa 8:35 am, 1 NM (1852 meters). Vessel continuous noise and sparker and SBP noise were present. Sparker was firing once every 5 seconds.

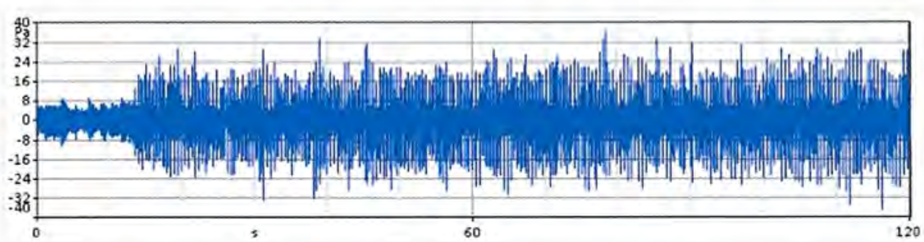

Figure 7. Time series sound pressure, Pa 8:41, am 0.5 NM (926 meters). Vessel continuous noise was present at start of data acquisition. Sparker startup occurred at 14 seconds, then firing twice per second.

Peak sound pressures (Pa) during sparker firing were identified with a custom Python script and plotted in Figures 8, 9 and 10 for the data acquired at 2, 1, and 0.5 NM. Brickwall filtering (48 dB/octave, Butterworth) was applied from 315 to 12000 Hz to remove low and high frequency sound outside the sparker's frequency range.

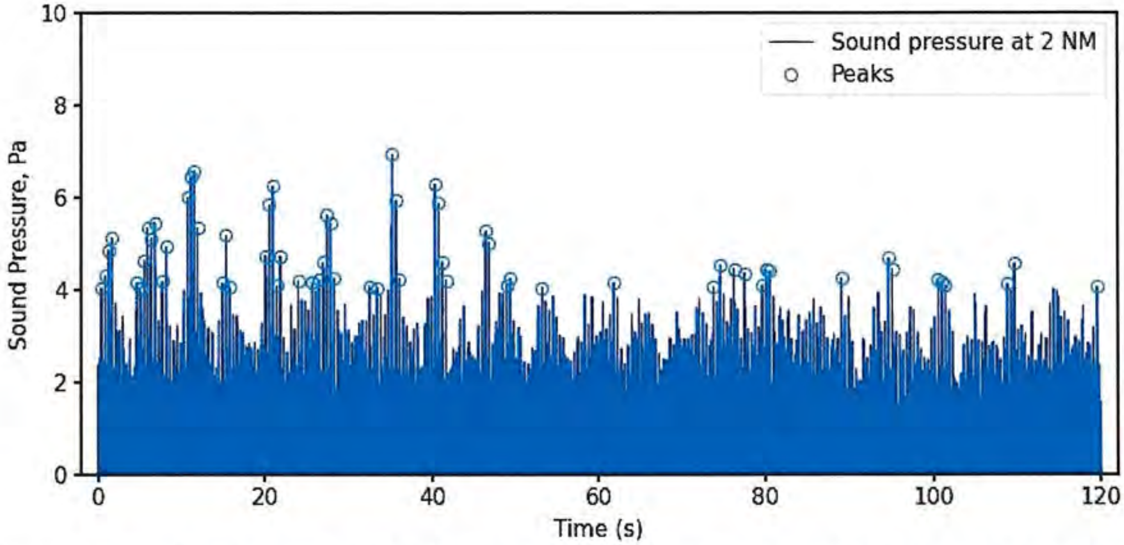

Figure 8. Time series sound pressure, Pa 8:09 am, 2 NM (3704 meters). Vessel continuous noise and sparker noise were present. Sparker peaks are circled. During this data acquisition, the sparker was firing off twice per second. Peaks were acquired for sound pressures above 4 Pa to avoid fluctuating vessel noise.

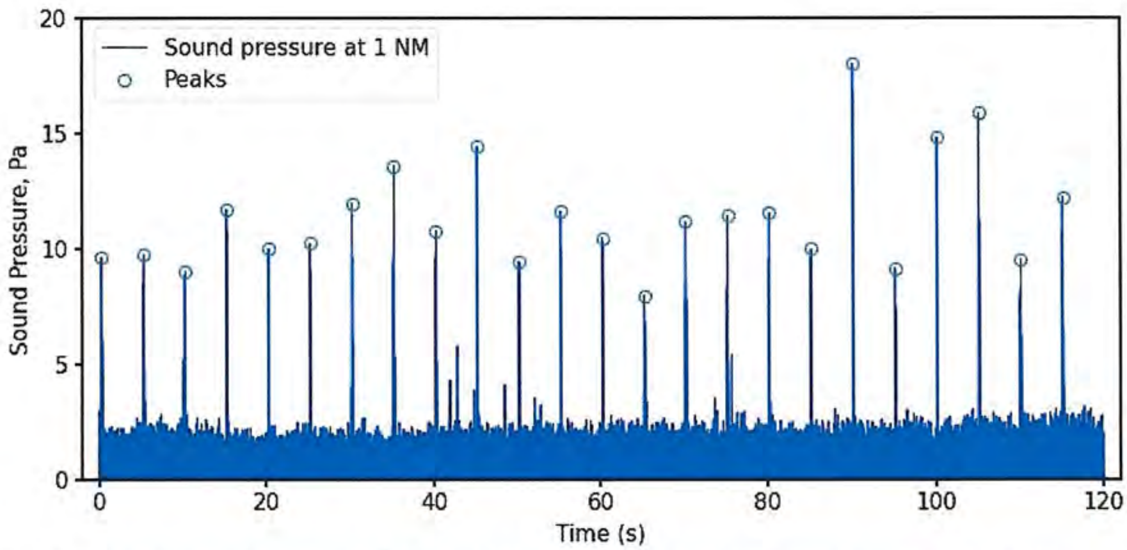

Figure 9. Time series sound pressure, Pa 8:35 am, 1 NM (1852 meters). Vessel continuous noise and sparker noise were present. Sparker peaks are circled. During this data acquisition, the sparker was firing off only one every 5 seconds..

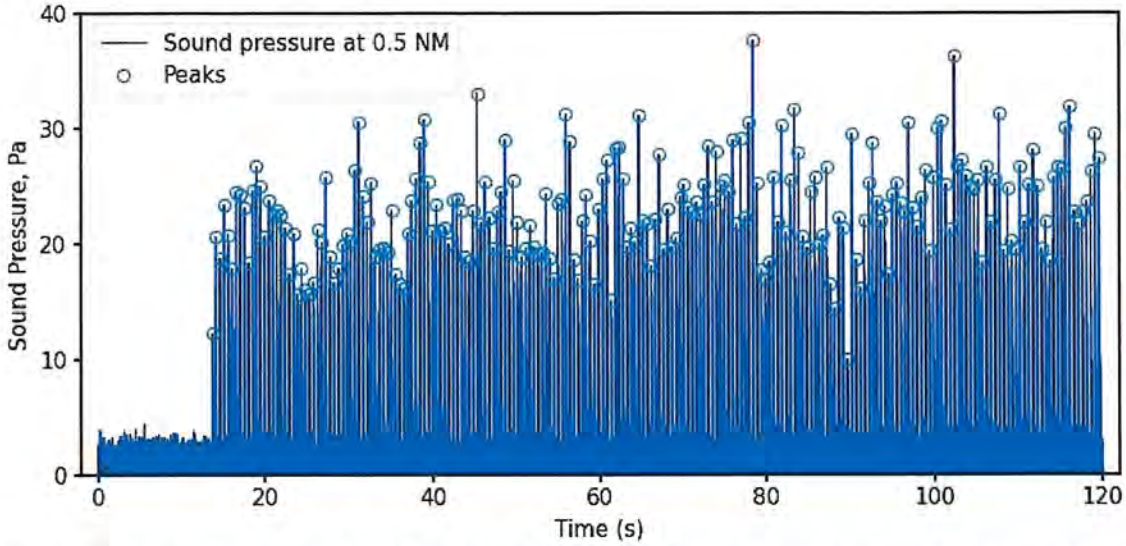

Figure 10. Time series sound pressure, Pa 8:41, am 0.5 NM (926 meters). Vessel continuous noise only was present at start of data acquisition. Sparker startup occurred at 14 seconds. Sparker peaks are circled. Sparker startup occurred without a 30-second ramp.

The data revealed acoustic features which are not accounted for in simple spherical spreading acoustic models such as used for the IHA. In Figures 11, an exemplar sparker pulse plot at 0.5 NM shows not one clean pulse as would be assumed from near-field manufacturer data or Crocker and Fratantonio (2016), but pulse groups.

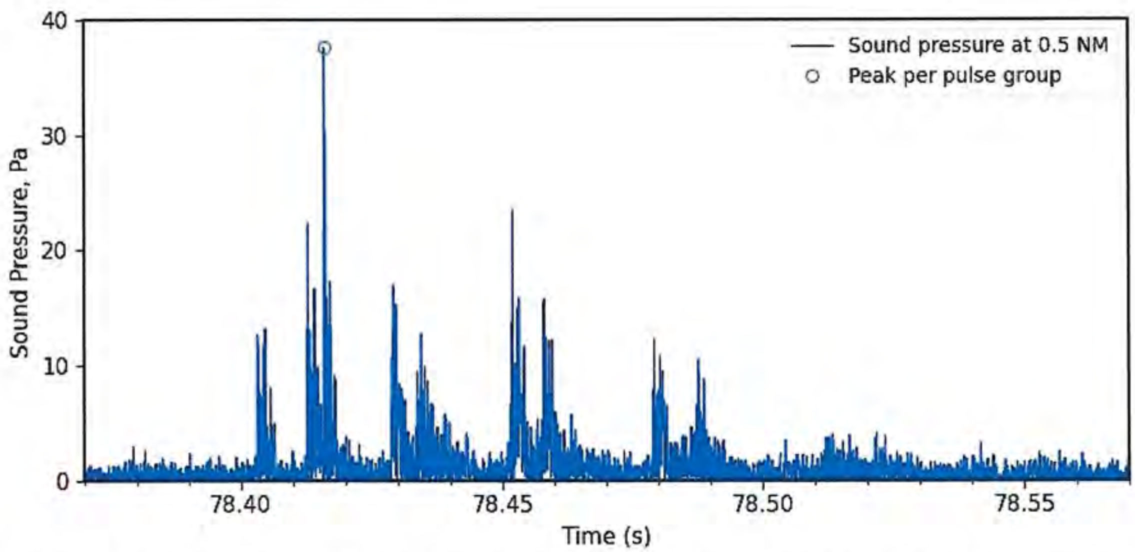

Figure 11. Time series sound pressure, Pa 8:41, am 0.5 NM (926 meters). Sparker pulse shows echo/reflection groups and dual sound speed paths characteristic of reflections off bottom and surface and differing sound speed above and below thermocline.

The data show a series of echo/reflection groups with different time arrivals consistent with acoustic path time and strength modifiers:

- Direct path from sparker to hydrophone
- Primary reflections off the water surface and the ocean bottom
- Two sound speed paths, likely one above and one below the thermocline
- Focusing and horizontal refraction
- Scattering

The waters in the survey area are shallow (approximately 45 to 50 meters) compared to the distances of the measurements (926, 1852, and 3704 meters). The diagram below illustrates the ratio of 50 meter water depth to the survey measurement range radii at 0.5, 1, 2 and 4 nm.

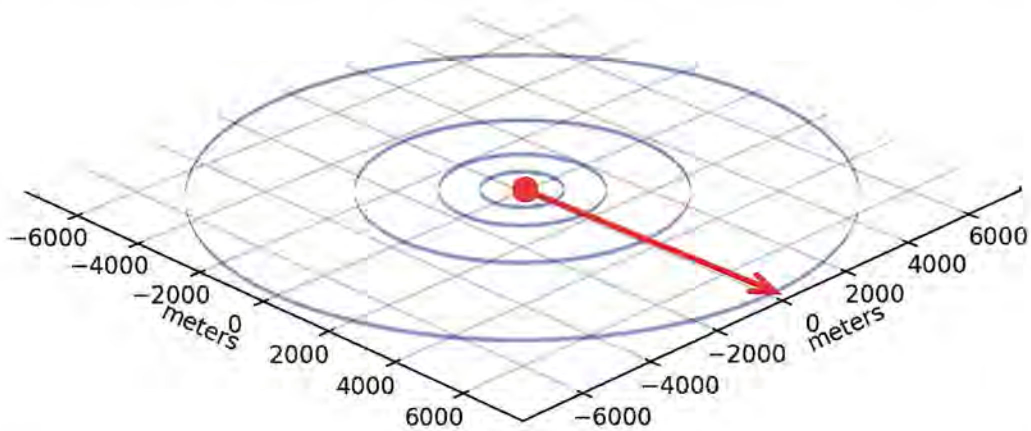

Figure 12. Illustration of water depth to sound radius ratios for offshore shallow littoral waters in the survey area. This diagram shows radii at 0.5, 1 and 2 nautical miles (926, 1852, and 3704 meters) from a sound source located at 0,0. Radii height is 50 meters. An arrow is shown indicating sound propagation outward from the source to receiver radii.

The water surface and sea bottom channel the acoustic energy horizontally, acting as containing surfaces with varying degrees of reflectivity and absorption from location to location between source (at 0,0) and receiver.

This is consistent with Oliveira et al [20], *"Three-dimensional (3D) effects can profoundly influence underwater sound propagation and hence soundscape at different scales in the ocean ... In the particular case of coastal seas, a range of physical oceanographic and geological features can cause horizontal reflection, refraction, and diffraction of sound."* The 50 meter ocean depth evaluated by Oliveira et al was similar to the water depths for this survey.

20 Oliveira, T., Lin Y.T., Porter, M., Underwater Sound Propagation Modeling in a Complex Shallow Water Environment, Front. Mar. Sci., 15 October 2021.

3.2 Sound level data at 0.5 nm

Table 1 provides overall and one-third-octave unweighted and weighted sound pressure levels, cumulative SEL (cSEL), and SEL per sparker pulse interval including all vessel operations noise emissions, at 0.5 NM. Marine species weightings are described in Section 1.5.

Level, dB re 1uPa	Unweighted	LF	MF	HF	PW
SPL,rms(120s)	128.5	127.1	118.4	117.1	122.9
peak (highest)	151.6	151.1	147.7	146.8	150.3
peak (negative)	-151.6	-150.9	-147.7	-146.8	-150.4
peak-to-peak	157.6	157.0	153.7	152.8	156.4
cSEL,120s (~2 pps) re 1uPa^{2}s	147.9	147.9	138.4	137.9	143.7
SEL per sonar pulse re 1uPa^{2}s	124.1	124.1	114.6	114.1	119.9
ANSI 1/3 Octaves, Hz	dB,rms re 1uPa				
40	100.9	99.3	11.3	56.8	90.3
50	98.1	96.5	8.8	54.1	87.5
63	97.8	96.2	8.8	53.8	87.2
80	95.7	94.1	7.2	51.7	85.1
100	96.0	94.4	8.3	52.1	85.5
125	96.1	94.5	9.4	52.3	85.6
160	96.5	94.9	11.3	52.8	86.1
200	104.3	102.7	21.9	61.0	94.0
250	114.6	113.1	33.2	71.4	104.4
315	102.4	100.9	24.2	59.8	92.4
400	104.0	102.6	29.6	62.2	94.3
500	112.8	111.5	42.4	72.2	103.6
630	113.1	111.9	47.7	74.1	104.7
800	116.4	115.4	55.0	79.0	108.7
1000	113.4	112.6	56.9	78.2	106.8
1250	112.5	112.0	61.8	80.0	107.2
1600	113.7	113.5	69.2	84.5	110.0
2000	115.4	115.4	77.0	89.4	113.0
2500	114.9	114.9	81.8	91.9	113.4
3150	111.8	111.7	83.9	91.8	110.9
4000	110.6	110.3	88.5	94.0	110.2
5000	111.0	110.5	93.9	97.5	110.8
6300	110.6	109.8	98.0	100.0	110.6
8000	104.9	103.7	95.8	96.8	104.8
10000	103.0	101.0	97.1	97.2	102.7
12500	102.3	99.2	98.9	98.5	101.5
16000	101.4	97.0	99.6	99.0	99.9
20000	117.5	111.3	116.8	116.2	115.0
25000	106.8	98.2	106.7	106.3	102.8
31500	100.7	90.2	100.7	100.5	95.5
40000	89.5	75.3	89.2	89.5	81.7
Octave band sum 40 Hz-40KHz	125.7	124.5	117.6	117.1	122.2

Table 1. Data compiled in Spectraplus-SE over a 120-second period with vessel propulsion, DP thruster and general operations noise, and the vessel's sparker operating at a rate of 2 firings per second and USBL sonars (19.5 to 32 KHz) firing every 2 seconds [21].

21 The Sinus Apollo and Spectraplus-SE analysis systems provided comparable data results, within 1 dB over comparable source data. The Spectraplus-SE was used during analysis of audio data acquired at 96 KHz providing analysis bandwidth for the high frequency sub bottom profilers observed at 19.5 to 32 KHz.

3.3 Multiple sonars

Digital recordings at 0.5 NM acquired on the Tascam X8 at 96 KHz were imported into Spectraplus SE and plotted as a spectrogram shown below in units of power spectral density Pa2/Hz.

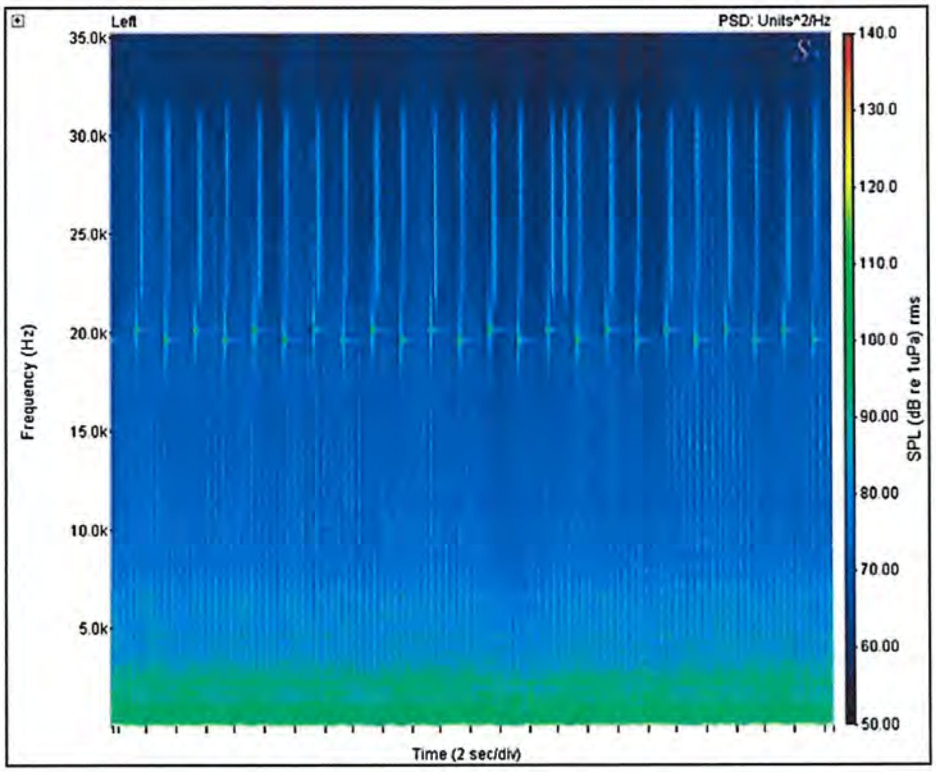

Figure 13. Spectrogram at 0.5nm (926 meters). Signal includes total vessel propulsion, DP thruster, and other equipment noise below 3 KHz, closely spaced sparker pulses filling the frequency range (vertically), and high frequency underwater positioning (USBL) sonars from 19.5 to 32 KHz.

The vessel sonar emissions are complex, consisting of a sparker with a dominant range from approximately 400-5000 Hz and several mid frequency (MF) positioning sonar signals at 19.5 to 32 KHz.

Sparker pulses were observed at a rate of 2 pulses per second and were dominant from 400 to 5000 Hz (thin green vertical lines) with pulse energy observed out beyond 20 KHz.

Sonars in the 19.5 to 32 KHz frequency range appears consistent with the ixBlue Gaps Medium frequency (MF) Ultra-Short Baseline (USBL) positioning system. The Attentive IHA did not list or evaluate USBL sonar noise.

According to the Attentive Energy IHA application, a high frequency (HF) sub bottom profiler (SBP) operating above 85 KHz was proposed for use that produces sound levels at frequencies above the limits of the monitoring equipment in use on this survey.

The two pulsed MF USBL sonars were observed at 19.5 KHz and 20 KHz. Those sonar signals exhibited impulsive characteristics [22]. Two MF swept-frequency (FM) USBL sonars were observed from 21 to 32 KHz. The two FM USBLs appeared to be sequenced with the 19.5 and 20 KHz pulsed USBLs. One FM USBL sweep intensity was more dominant in the range of 21 to 27 KHz, while the other was dominant in the 27 to 32 KHz range. Occasional misfires or rapid repeat firing of the FM USBLs were observed and can be seen in Figure 13 as out-of-step vertical streaks from 22 to 32 KHz.

Peak unweighted sound pressure levels at 0.5 NM for the 19.5 KHz and 20 KHz pulsed MF USBL signals were approximately 131 dB,peak re 1uPA, and for the FM USBL signals in the range of 21 to 32 KHz, 124 dB,peak re 1uPA.

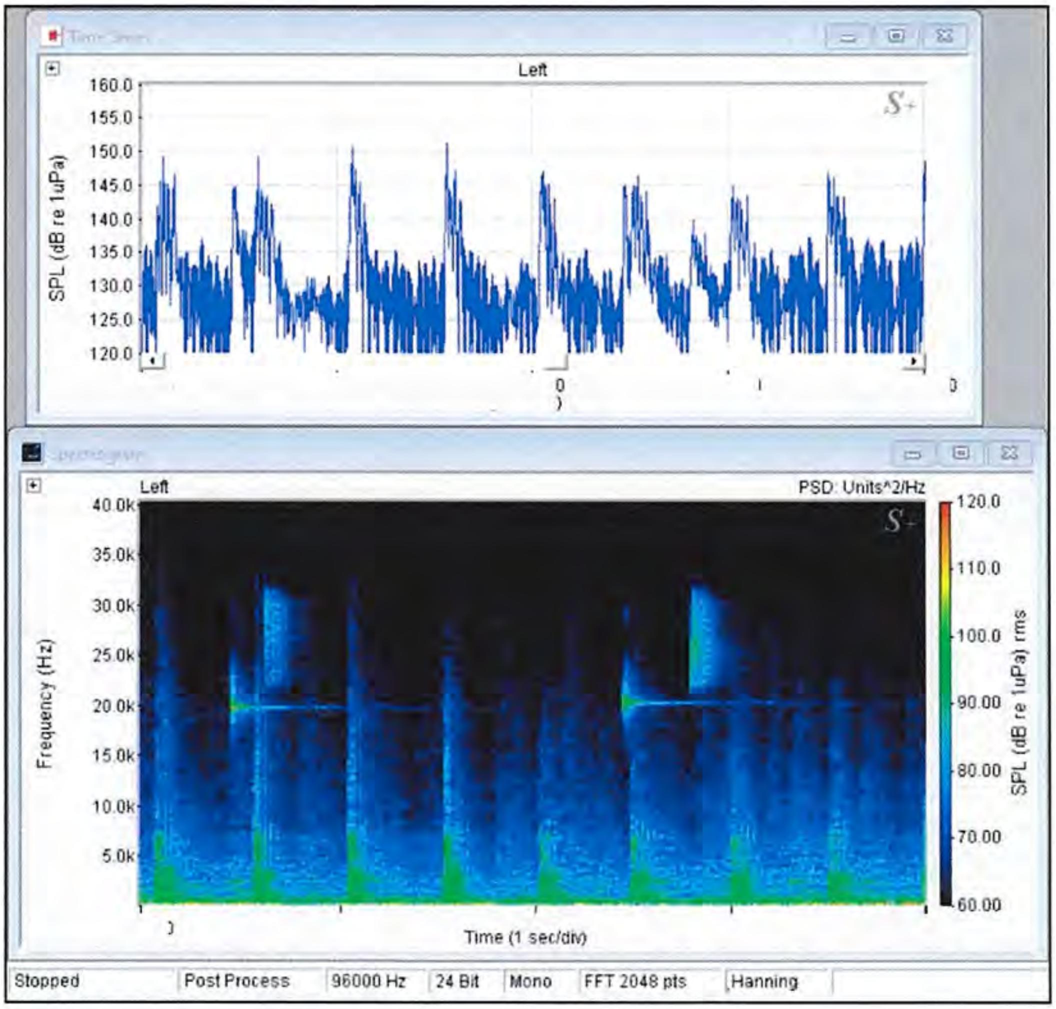

Figure 14. Sound pressure and spectrogram at 0.5nm (926 meters). Signal includes total vessel propulsion, DP thruster, and other equipment noise below 3 KHz, regularly spaced sparker pulses (vertical stripes), and alternating USBL sonar signals at 19.5, 20, and 22 to 32 KHz.

[22] Southall et al, Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations, Aquatic Mammals, Volume 33, Number 4, 2007 ISSN 0167-5427, accessed 9/5/2023. Table 1, Single or Multiple pulses, > 3-dB difference between received level using impulse vs equivalent continuous time constant. Examples include sparkers pulses, single ping of certain sonars, and pingers.

RMS levels for the impulsive MF USBLs are estimated at 125 dB,rms at 0.5 NM, utilizing the NMFS 2020 guideline defining the difference between SPL,peak and SPL,rms as 6 dB for the Single Frequency sonar, listed in Table 1 of the guidelines issued by NMFS in 2020 [23]. Survey RMS levels in the 20 KHz band were 117.5 dB,rms, a ratio of 14 dB below USBL SPL,peak levels.

Figure 14 shows an expanded 4-second time section at 0.5 NM with a times-series sound pressure chart at top and a 2048-point FFT spectrogram underneath lined up in time [24]. The pulsed MF USBLs are clearly visible at 19.5 and 20 KHz, occurring every 2 seconds.

Similarly, the repetitive sparker pulses are easily observed occurring twice per second. Multiple reflections were observed for each sparker pulse. Sound pressures between pulses are dominated by vessel continuous noise and influenced by scattering and reverberation.

3.4 Vessel continuous noise

Vessel noise was observed to be continuous, tonal and highly audible at all measurement locations. As shown in Figures 15 and 16, vessel noise contains numerous tonal components from below 20 Hz to several kilohertz. Noise levels are discussed here for two ranges, 40 Hz up and below 40 Hz. Above 40 Hz, vessel noise is observed to be tonal from multiple propulsion and machinery noise emissions.

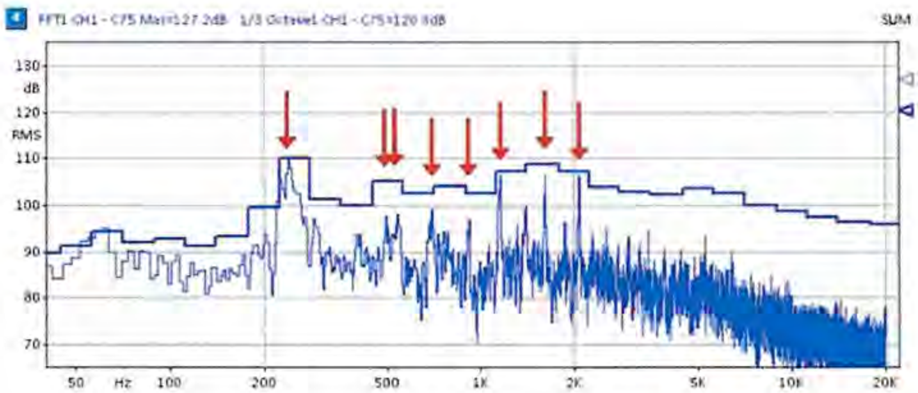

Figure 15. Spectrum chart of one-third-octave and narrow-band 12800 FFT at 0.5nm (926 meters), 4 second span between sonar pulses 841 am. Vessel continuous tones highlighted.

23 Guan, S., Recommendation For Sound Source Level And Propagation Analysis For High Resolution Geophysical (HRG) Sources, National Marine Fisheries Service, Version 4.0, April 2, 2020.

24 The spectrogram's PSD computations employed a 2048-point FFT which displays fractional sound levels per bin due to FFT division of the total received sound pressure at each moment in time shown in the top time series chart, normalized to a 1-Hz bandwidth.

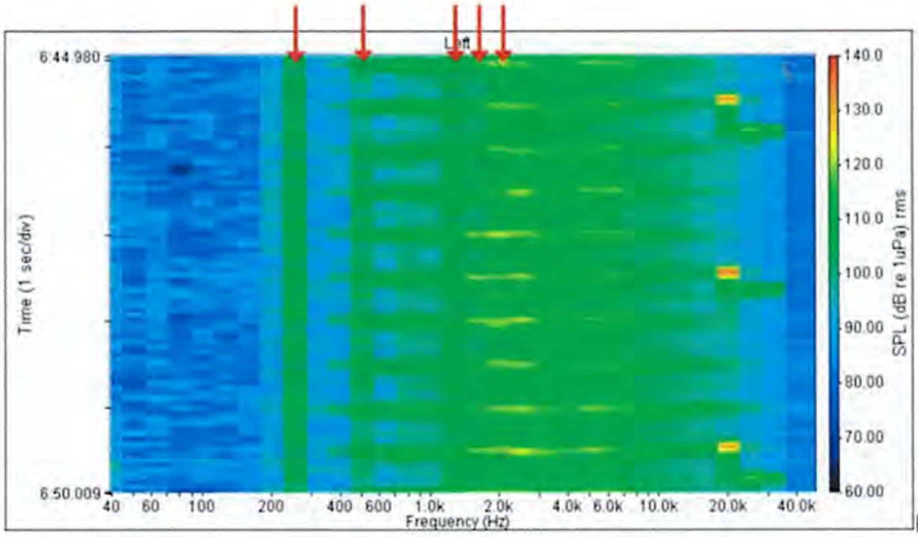

Figure 16. Spectrogram of one-third octave bands, rms at 0.5nm (926 meters), 5 second span. One-third octave bands controlled by vessel tonal noise are highlighted with red arrows. Ultrasonic SBP pulses are observable in the 20, 25 and 31.5 KHz one-third octave bands.

Continuous vessel noise above 40 Hz is observed in the one-third-octave band spectra between sparker pulses, including prominent audible tones in the 250, 500, 630, 800, 1000, 1250, 1600, and 2000 Hz bands. The vessel noise level from 40 Hz to 40 KHz (without sparker and MF USBL positioning sonars) totals approximately 120 dB,rms unweighted.

The frequency range below 40 Hz is an important sonic range for LF cetacean long-range communications. The hydrophone recording at 0.5 NM (926m, approximately 1 kilometer) was decimated 50x with 8192 FFT to analyze vessel-radiated noise below 40 Hz. Vessel noise emissions were assessed with one-third octave band analysis. Vessel noise levels below 40 Hz total 125.4 dB,rms at 0.5 NM (120s). Noise emissions are dominant in the 10 and 12 Hz one-third octave bands as highlighted in Figure 17. These are below human pitch detection range but within the range of data collected.

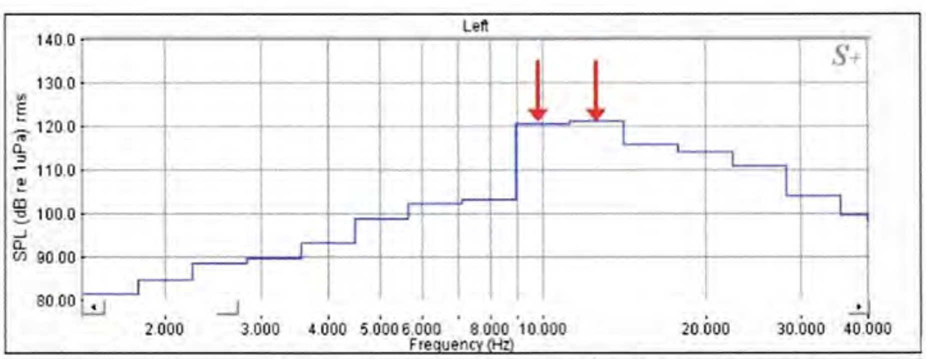

Figure 17. Spectrum of one-third octave bands, rms at 0.5nm (926 meters), 120s span.

To obtain a better picture of vessel emissions at low frequencies with FFT analysis, the recording at 0.5 NM was sped up 10x. Figure 18 shows a 120-second spectrogram at 10x playback speed. Frequencies listed are 10x actual.

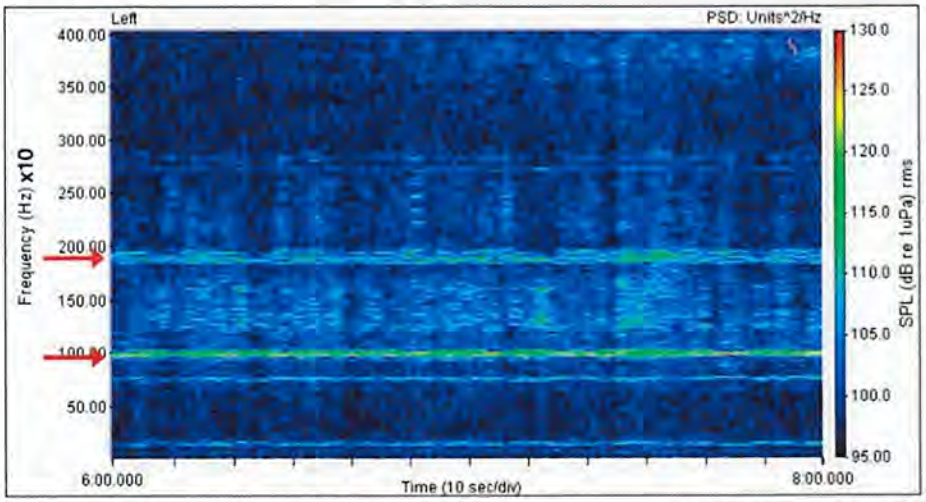

Figure 18. Spectrogram at 0.5nm (926 meters), 120s span, 10x frequency, power spectral density dB re 1uPa²/Hz. Vessel machinery, possible DP thruster noise or propeller cavitation at 9.5 Hz and 19 Hz. Secondary machinery noise observed at 7.3 and 1.2 Hz. Noise at 19 Hz exhibits apparent multiple harmonics.

Noise emissions in this frequency range exhibit fundamentals and harmonics located at approximately 9.5 and 19 Hz. The 9.5 Hz range is consistent with a rotational rate close to 600 RPM. Multiple frequencies at 19 Hz (190 Hz in this 10x chart) are distinct when the 9.5 Hz noise (95 Hz in this 10x chart) is more concentrated. Harmonics in the 19 Hz range shift slightly up and down in frequency over time. Secondary machinery continuous frequencies are observed at 7.3 and 1.2 Hz. By inspection, the noise emissions below 40 Hz are man-made and continuous.

Summary of vessel noise analysis: The vessel noise was *continuous* with no discernible impulsivity. Vessel noise included numerous tonal components from propulsion, DP thruster and other machinery, with a strong cyclical grating sound. Combining the noise emissions below 40 Hz (125.4 dB,rms) with the vessel noise above 40 Hz observed between sparker pulses (120 dB,rms), the total vessel *continuous* noise is estimated at 126.5 dB,rms at 0.5 NM. Vessel continuous noise levels remained above the ambient sound level at 0.5, 1 and 2 NM.

3.5 Reverberation

Reverberation time in the shallow littoral waters at the measurement location (depth 45 meters) was estimated with T20 decay estimation and Schroeder backward integration on selected portions of the audio recording at 0.5 NM, employing the vessel's sparker and MF USBL positioning impulsive sonars as test source. Reverberation was estimated at approximately 1 seconds at 400 Hz and 0.75 seconds at 20 KHz. Total operational noise between sparker firings appears elevated some 10 dB compared to the continuous noise observed from vessel operations prior to sparker firings. This observation is consistent with the well-known acoustic property of reverberation sustaining noise levels between acoustic pulses.

3.6 Sparker Sound Levels

Peak pressure levels controlled by the sparker at 0.5, 1, and 2 NM (shown in Figures 8, 9, and 10) were tabulated and plotted relative to equivalent distance in meters. Peak data acquisition at 1 NM (1852 meters, n=24) was thinned by the sparker firing only once every 5 seconds, as compared to the nominal 2 times per second at 926 and 3704 meters. Peak data selection threshold at 3704 meters was set to 4 Pa to avoid including vessel noise. Figure 19 shows sparker peak pressure levels and calculated transmission loss (TL) trends.

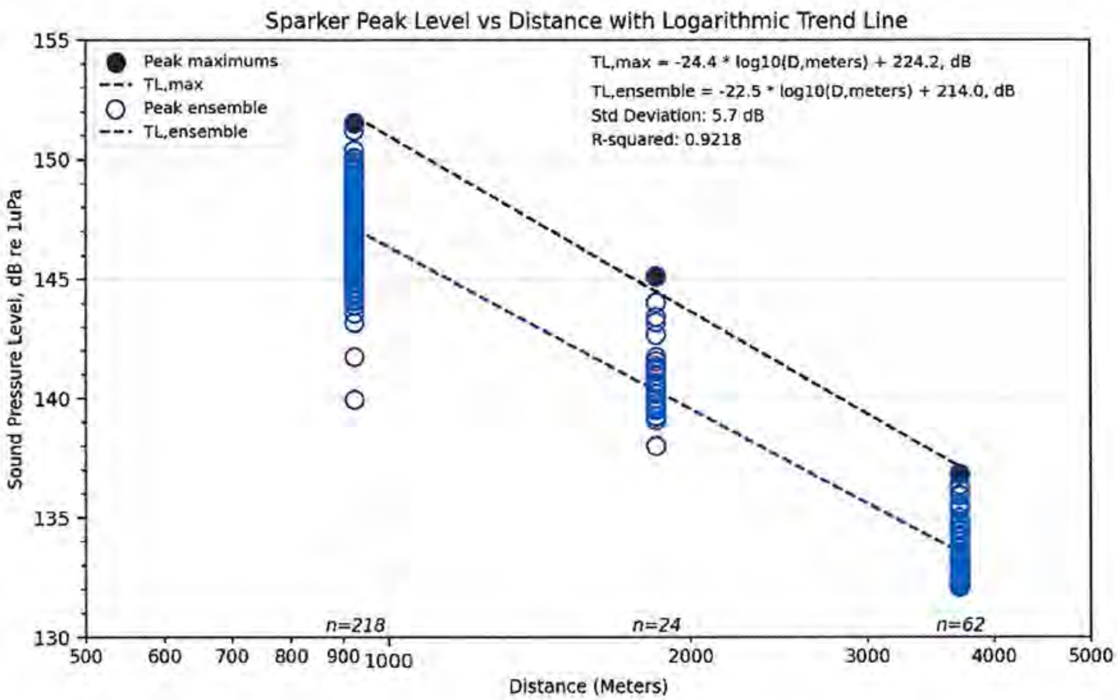

Figure 19. Transmission loss (TL) simple model estimation for peak sound pressure of pulsed sparker, acquired at 0.5, 1, and 2 NM (blue data points), scaled in meters. Trend means for maximum and ensemble peak levels shown as dashed lines..

The sparker SL,peak is conservatively estimated from the top peaks as 224 dB,peak re 1uPA@1m. A second upper prediction limit (UPL) for SL,peak was derived from ensemble peaks variously exhibiting excess attenuation by scattering and interference, employing the trend mean constant (214.0 dB) plus SDx1.96 for 95% confidence (1.96 * 5.7 or 11.2 dB) arriving at 225.2 dB,peak re 1uPA@1m. As discussed further on, both conservative SL,peak estimates are in line with the manufacturer listed typical SL,peak of 2 Bars/m or 226 dB re 1uPA@1m.

The 'max' peaks TL coefficient is estimated at 24.4 dB per decade, approximately 7 dB per doubling of distance. The 'ensemble' peaks TL is 22.5 dB per decade, somewhat closer to spherical spreading. The differential suggests spectra were dynamically attenuated at higher frequencies by phase interference, scattering and shallow-water propagation conditions generally above 3000 Hz in the roughly 50-meter depth at the relatively long distances to the survey measurement locations. The 'ensemble' peaks TL slope appears constrained slightly by the reduced data range at 1 NM and the upward compression of the data at 2 NM (from selecting peaks only above 4 Pa to avoid introducing vessel noise into the data set). It is possible the sparker SL,peak computed from 'ensemble' peaks understates the sparker peak level.

3.7 Transmission Loss

Transmission loss describes the rate of change in sound level versus distance. Transmission loss (TL) coefficients over distance were estimated using the values for SPL,peak(10-24000 Hz) shown in Figure 20, plus TL for one-third octave band rms levels from 400 to 5000 Hz, and the average transmission loss for those bands (SUM). The results were scaled to propagation spreading coefficient α as in αlog10(r) and the results shown in Figure 20.

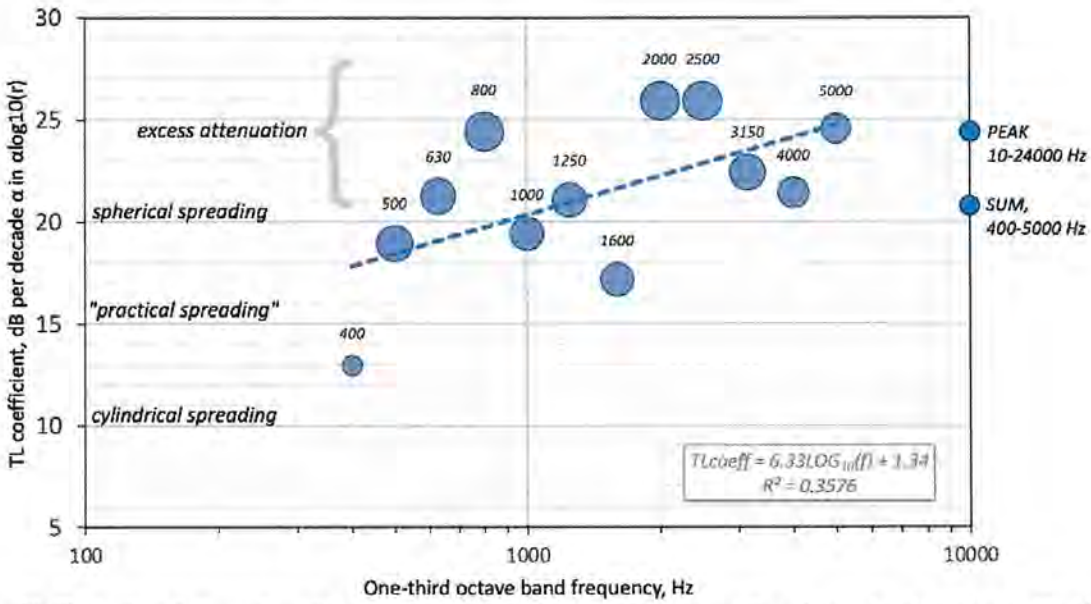

Figure 20. Illustration of attenuation with distance for one-third-octave bands, summation of those bands, and peak. The 1600 Hz band was controlled by vessel tonal noise and was evaluated from 0.5 to 4 NM. All other data were evaluated from 0.5 to 2 NM. The plotted one-third octave band data points are labelled by frequency and scaled visually to measured decibel levels at 0.5 NM. Larger on-third octave band points contain more operations noise.

The one-third octave bands from 500 to 2500 Hz contained vessel continuous operational tonal noise and were strongly influenced by repetitive sparker impulsive noise. The 1600 Hz one-third octave band rms sound level was controlled by continuous vessel tonal noise. Evaluated from 0.5 to 4 NM, the 1600 Hz band level dropped more slowly with distance, with attenuation closer to "practical spreading". The remaining one-third octave bands were evaluated from 0.5 to 2 NM. Overall, sparker peak levels dropped with distance at a faster rate than vessel propulsion and DP thruster noise.

Transmission loss (TL) propagation rates exhibit the effects of excess attenuation notably in the 800, 2000, 2500 and 5000 Hz one-third octave bands where sparker impulse energy is prominent (refer to Figure 16). The TL best fit slope is upward with increasing frequency, consistent with increased excess attenuation at higher frequencies. Several bands exhibit transmission loss slower than spherical spreading; 400, 500, 1000 and 1600 Hz.

These results underscore challenges of accurately estimating SL and far-field SPL sound levels for differing frequency ranges from a single transmission loss coefficient.

3.8 Sparker Level B Harassment Acoustic Threshold Review

NMFS regulates impulsive noise sources based on the impulsive source level SL,rms, including determination of mitigation requirements and methods using a 160 dB,rms isopleth for Level B Harassment. Sparker devices produce impulsive sounds that are subject to NMFS' 160 dB,rms limit and are a primary focus of this survey analysis.

NMFS' guidance for determining sparker source peak and RMS levels directs applicants to use source levels provided by Crocker and Fratantonio (2016). In cases where Crocker and Fratantonio (2016) does not provide source peak and RMS levels for the proposed configuration, NMFS recommends applicants use the manufacturer's specification. Finally, if only peak source levels are available, NMFS allows for approximating the source level RMS by subtracting a certain number of decibels from the reported peak values (Table I, S. Labak, pers. comm., 16 August 2019). Figure 21 shows the NMFS 2020 Table I.

Table I. Amount of decibels subtraction from known SPL_{pk} to approximate the corresponding SPL_{rms} source levels for different types of HRG sources.

Source Type	Difference between SPL_{pk} and SPL_{rms} (dB)
Ideal tone*	3 dB
Boomer	7 dB
Single frequency/FM sonar	6 dB
Sparker	7 dB
GI airgun	6 dB
Bubblegun	6 dB

*** Shown as comparison to actual HRG sources listed below.**

Figure 21. NMFS 2020, Amount of decibels subtraction from known SPLpk to approximate the corresponding SPLrms source levels for different types of HRG sources.

The IHA application proposed using the Geo-Marine sparker with 400 tips to be energized at 800 Joules. With no equivalent unit defined in Crocker and Fratantonio (2016), the manufacturer's data sheet for the sparker was consulted which showed an acoustic waveform with a peak of 2 Bars/m at 800 Joules [25] (see Attachment B). Applying a standard Bars to decibel conversion, this equates to a SL peak of 226 dB which is consistent with sparker source levels determined from survey measurements (i.e. 224 to 225.2 dB,peak re 1uPa@1m). Applying the NMFS Table I for RMS, the sparker RMS level is 226 – 7 = 219 dB,rms re 1uPa.

The IHA did not follow NMFS' guidance, and instead selected a proxy source from Crocker and Fratantonio (2016) listed at 211 dB,peak and 203 dB,rms which are substantially lower than test data of 2 Bars/m (226 dB re 1uPA@1m) published by manufacturer Geo-Marine for the Geo-Source 400 at 800 Joules.

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25 Geo-Marine Geo-Source 400, https://ww2.geosys.nl/products/sparkers/geo-source-400, accessed 9/2/2023.

Nothing in the Geo-Marine data sheets (see Attachment E for analysis) suggests that an SL of 211 dB,peak re 1uPa would be appropriate for a Geo-Source 400 Tips sparker energized at 800 Joules. Similarly, data sheets for the competitor model Applied Acoustics Dura Spark 400 Tips at 600 Joules list an SL,peak of 225.1 dB [26], consistent with the Geo-Marine sparker data.

The difference in SL,rms between the IHA "proxy" sparker and the Geo-Marine sparker prompted review below of the IHA Level B Harassment thresholds for the sparker.

The IHA listed a threshold distance of ***141*** meters for the SL of 203 dB,rms re 1uPa@1m. The IHA spreadsheet is included in Attachment F and copied below in Figure 22.

INPUT VALUES (LEVEL B)	
Threshold Level	160
Source Level (dBrms)	203
Frequency (kH)	1
Beamwidth (degree)	180
Water depth (m)	60

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.00882342
TL coefficient	20
Slant distance of threshold (m)	**141**
Vertical depth of threshold (m)	8.63376E-15
Horizontal Threshold Range (m)	**141**

Figure 22. IHA application spreadsheet calculation for impulsive Level B harassment threshold isopleth for the IHA listing of the Dual Geo-Spark 2000X 400 Tip, 800 Joule.

Using the same spreadsheet, an input value for 'Source Level (dBrms)' of 219 dB,rms determined previously from the Geo-Marine Geo-Source 400 data sheet (400 tip, 800 Joules) peak rating of 2 Bars/m (226 dB,peak re 1uPa@1m), and the decibel ratio of peak to rms recommended by NMFS rule (7 dB), the resulting Level B harassment threshold isopleth distance is ***890*** meters shown in Figure 23.

INPUT VALUES (LEVEL B)	
Threshold Level	160
Source Level (dBrms)	219
Frequency (kH)	1
Beamwidth (degree)	180
Water depth (m)	60

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.00882342
TL coefficient	20
Slant distance of threshold (m)	**890**
Vertical depth of threshold (m)	5.44968E-14
Horizontal Threshold Range (m)	**890**

Figure 23. NOAA/NMFS spreadsheet calculation for impulsive Level B harassment threshold isopleth with the Geo-Marine Geo-Source 400 data sheet (400 tip, 800 Joules) and NMFS recommendations of decibel ratio of peak to rms for sparkers, NMFS 2020.

This 160 dB,rms isopleth analysis suggests that the Level B Harassment threshold distances calculated in the IHA application are underestimated. Note: Using a lower RMS level has a direct effect on the distances and methods of acoustic mitigation for protecting marine life.

26 Applied Acoustics Dura Spark UHD Operation Manual, SPK-DURA-8003/1, Lower Deck Typical Dura Spark Pulse Signature at 600J with 400 tips. https://www.subseatechnologies.com/files/2849/ accessed 9/4/23.

3.9 Sparker SEL and Distances to Level B and Level A Thresholds

From professional experience with industrial noise pollution impacts and statistical audio noise dosimetry in power plant environments [27], questions arose during analysis as to the length of time required to breach NOAA/NMFS Level B and Level A thresholds associated to temporary and permanent threshold shifts (TTS and PTS). The cumulative sound exposure level (cSEL) is computed by summation of sound exposure over time exposed to sound level, expressed in dB re 1 μPa2s. The longer the time, the higher the exposure. Two methods were used to estimate the sparker SEL for a 1-second period which is then extrapolated to longer time periods and assessed against distance using NOAA spherical spreading 20log(r).

SEL from manufacturer data: The peak level for the Geo-Marine 400 Tips 800 Joules sparker is 226 dB re 1uPa. The NMFS RMS rule for sparkers subtracts 7 dB from the peak level to obtain the RMS level, 226 – 7 = 219 dB re 1 uPa. The SEL is the SPL,rms + 10log(t), t in seconds. The manufacturer data suggest a pulse width of 2 milliseconds, yielding 291 – 10log(0.002) = 219 – 27 = 192 dB re 1 uPa^2s for one pulse. At a rate of two pulses per second, the 1-second sparker SEL is 192 + 10log(2) = 192 + 3 = 195 dB re 1uPa^s. This value is derived from two clean sparker pulses per second without reflections or reverberation.

SEL from survey data: The sparker SEL level at 0.5 NM (926 meters) was calculated from RMS data at 124.1 dB re 1uPa^2 for one sparker pulse. At a rate of two pulses per second, the 1-second sparker SEL is 124 + 10log(2) = 124 + 3 = 127 dB re 1uPa^2s at 926 meters. It is assumed that the sparker impulsive RMS level follows the sparker peak level and the sparker impulsive transmission loss (TL) coefficient which measured 24.4 dB per decade. The effective sparker source level SEL in the reflective ocean environment, operating at two sparks per second, is estimated at 127 + 24.4log(926) = 127 + 72 = 199 dB re 1uPa^2s.

Reflections and reverberation add energy and increase sound exposure level compared to the close-in, single-pulse test measurement. The increase for the survey-derived sparker source 1-second SEL, dB re 1uPa^2s,1m in the reflective ocean environment compared to the manufacturer-derived clean-pulse, near-field sparker SEL, dB re 1uPa^2s,1m is 199 – 195 = +4 dB. This increase in the reflective ocean environment is in good agreement and consistent with the presence of multiple reflection groups arriving at survey locations.

By contrast, the IHA application for this vessel used a proxy SEL for a single sparker pulse of 173.4 dB, 19 dB lower than the manufacturer-sourced SEL and 23 dB lower than survey measurements for a single sparker pulse SEL.

Using the 1-second SEL of 195 dB re 1 uPa2s developed from manufacturer data and the NMFS peak-to-RMS guidelines, cSEL was estimated for a range of distances and times assuming fixed source and receiver distances. Figure 24 provides a log plot showing exposure times for the LF Cetacean marine species at Level B (TTS) and Level A (PTS) thresholds, 168 dB and 183 dB re 1uPa^2s, respectively. NOAA's spherical spreading 20log(r) is used for plotting exposure times

[27] Teplitsky, AM, Bradley, WE, Rand, RW and Suuronen, DE, "Statistical Audio Dosimetry Methodology", American Speech-Language-Hearing Association, November 1984. Research and work products were developed under contract with the New York Empire State Electric Energy Corporation (ESEERCO).

versus distance. The results match calculations using the NMFS User Spreadsheet Version 2.2 (2020) Tab 'E' (Stationary).

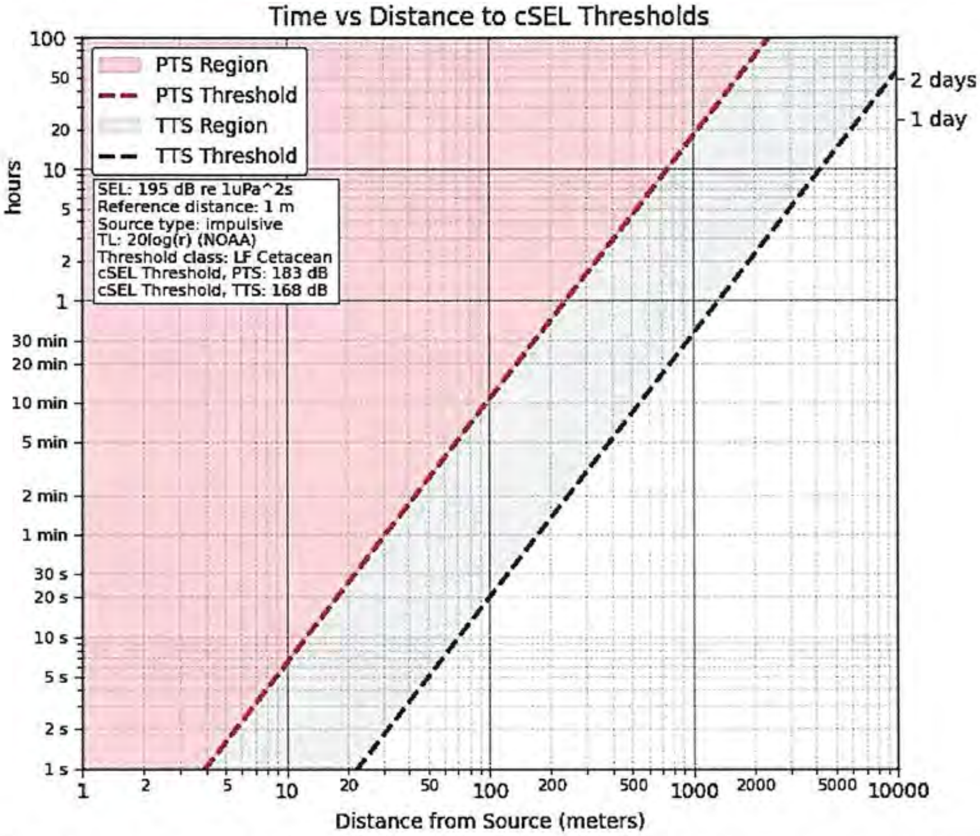

Figure 24. Log plot showing exposure times associated to Level B (TTS) and Level A (PTS) thresholds for the LF Cetacean marine species, 168 dB and 183 dB re 1uPa^2s, respectively, assuming exposure at a fixed position.

Figure 24 illustrates the range of cumulative sound exposure (cSEL) versus distance and time for the 400 Tips/800J sparker operating at 2 pulses per second. For example, a sound exposure of ten minutes at 500 meters yields a cSEL exceeding the TTS threshold (temporary threshold shift, hearing impaired). A sound exposure of five hours at 500 meters yields a cSEL exceeding the Level A PTS threshold (onset of permanent hearing loss). A sound exposure of roughly 25 minutes at the IHA Level B threshold of 141 meters could cause the onset of PTS.

4 Conclusions

This paper presents the methodology, analysis and results of a brief independent investigation of underwater noise levels from a sonar survey vessel, conducted offshore New Jersey on May 8, 2023. The survey results find elevated continuous sound levels at large distances, note disparities between measured sound and IHA equipment listings, and raise concerns about federal acoustic monitoring, noise mitigation, and project oversight.

1. Technical data sheets for the Geo-Marine sub-bottom profiler Geo-Source 400 tip, 800 Joule sparker list 2 Bar/m peak pressure, which is 226 dB,peak re 1uPa@1m, 15 dB higher than the 'proxy' sparker source level (SL) peak of 211 dB re 1uPA taken from Crocker and Fratantonio (2016) for the IHA application.

2. This survey analysis conservatively estimates vessel sparker SL,peak at 224 dB,peak re 1uPa@1m, consistent with Geo-Marine's published SL data.

3. Geo-Marine data sheets don't list the RMS source level. Where sparker SL,peak is available and SL,rms is not available, NFMS recommends using a decibel ratio (peak minus rms) of 7 dB, yielding a sparker SL,rms level of 219 dB re 1uPa@1m.

4. The Level B harassment threshold distance for a sparker SL of 219 dB,rms is 890 meters. Whereas the IHA application used a proxy sparker SL.rms of 203 dB,rms and calculated a Level B harassment threshold distance of 141 meters.

5. Sparker sound exposure level (SEL) determined from Geo-Marine data and NMFS methods was 19 dB higher than the 'proxy' SEL listed in the project IHA application. Survey analysis found measured sparker SEL in the ocean environment another 4 dB above SEL determined from Geo-Marine data. The increase is consistent with multiple sparker echo/reflection groups found in the analysis. Sparker pulse reflections from sea bottom and surface are not factored in NOAA analysis. Cumulative SEL for TTS and PTS impact was plotted for time vs distance for the LF Cetacean (including the critically endangered North Atlantic Right Whale).

6. Several mid-frequency (MF) positioning system sonars (USBL) were measured including two impulsive, intermittent USBLs at 19.5 and 20 KHz, and two FM swept-sine USBLs at 21 to 32 KHz. The four MF USBLs were prominent in their frequency range at 0.5 NM, tens of decibels above the background. Their frequencies are at or near the top hearing sensitivity of cetaceans and phocids. The impulsive MF USBLs measured 131 dB,peak and 117.5 dB,rms at 0.5 NM. The USBLs were not listed or analyzed in the IHA application. USBLs are necessary components for geophysical surveying towing a hydrophone array. It is unclear why NMFS did not require impulse analysis for these sonars.

7. HF sub bottom profilers (SBPs) operating above 85 KHz, if any, could not be acquired during this survey.

8. The IHA application spreadsheets did not show calculations of a Zone of Influence (ZOI) for the 120-dB Level B harassment threshold for continuous noise. The IHA application did not evaluate vessel propulsion, DP thruster or combined continuous noise levels by vessel operations in the lease area. The IHA application treated the vessel as if it were silent.

9. Vessel-only *continuous* noise at 0.5 NM (126.5 dB,rms unweighted) exceeds the NMFS behavioral harassment threshold of 120 dB,rms for continuous noise. DP thruster noise appears to be a significant, even primary contributor to overall vessel noise levels. Total operations noise including sparker was 128.5 dB,rms re 1uPA at 0.5 NM (120s sample).

10. In order to meet the NMFS 120 dB,rms behavioral harassment limit for *continuous* noise, the distance required is approximately 1 nautical mile.

11. NMFS appears to have abandoned evaluation of Level B behavioral harassment at 120 dB,rms.

12. Level A harassment due to cumulative SEL appears feasible depending on time periods occupied at various distances to the sparker. It is unclear that the mitigation methods set in place are adequate to protect the NARW and other ESA-listed mammals and marine species.

13. The results from the survey underscore that absent continuous near-field acoustic monitoring and operations monitoring, NMFS cannot know what noise emissions are occurring during vessel operations. Disparities between IHA application data and the equipment acoustic signatures detected during the survey are concerning. The results suggest a need for comprehensive acoustic monitoring and management of survey equipment prior to and during survey operations.

Limitations

Sonar equipment in the project IHA application was listed as "Proposed". The vessel surveyed (a sister-vessel substitute for the vessel listed in the IHA application) may be outfitted with sonars from different manufacturers and models, with noise levels emissions at other frequencies and levels, than reviewed and approved in the IHA permit.

Geophysical sonar equipment listed for the vessel operating above 85 KHz, if present, was not measured as it was above instrumentation range.

Survey recordings at 4 NM were set aside generally due to increased sea state and wave slap on the investigator boat hull at the time of the 4-nm data acquisition. Vessel tonal noise in the 1600 Hz one third octave band was usable.

Source Level SL estimations from far field measurements can differ significantly depending on the sound attenuation versus distance. Sound attenuation with distance underwater could differ from the results found during this survey depending on factors including absorption and scattering, winter versus summer sound speed gradients, thermocline strength, sea state, and sea bottom absorption and reflectivity. Increased TL at upper frequencies are generally due to increased excess attenuation at higher frequencies, which is expected for the distances measured and shallow-water acoustic conditions above 3000 Hz. The May time of year, the presence of a shallow seasonal thermocline at 18 to 23 meters, and the measured attenuation of 24.4 dB per decade that is steeper than the standard 20 dB per decade all suggest sound attenuation measured during the survey is closer to a summer condition than a winter condition.

Declaration of Conflicting Interests

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this report. INCE Members are required by professional ethics to ensure compliance with regulatory requirements and hold paramount the safety, health and welfare of the public. The author extends the same professional commitments to marine species.

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Acknowledgements

Many thanks to investigator boat captain Brian and trip coordinator Greg for a safe and successful voyage out of Barnegat Light, NJ. Many thanks to Adam Sniff P.E. of Cetacean Research Technology and Richard Craig at BRC Engineering for consultation and support with system design and calibration, and John Pattee of Pioneer Software LLC for review of rms calculations. Many thanks to the anonymous reviewer who provided invaluable proofreading and helpful comments.

5 Attachments

Attachment A: Vessel acoustic equipment proposed in project IHA application.

Table 1-3 Proposed Acoustic Equipment for HRG Surveys for the Project

Equipment Type	Equipment Make/Model	Operating Frequency (kHz)	Source Level (RMS dB re 1 μPa @1m)	Source Level (Peak dB re 1 μPa @1m)	Sound Exposure Level (dB re 1μPa²-s; NR=not reported)	Reference for Source Level	Pulse Duration (milliseconds)	Repetition Rate (Hz)	Beam Width (degrees)
Mobile, Non-impulsive, Intermittent									
Side-Scan Sonar	EdgeTech 4205	300/600 or 300/900	NR	NR	NR	NR	NR	NR	50
Multi-beam Echosounder	Dual head Norbit Winghead	400	NR	NR	NR	NR	NR	60	NR
Gradiometer/ Altimeter*	Geometrics G882	200	190	192	NR	Crocker and Fratantonio 2016†	1.13	50	7
Shallow SBP	Innomar SES-2000	85-115	241	247	NR	Manufacturer	2	40	2
Mobile, Impulsive									
Deep SBP	Dual Geo-Spark 2000X (400 tip/800 J)	0.3–1.2	203	211	174	Crocker and Fratantonio 2016‡	1.1	4	180

*Acoustic specification applies to the optional altimeter on the gradiometer.

†Odom Echo Trac Proxy

‡Applied Acoustics Dura-spark 500 J to 2,000 J Proxy

Key:

NR – Not reported

SBP – sub-bottom profiler

Hz – hertz

kHz – kilohertz

μPa – microPascal

RMS – root mean square

dB – decibel

re – referenced at

m – meters

s – seconds

Table 1-4 Level A and Level B Threshold Distances for the Proposed Sub-Bottom Profilers

Equipment Make/Model	Distance to 160 dB (m)	Horizontal Distance to 160 dB (m)	Distance to Level A Isopleth (m)				Distance to Level B Isopleth (m)
			Low Frequency	Mid Frequency	High Frequency	Pinnipeds	All
Innomar SES-2000	116	1.05	<1	<1	135.9	<1	1.05
Dual Geo-Spark 2000X (400 tip/800 J)	141	141	<1	<1	2.8*	<1	141

Level A distances are based on the SELcum threshold unless denoted with *, in which case it is based on the Peak threshold (higher of the two values is shown).

Key:

m – meters

J - joules

dB – decibels

Attachment B. Geo-Marine Geo-Source 400 sparker data sheet

GEO
MARINE SURVEY SYSTEMS

Geo-Source 400

MARINE MULTI-TIP SPARKER SYSTEM

Versatile maintenance free negative discharge sparker designed for small and larger operations.

Description

INNOVATIVE PRESERVING ELECTRODE MODE
The Geo-Source 400 is designed to operate with the 2000 X Geo-Spark Pulsed Power Supply or higher. It uses the the "Preserving Electrode Mode", a patented concept that consists of using a NEGATIVE electric discharge pulse, instead of positive.

Note that working with a negative pulse is NOT the same thing as reversing the polarity of an antique power supply, which is generating a positive pulse.

MAINTENANCE FREE ELECTRODES 5 YEAR GUARANTEE
The Preserving Electrode Mode reduces the tip wear to practically zero. You can shoot day after day, week after week, month after month with practically NO tip maintenance.

OPTIMUM ACOUSTIC REPEATABILITY
Zero tip wear is essential for the repeatability of the acoustic pulse, which depends largely on a constant, unaltered electrode surface.

Operational Features

→ Water depths from 2 to 1500 m.

→ Penetration higher than 400 ms below seabed depending on geology.

→ Vertical resolution of 10 - 30 cm.

→ You don't need to trim tips during the survey - electrodes do NOT burn off.

→ Successfully employed in wind farm surveying, coastal engineering, sand search, site and route surveys and many others.

geo-spark.com

Attachment B (cont.) Geo-Marine Geo-Source 400 sparker data sheet

MARINE SURVEY SYSTEMS

Geo-Source 400

MARINE MULTI-TIP SPARKER SYSTEM

Geo Spark 400 with a 48 ch. Multi-channel streamer - see more examples at our gallery.

signal spectrum at 800 J and source 30 cm deep.

No wear of the tips even after 3 years of use.

Additional Features

CONTROL OF ALL SPARKER PARAMETERS
The effective source depth is 15-20 cm. A constant source depth at 1/4 of the wavelength is essential in order to optimize the constructive interference between the primary pulse and surface ghost. But this can be easily customized by the user with the use of extensions, for instance, in situations where penetration should be a priority.

SOURCE GEOMETRY AND CONFIGURATION OF THE TIPS
The electrode modules are evenly spaced in a planar array of 0.50 m x 1.00 m. This geometry not only enhances the downward projection of the acoustic energy, it also reduces the primary pulse length, since all tips are perfectly in phase. Each tip has an exposed surface of 1.4 mm, suitable for maximum 10 Joules per tip and with this configuration it gives an excellent pulse over the 400 - 2000 Joule power range.

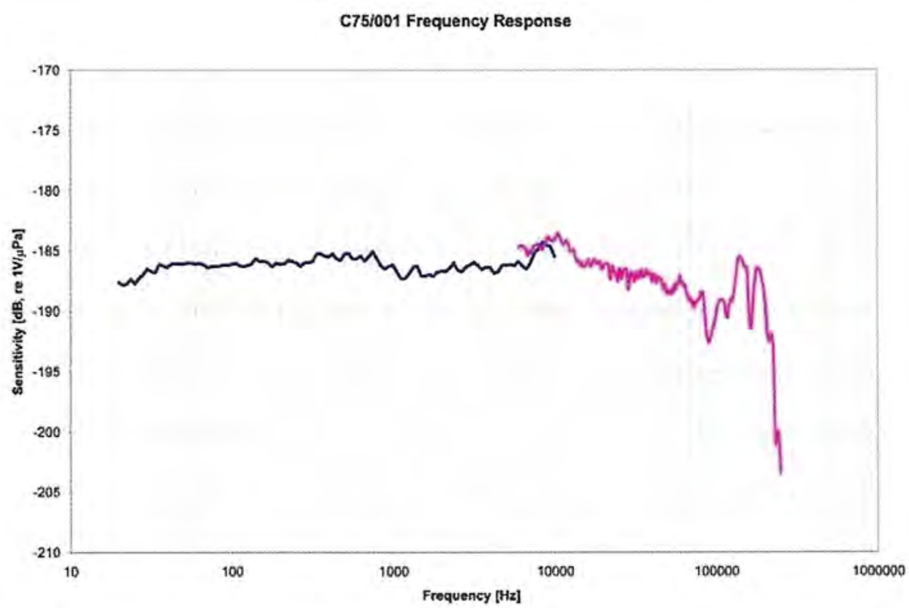
FLEXIBLE AND FLOATING HV TOW CABLE
The Geo-Source 400 is towed by a very high quality, Kevlar reinforced, coaxial power/tow cable with stainless steel kellum grip. This dedicated high voltage (HV) cable contains 4 × 10 mm² cores (negative) plus a 40 mm braiding (ground-referenced). It is designed to have a very low self inductance to preserve the high dI/dt pulse output of the Geo-Spark 2000 PPS. The coaxial structure of the HV cable reduces the electromagnetic interference to the absolute minimum.

Specification

Dimensions (cm) & Weight	110 (L) x 120 (W) x 60 (H) for 80 kg
Number of Tips	400
Operation Depth (m)	2 - 1500
Dominant Frequencies	1000 - 1500 Hz (at 800 J)
Better if used with	Geo-Spark 2000, BE single-channel Streamer, multi-channel streamer
Recommended interface system	Mini-Trace II or Multi-Trace Server
Power Requirements	5kVA generator (for the Power Supply)

geo-spark.com

Attachment C. Cetacean Research hydrophone frequency response (manufacturer test).



Attachment D. GRAS Model 42AG Acoustic Calibrator calibration certificate.

Calibration Chart

GRAS 42AG Multifunction Sound Calibrator, Class 1

Serial No	281474
Calibration date	14. Feb. 2023
Operator	ZBA

Environmental calibration conditions

Temperature	23 °C
Relative humidity	44 %
Barometric pressure	1030 hPa

	Nominal Frequency [Hz]	Measured SPL [dB re. 20 uPa]	Measured Frequency [Hz]	Measured THD [%]	Measured THD + Noise [%]	Status
Tolerance		±0.20	±0.30	1.5	2.0	
Uncertainty		±0.08	±0.02	±0.1	±0.1	
94 dB	251.19	94.00	251.20	0.08	1.03	Pass
114 dB	251.19	114.02	251.20	0.13	0.23	Pass
94 dB	1000	94.02	1000.00	0.01	1.47	Pass
114 dB	1000	114.02	1000.00	0.02	0.13	Pass

Calibration

The performed tests refer to the sections 5.2, 5.3 and 5.5 in IEC 60942 (2003): Electroacoustics - Sound Calibrators. The calibrator has been tested ad described in Annex B of the IEC 60942 standard.

Approved by

Quality Manager

14. Feb. 2023

Date

GRAS Sound & Vibration

GRAS Sound & Vibration A/S
Skovlytoften 33, 2840 Holte, Denmark
Email support@gras.dk · gras.dk

Attachment D (continued). BRC hydrophone adapter calibration certificate.

BRC Engineering

21870 Eighth St. E
Unit # C-4
Sonoma, CA 95476

Tel. 707-226-3332
Fax 707-236-8964
E-Mail: brcnorcal@aol.com

CALIBRATION CHART for TYPE HADP42AG-C75 S/N: 65506

Hydrophone Adapter for Calibrator Type # 42AG used to

Calibrate CETACEAN Hydrophone Type # C75

Pressure Correction Factor: 0 dB +/- 0.5 dB at reference conditions

Nominal Frequency: 250 Hz

There is no pressure correction factor for the HADP42AG-C75. The sound pressure level inside the adapter is determined by the pressure level chosen on the G.R.A.S. 42AG, either

1 Pa or 94 dB re 20 microPa or 120 dB re 1 microPa

or

10 Pa or 114 dB re 20 microPa or 140 dB re 1 microPa

Note: 250 Hz preferred for best accuracy

Reference Conditions:

Ambient Temperature: 14.7 C
Ambient Static Pressure: 101.0 kPa
Relative Humidity: 64%

Reference Equipment:

Calibrator Type: G.R.A.S. # 42AG
Microphone Type: LD Type 377B02
Hydrophone Type: C-75

Approved by: Richard Craig

Signature: [signature]

Date: May 3, 2023

Attachment E. Sparker Data Review

The IHA application listed the "Geo-Marine Dual Geo-Spark 2000X" (400 tip/800 J) in the sparker identification field. The model 2000X is the power supply for the sparker. The power supply doesn't emit sound underwater. It's housed in a weather-proof work shed on deck and supplies voltage to the sparker. The sparker (Geo-Source 400 Tips) is towed behind the vessel in a sled with a strong tow cable and is connected to the power supply with electrical cable. The sparker is energized at the listed Joules level. Figure E-1 shows the Geo-Marine 2000X power supply (left) and the Geo-Marine 400 sparker (right).

Figure E-1. Geo-Marine Dual Geo-Spark 2000X Power Supply (left) and Geo-Source 400 sparker sled (right).

The Geo-Marine Geo-Source 400 data sheet shows an acoustic waveform with a peak of 2 Bars/m at 800 Joules [28]. This is the configuration listed in the IHA application (400 tip / 800 Joules). Determining SL in dB re 1uPA requires conversion from Bars to pascals (1 Bar = 100,000 Pa) and then to decibels re 1uPA, that is, 20 * log10(2* 100,000/0.000001) = **226** dB re 1uPa@1m. This report's sparker SL estimates of 224 to 225.2 dB,peak re 1uPa@1m are consistent with the manufacturer's published data.

Bracketing the Geo-Source 400, the smaller Geo-Marine Geo-Source 200 data sheet (200 tip) shows a test waveform with a peak of 0.91 Bars/m at 300 Joules, equivalent to **219.2** dB,peak re 1uPa@1m [29]. The larger Geo-Marine Geo-Source 800 data sheet (800 tip) shows a test waveform with a peak of 2.2 Bars/m at 6000 Joules, equivalent to **226.8** dB,peak re 1uPa@1m [30].

Nothing in the Geo-Marine data sheets suggests that an SL of 211 dB,peak re 1uPa would be appropriate for a Geo-Source 400 Tips sparker energized at 800 Joules. Similarly, data sheets for

28 Geo-Marine Geo-Source 400, https://ww2.geosys.nl/products/sparkers/geo-source-400, accessed 9/2/2023.
29 Geo-Marine Geo-Source 200, https://ww2.geosys.nl/products/sparkers/geo-source-200, accessed 9/2/2023.
30 Geo-Marine Geo-Source 800, https://ww2.geosys.nl/products/sparkers/geo-source-800, accessed 9/2/2023.

the competitor model Applied Acoustics Dura Spark 400 Tips at 600 Joules list an SL,peak of 225.1 dB, consistent with the Geo-Marine sparker data.

Figure E-2 shows sparker SL,peak sound level output by input in Joules for 1) the Geo-Marine and Applied Acoustics Dura-Spark manufacturer data sheets, and 2) the test data in Crocker and Fratantonio (2016) Table 10.

The Geo-Marine manufacturer's data for the Geo-Source 400 Tips at 800 Joules is shown with blue dot. The Applied Acoustics manufacturer's data for the Dura-Spark 400 Tips at 600 Joules (lower sled) is shown with orange dot.

By inspection, the 'proxy' sparker source peak sound level selected for the IHA application is much lower than the manufacturer data, and lower than most data in Crocker and Fratantonio (2016) Table 10.

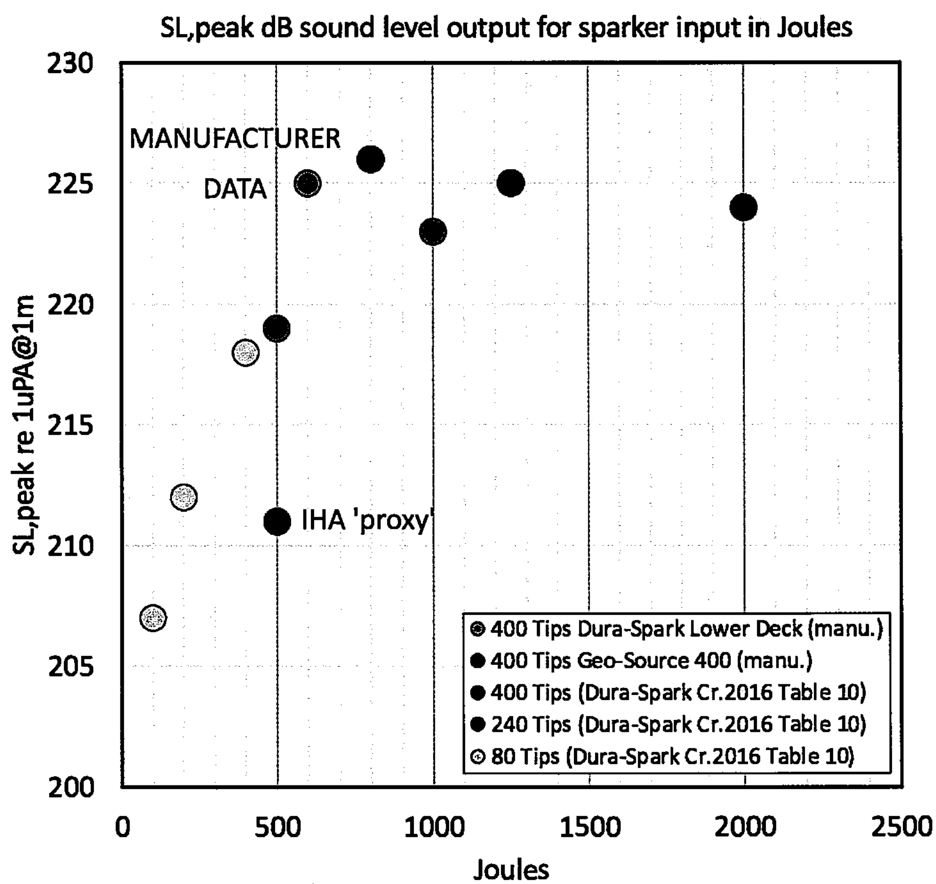


Figure E-2. Sparker SL,peak sound level output by input in Joules for 1) the Geo-Marine and Applied Acoustics Dura-Spark manufacturer data sheets, and 2) the test data in Crocker and Fratantonio (2016) Table 10.

Attachment F. IHA Appendix B Spreadsheet Results

Application for Incidental Harassment Authorization for the Non-Lethal Taking of Marine Mammals during a Site Characterization Survey

F: MOBILE SOURCE: Impulsive, Intermittent ("SAFE DISTANCE" METHODOLOGY)
VERSION 2.2: 2020

KEY

(green)	Action Proponent Provided Information
(pink)	NMFS Provided Information (Technical Guidance)
(blue)	Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Attentive Energy HRG Surveys
PROJECT/SOURCE INFORMATION	Dual Geo-Spark 2000X (400 tip/800J)
Please include any assumptions	
PROJECT CONTACT	Sarah Courbis/Melissa Snover

STEP 2: WEIGHTING FACTOR ADJUSTMENT

		Specify if relying on source-specific
Weighting Factor Adjustment (kHz)¥	1	NMFS recommended

¥ Broadband: 95% frequency contour percentile (kHz); For appropriate default WFA: See INTRODUCTION tab

CONVERSIONS

Source Level ($L_{pk,pk}$)			
Source Level (L_{0-pk})	6	**Source Level (L_{0-pk})**	
Source Level (L_{rms})	12	**Source Level (L_{rms})**	-5
Source Level ($L_{E,p, single shot}$)	22	**Source Level ($L_{E,p, single shot}$)**	-16

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 68), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: METHOD F1 is PREFERRED method when SEL-based source levels are available (because pulse duration is not required). Only use method F2 if SEL-based source levels are not available.

F1: METHOD† TO CALCULATE PK and SEL[illegible] (SINGLE SHOT/PULSE EQUIVALENT) PREFERRED METHOD (pulse duration not needed)

SEL_{cum}

Source Level ($L_{E,p}$ [illegible])	173.4
Source Velocity (meters/second)	2.06
1/Repetition rate^ (seconds)	0.25
Source Factor	8.75105E+17

loss of 20 log R; Activity duration (time)
^Time between onset of successive pulses (inverse of repetition rate or inter-pulse interval)

PK

Source Level (L_{pk} [illegible])		211

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS*

*Impulsive sounds have dual metric thresholds (SEL cum & PK). Metric producing largest isopleth should be used.

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	183	185	155	185	203
PTS SEL_{cum} Isopleth to threshold (meters)	0.7	0.0	0.1	0.1	0.0
PK Threshold	219	230	202	218	232
PTS PK Isopleth to threshold (meters)	NA	NA	2.8	NA	NA

"NA": PK source level is ≤ to the threshold for that marine mammal hearing group.

Application for Incidental Harassment Authorization for the Non-Lethal Taking of Marine Mammals during a Site Characterization Survey

	A	B	C
1	Slant Distance	TL	RL
2	1	8.82E-06	203
3	2	6.020618	196.9794
4	3	9.542452	193.4575
5	4	12.04124	190.9588
6	5	13.97944	189.0206
7	6	15.56308	187.4369
8	7	16.90202	186.098
9	8	18.06187	184.9381
10	9	19.08493	183.9151
11	10	20.00009	182.9999
12	11	20.82795	182.172
13	12	21.58373	181.4163
14	13	22.27898	180.721
15	14	22.92268	180.0773
16	15	23.52196	179.478
17	16	24.08254	178.9175
18	17	24.60913	178.3909
19	18	25.10561	177.8944
20	19	25.57524	177.4248

Source Name:

INPUT VALUES (LEVEL B)	
Threshold Level	160
Source Level (dBrms)	203
Frequency (kH)	1
Beamwidth (degree)	180
Water depth (m)	60

COMPUTED VALUES (LEVEL B)	DO NOT CHANGE
alpha (dB/km)	0.00882342
TL coefficient	20
Slant distance of threshold (m)	**141**
Vertical depth of threshold (m)	8.6373E-15
Horizontal threshold range (m)	**141**

Level B

Ready

Attachment F (continued). IHA Appendix B Spreadsheet Results

D: MOBILE SOURCE: Non-Impulsive, Intermittent ("SAFE DISTANCE" METHODOLOGY)

VERSION 2.2: 2020

KEY

- Action Proponent Provided Information
- NMFS Provided Information (Technical Guidance)
- Resultant Isopleth

STEP 1: GENERAL PROJECT INFORMATION

PROJECT TITLE	Attentive Energy HRG Survey
PROJECT/SOURCE INFORMATION	Innomar Sub-Bottom Profiler
PROJECT CONTACT	Sarah Courbis/Melissa Snover

STEP 2: WEIGHTING FACTOR ADJUSTMENT

Weighting Factor Adjustment (kHz)¥	85	[illegible]

¥ Broadband: 95% frequency contour percentile (kHz) OR Narrowband: frequency (kHz); For appropriate default WFA: See INTRODUCTION tab

† If a user relies on alternative weighting/dB adjustment rather than relying upon the WFA (source-specific or default), they may override the Adjustment (dB) (row 61), and enter the new value directly. However, they must provide additional support and documentation supporting this modification.

STEP 3: SOURCE-SPECIFIC INFORMATION

NOTE: METHOD D1 is PREFERRED method when SEL-based source levels are available (because pulse duration is not required). Only use method D2 if SEL-based source levels are not available.

D1: METHOD† (SINGLE PING/PULSE EQUIVALENT) : PREFERRED METHOD (pulse duration not required)

Source Level ($L_{E,p}$ single ping/pulse)	178
Source Velocity (meters/second)	2.06
1/Repetition rate^ (seconds)	0.025
Source Factor	2.52383E+19

†Methodology assumes propagation loss of 20 log R; Activity duration (time) independent

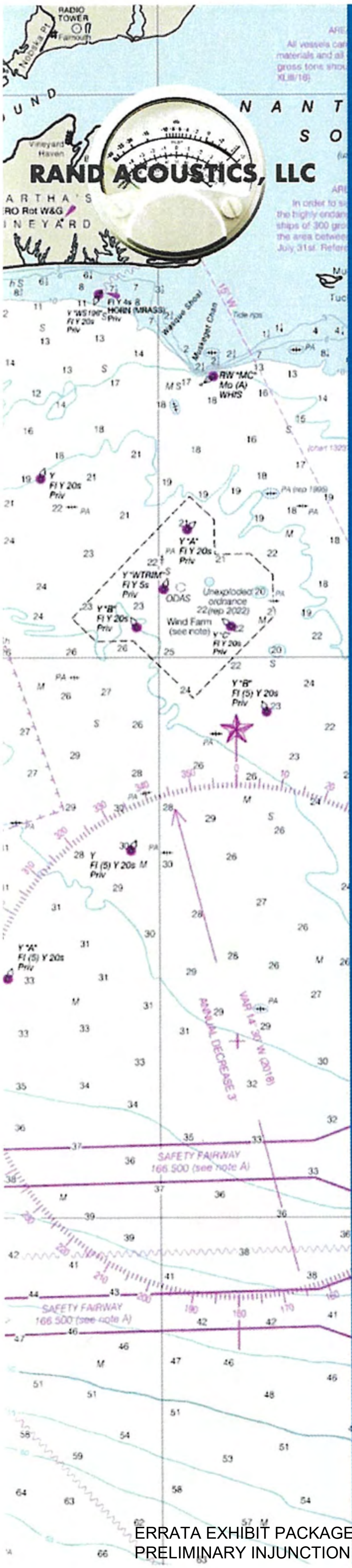
^Time between onset of successive pulses (inverse of repetition rate or inter-pulse interval).

NOTE: The User Spreadsheet tool provides a means to estimates distances associated with the Technical Guidance's PTS onset thresholds. Mitigation and monitoring requirements associated with a Marine Mammal Protection Act (MMPA) authorization or an Endangered Species Act (ESA) consultation or permit are independent management decisions made in the context of the proposed activity and comprehensive effects analysis, and are beyond the scope of the Technical Guidance and the User Spreadsheet tool.

RESULTANT ISOPLETHS

Hearing Group	Low-Frequency Cetaceans	Mid-Frequency Cetaceans	High-Frequency Cetaceans	Phocid Pinnipeds	Otariid Pinnipeds
SEL_{cum} Threshold	199	198	173	201	219
PTS Isopleth to threshold (meters)	0.0	0.3	135.9	0.0	0.0

D



PILE DRIVING NOISE SURVEY
Technical Report

Survey Date:
November 2, 2023

Report Date:
March 28, 2024

Rand Acoustics, LLC
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Brunswick, ME 04011

Abstract

This technical report presents the methodology, analysis, and results of an independent investigation of underwater noise levels from wind turbine pile driving operations, conducted southwest of Nantucket on November 2, 2023.

Keywords: noise, offshore, survey, vessel, hydrophone, pile driving, piling, hammer, threshold, transmission loss, peak, RMS, SEL, thermocline, bubble curtain

Foreword

This technical report serves as a comprehensive document intended to provide valuable insights, analysis, and information pertaining to wind turbine pile driving noise. It has been prepared to support understanding of pile driving noise levels versus distance for a diverse audience, including professionals, researchers, policymakers, and interested stakeholders. The primary purpose of this report is to facilitate informed decision-making, foster discussion, contribute to the advancement of knowledge in this field, and improve noise control protections for the critically endangered North Atlantic right whale and other ESA-listed mammals and marine species.

Disclaimer

The information contained in this technical report is presented in good faith and based on the best available data and analysis at the time of publication. However, it is important to note that the content is subject to change as new research, developments, or circumstances emerge. The author makes no representations or warranties, either express or implied, regarding the accuracy, completeness, or suitability of the information provided. Users of this report are encouraged to verify the information independently and consider consulting relevant experts when making decisions based on its content.

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Version	Date	Author	Purpose
1	3/28/24	rwr	Published
1.1	3/28/24	rwr	Reference broken in pdf creation corrected.

CONTENTS

EXECUTIVE SUMMARY

Recent whale and dolphin fatalities on the Eastern seaboard, coupled with concerns about the acoustic impact of offshore wind farm construction, prompted an independent investigation to measure and assess underwater noise emissions from pile driving activities. Specifically, this assessment focused on the operations of the pile driving vessel Orion within the Vineyard Wind project area, with recordings taken in the waters southeast of Nantucket Island.

Key Findings:

- Pile driving noise, even with advanced noise-mitigation techniques, rivals the loudness and frequency range of seismic air gun arrays, with impulsive peak noise levels measured up to 180 dB over 1 kilometer away and RMS levels over 160 dB at over 3.3 kilometers.
- The standard 90-percent RMS metric utilized by the National Marine Fisheries Service (NMFS) underestimates the sound level experienced by cetaceans by as much as 6 dB, potentially cutting the protective distances in half and reducing marine mammal safeguarding zones by up to 75%.
- The continuous noise generated by vessel propulsion and dynamic positioning (DP) thrusters significantly surpassed the federal threshold for behavioral harassment, with noise levels exceeding 120 dB out to over 6 kilometers. Given federal agencies' concerns over the compound effects of continuous and impulse noise, this frequently overlooked issue in regulatory assessments constitutes a definitive risk of behavioral harassment to marine mammals, underscoring the need to reevaluate current protective measures.

Conclusion:

This investigation discovered a substantial underestimation of both impulsive and continuous noise levels by current regulatory standards, suggesting that the actual exposure to harmful noise levels from pile driving for marine mammals like the critically endangered North Atlantic Right Whale is substantionally greater than NMFS acknowledges in its existing protective measures. This indicates an urgent need to review and possibly revise NMFS monitoring protocols and mitigation strategies for pile driving to ensure adequate protection for marine mammals against both impulse and continuous underwater noise pollution. The findings detailed in this report underscore the need for immediate action due to the substantial underestimations uncovered by this independent investigation.

Recommendations:

- Immediate reassessment of RMS computation methods to more accurately represent the potential risk of pile driving noise to marine mammal hearing.
- Inclusion of continuous noise assessment from vessel operations in regulatory reviews, with a focus on managing combined noise levels to remain below NMFS thresholds for behavioral harassment during impulsive activities such as pile driving.
- Enhancement of protective radii and mitigation distances to shield marine mammals from the risk of behavioral harassment and auditory injury.

1 Introduction

1.1 Background

Reports of recent whale and dolphin deaths along the Eastern seaboard, coupled with concerns of marine noise impacts from offshore wind development activities, prompted an independent investigation into pile driving noise levels in ocean areas leased by the Bureau of Ocean Energy Management (BOEM). The crane ship Orion (IMO: 9825453) has been utilized as a pile driving vessel in the Vineyard Wind BOEM Lease Area OCS-A 0501 southwest of Nantucket.

Figure 1. The Orion, drone view, in Vineyard Wind lease area. Photo by DEME [1], shows Orion (right) at stationary position with hammer on starboard side, monopile sections in laydown amidships. Bubble curtain support vessel at left.

The Orion is an offshore heavy lift vessel registered in Belgium [2]. The Orion is 216.5 m long, 49 m wide, with an operating draft of 11 m. It is equipped with a main crane with 5,000 ton capacity and an auxiliary crane with 1,500 ton capacity. Propulsion includes 4 x 4.500 kW Azimuth thrusters, 2 x 4,200 kW Retractable Thrusters, and 2 x 2,500 kW Tunnel thrusters. It is equipped with Dynamic Positioning (DP3, redundant hardware and control for assured positioning).

The Orion is equipped with an IHC IQIP S-4000 pile driving system rated for a 4,000 kiloJoule (kJ) maximum hammer blow energy, 397 kJ minimum hammer blow energy, hammer blow rate up to 36 bl/min, ram weight 200 tons, and hammer weight 430 tons.

1 https://www.deme-group.com/news/offshore-works-kick-vineyard-wind-farm-us-installation-first-foundation, publication date 06 JUN 2023.

2 DEME Orion, DP3 offshore installation vessel, https://www.deme-group.com/technologies/orion

Noise controls include a hydro sound damper and double bubble "Big Bubble" curtains [3,4,5,6] for pile driving noise reduction (HSD + DBBC). Appendix A provides details on the bubble curtain technology, which uses compressed air supplied by a nearby support vessel. Outer bubble curtain radius is roughly 150 to 200 meters. Hydro sound dampers are vertical nets with acoustic elements supported around the monopile and do not use compressed air. These noise reduction technologies may be considered "best available" for pile driving.

Figure 2. Drone view of he Orion showing double bubble curtains operating. Air compressor support vessel is out of frame at lower left edge of photo. The hydro sound damper is hung around the monopile from sea level to seabed. Photo by DEME [7].

3 A hydro sound damper is a donut-shape cylindrical net vertically surrounding the monopile being driven. The damper net contains polyethylene foam or rubber material elements. Noise reduction is obtained with acoustic resonance, dissipation and damping, impedance shifts and sound speed reductions in the net elements.

4 https://www.researchgate.net/publication/293465032_Hydro_sound_emissions_during_impact_driving_of_monopiles_using_Hydro_Sound_Dampers_and_Big_Bubble_Curtain, accessed 1/1/24.

5 https://www.eenews.net/articles/blowing-bubbles-offshore-winds-new-strategy-to-save-whales/

6 https://www.hydrotechnik-luebeck.de/portfolio-items/compressed-air-hydro-sound-mitigation/

7 https://www.deme-group.com/technologies/orion#/media/5

1.2 Pre-Operational Noise Impact Assessments

In preparing this report, four project documents furnishing noise impact models and estimates were reviewed [8,9,10,11]. Underwater acoustics metrics are discussed in this report's Section 2.

- Vineyard Wind 1 Construction and Operations Plan Appendix III-M: Supplemental (Dec 2018)
- Offshore Wind Energy Project Biological Assessment (BOEM Mar 2019)
- IHA Application (Apr 2019)
- IHA Authorization (May 2021)

Key points are summarized below:

- PTS injury is estimated from weighted sound exposure accumulated over 24 hours (cSEL) or from very loud instantaneous sound pressure levels. TTS injury is estimated from weighted sound exposure accumulated over 24 hours (cSEL).

- Behavioral harassment is classified as a Level B harassment for received RMS sound levels above 120 dB and as the probability of 10%, 50% and 90% behavioral response using auditory weighting for received RMS sound levels respectively at 120, 140, and 160 dB re 1uPa.

- The NOAA (2005) behavioral threshold for all hearing groups is a Root Mean Square (RMS) sound pressure level (SPL, unweighted) of 160 dB re 1uPa. For this pile driving operation, NOAA has defined an estimated distance to 160 dB RMS re 1uPa of 2739 meters assuming a 12 dB noise attenuation utilized during pile driving.

- The Vineyard Wind noise model is completely redacted. Consequently, it is not possible to validate the noise model source level, propagation loss, or noise control insertion loss with the data acquired during this survey.

- For extent of Level B harassment zone verification, Vineyard Wind must report the measured or extrapolated distances where the received levels SPLrms decay to 160 dBrms, as well as integration time for such SPLrms.

---

8 Appendix III-M, Revised Draft - Supplemental Information for the Assessment of Potential Impacts to Marine Mammals and Sea Turtles During Construction, Operation, and Decommissioning of the Vineyard Wind Project. Technical Report by JASCO Applied Sciences, November 20, 2018.

9 Vineyard Wind Offshore Wind Energy Project Biological Assessment December 2018 (Revised March 2019), Bureau of Ocean Energy Management.

10 Request for an Incidental Harassment Authorization, Vineyard Wind BOEM Lease Area OCS-A 0501, Vineyard Wind, April 2019. https://media.fisheries.noaa.gov/dam-migration/vineyardwind_2019iha_app_opr1.pdf

11 Incidental Harassment Authorization, issued to Vineyard Wind 1, LLC (Vineyard Wind), valid from May 1, 2023 through April 30, 2024. Digitally signed by Catherine Marzin, Acting Director, Office of Protected Resources, National Marine Fisheries Service, May 21, 2021. https://media.fisheries.noaa.gov/2021-05/VWconstr_FinalIHA_OPR1.pdf

- Cetaceans rely heavily on acoustics for communication, foraging, mating, avoiding predators, and navigation. North American Right Whales (NARW) frequent the Lease Area throughout the year and most often during winter and spring. Noise exposure associated with the proposed action can interfere with foraging, orientation, migration, predator detection, social interactions, or other activities, with the potential to cause a range of responses ranging from insignificant behavioral changes to ear injury, depending on the intensity and duration of the exposure.

2 Methodology

2.1 Instrumentation

Underwater sound pressure levels were acquired with a Cetacean Research (Golden, CO) C75 research-grade pre-amplified omnidirectional hydrophone. The C75 has an effective sensitivity of -180 dB re 1V/1uPA, an equivalent self-noise of 51 dB re 1uPA/√Hz, and a linear frequency response range of +/-1 dB from 25 Hz to 10 KHz and +/-3 dB from 20 Hz to 170 KHz (see Appendix B). The hydrophone preamp DC power supply was modified to provide 192 dB re 1 uPa full scale before clipping. The hydrophone output was input to a Tascam (Santa Fe Springs, CA) X8 digital audio recorder line-in at 192 KHz, 24-bit resolution. The Tascam X8 has a frequency response of 20 Hz – 40 kHz at 96 kHz: +0/-0.4 dB and 20 Hz – 60 kHz at 192 kHz: +0/-2.5 dB (JEITA).

The C75 hydrophone and Tascam recorder were calibrated end-to-end with a GRAS (Beaverton, OR) 42AG acoustic calibrator at a sound pressure level in air of 114 dB re 20 uPA at 251.2 Hz, an equivalent to the sound pressure in water at 251.2 Hz of 140 dB re 1 uPA, using a custom machined hydrophone calibrator adapter Model HADP42AG-C75 from BRC Engineering (Sonoma, CA) with calibration current and certified traceable to NIST (see Appendix C). Post-survey analysis was conducted with Spectraplus-SC software version 5.3.0.12C (Pioneer Hill Software, Sequim, WA). Custom Python scripts (The Python Software Foundation [12], V3.9.12) and Excel were utilized for data review, analysis, and plotting.

The acquired recordings had high signal to noise in the frequency ranges of interest and sufficient headroom to prevent digital signal clipping. Particle motion was not acquired during this survey.

2.2 Survey Locations

Underwater acoustic recordings were acquired on November 2, 2023 between 11:05 am and 2:45 pm, approximately 8 to 13 miles southwest of Nantucket Island (see Figure 3 below).

12 See www.python.org (Last viewed 25 March 2024).

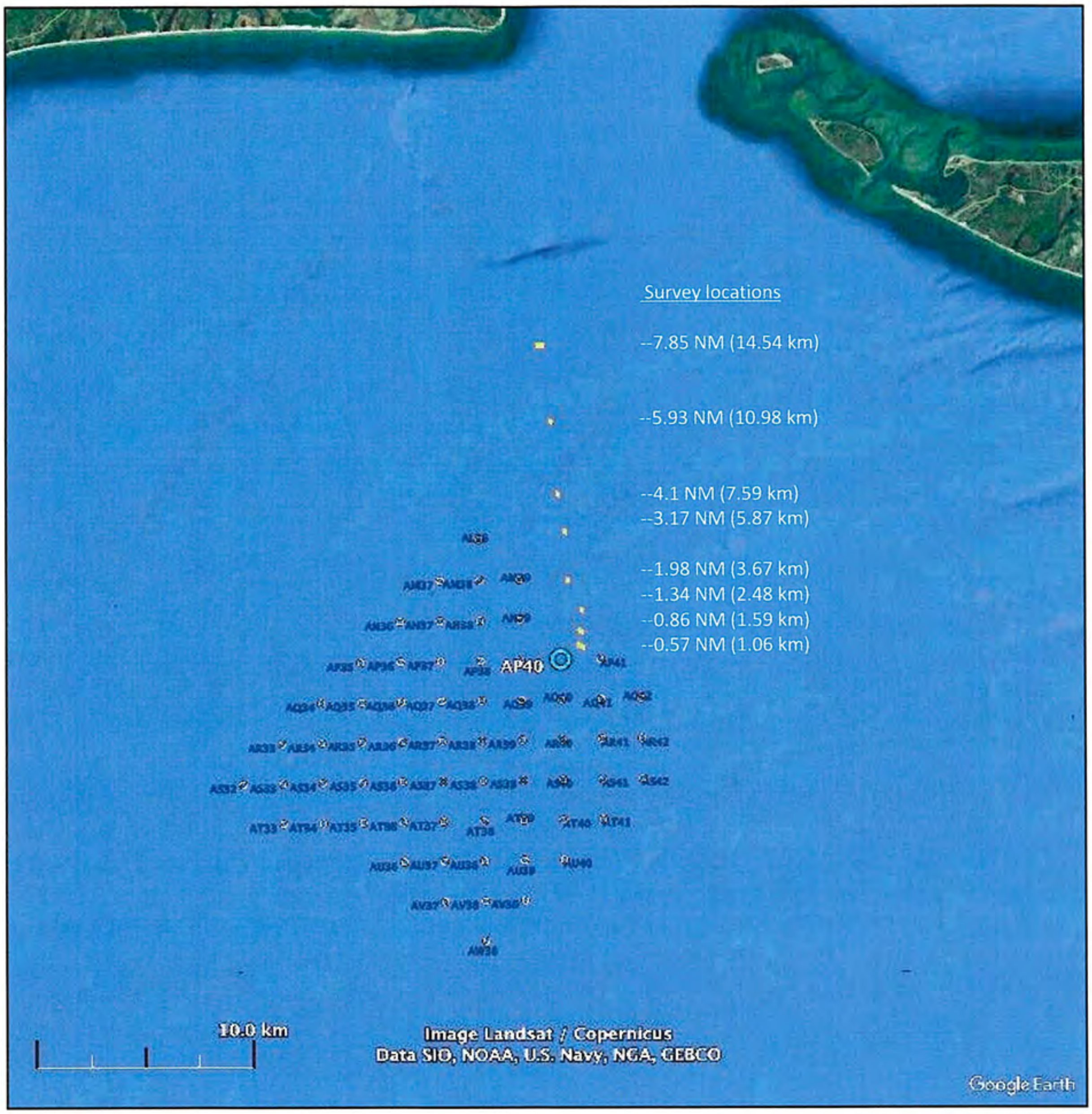

Figure 3. Survey locations marked withwhite dots and notations. Orion location at monopile AP40.

Passive acoustic monitoring (PAM) was conducted with a hydrophone dipped by hand to a 20 meter depth from the side of a 29-foot center-console sport-fishing boat ("investigator boat") at eight separate distances from the AP40 monopile [13]. These distances were 7.85, 5.93, 4.1, 3.17, 1.98, 1.34, 0.86, and 0.57 NM (14.54, 10.98, 7.59, 5.87, 3.67, 2.48, 1.59 and 1.06 km). Initial distance to the stationary Orion was estimated using the investigator boat's onboard marine radar prior to shutting off systems for acoustic recording. Distance to monopile was confirmed in post analysis with GPS tracking logged on cellular phone (iSailGPS, James Associates). A distance to

13 Recordings were made at all locations but pile-driving was not occurring while at 7.85 and 5.93 NM.

source uncertainty of ±60 m (worst case +/- 0.5 dB at 0.57 NM over 120 seconds) is assumed based on the measured investigator boat drift rate of 1.1 knots.

Weather conditions were sunny, with unlimited visibility, thin high clouds, air temperature 43 to 46 degrees F (6 to 8 C), light to moderate winds from the WNW, sea state Beaufort 2 to 3, 1 to 3 foot swells, light surface ripples, and occasional crest breaks. Water depth was 29 to 38 meters. Water temperature at the surface was 58 degrees F (14 C). Salinity was not measured. A shallow thermocline was visible on the onboard Simrad fishing sonar at 2 to 4 fathoms (roughly 4 to 7 meters). The investigator boat was seaworthy and stable with engine located amidships, and was allowed to drift downwind with engine off during hydrophone recording to minimize wave slap. Drift rate was calculated from GPS data at approximately 1.1 knot (~ 0.5 m/s).

The survey was conducted using methods consistent with NMFS guidelines [14] for hydrophone measurements including selection of a "far range" location of at least 20 times the water depth, and hydrophone depth at least 5 meters.

2.3 Acoustic Propagation

For purposes of regulatory management, marine mammalian hearing is based on sound pressure detection. Sound pressure in water is quantified as a sound pressure level using decibels referenced to 1 microPascal (μPa). Underwater sound pressure levels differ from those in air by 26 dB (the difference in the reference levels of 1 μPa in water versus 20 μPa in air), plus 36 dB (the difference in acoustic impedance between water and air). The differential is approximately 62 dB. For example, a sound pressure level of 160 dB re 1 μPa in water would equate roughly to 98 dB re 20 μPa in air. For humans in air, most acoustic energy bounces off the body due to the impedance contrast [15]. However, for marine mammals whose body acoustic impedance is similar to ocean water [16], sound pressure transients are expected to penetrate their bodies with little reduction in energy.

Acoustic waves in water have sound pressure and particle motion components. Water is compressible, like air (although denser), thus longitudinal pressure waves occur in the water fluid medium as they do in air: particles vibrate in the direction the sound is moving. The speed of sound in water is about 1500 m/s, nearly five times faster than in air (343 m/s). Underwater apparent sound "source level" (SL) is referenced at 1 meter and derived in practice from sound pressure measurements calculated back to 1 meter. Indeed, SL is a far-field property of the source and is not an actual sound pressure level at 1 meter [17].

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14 NMFS Northwest Region and Northwest Fisheries Science Center, Guidance Document: Sound Propagation Modeling to Characterize Pile Driving Sounds Relevant to Marine Mammals, January 1, 2012.

15 Low frequencies of sufficient intensity may resonate organs. Acoustic energy below 20 Hz activates OHC efferent function as cochlear amplifier. Acoustic forces at very low frequencies may affect balance organs, per Schomer 2015 https://doi.org/10.1121/1.4913775.

16 Dong J, Song Z, Li S, Gong Z, Li K, Zhang P, Zhang Y, Zhang M. Acoustic properties of a short-finned pilot whale head with insight into temperature influence on tissues' sound velocity. J Acoust Soc Am. 2017 Oct;142(4):1901. doi: 10.1121/1.5005509. PMID: 29092562.

17 M. A. Ainslie, M. B. Halvorsen and S. P. Robinson, "A Terminology Standard for Underwater Acoustics and the Benefits of International Standardization," in IEEE Journal of Oceanic Engineering, vol. 47, no. 1, pp. 179-200, Jan. 2022, doi: 10.1109/JOE.2021.3085947.

Sound pressure level (SPL, dB re 1 μPa) at a distance beyond 1 meter is lower than the calculated SL due to attenuation with distance, referred to as propagation loss (PL) or "transmission loss" (TL) [18]. Propagation loss is influenced by underwater acoustic factors including sound speed gradients in winter versus summer, thermocline strength, and salinity. A first-order estimate of SPL using spherical spreading, ignoring absorption in the medium versus frequency, seabed topography, and other factors, is:

SPL, dB at r, meters = SL – 20log10(r), dB (spherical)

The drop in sound pressure level with distance using this equation is 20 dB per decade, or 6 dB per doubling of distance. NMFS applies spherical spreading for shallow water conditions. For near-shore conditions, NMFS recommends a "practical spreading" loss model to estimate the sound pressure level from a source level near shore. Using the practical spreading loss model, TL in dB units is defined by:

SPL, dB at r, meters = SL – 15log10(r), dB "practical spreading" (NMFS)

The drop in sound pressure level with distance using this equation is 15 dB per decade or roughly 4.5 dB per doubling of distance.

Acoustic propagation of pile driving hammer blows proceeds into the ocean water directly, via an angled pressure wave (line source) penetrating the water and via hammer shock entering the seabed from the monopole base. See Figure 4 below.

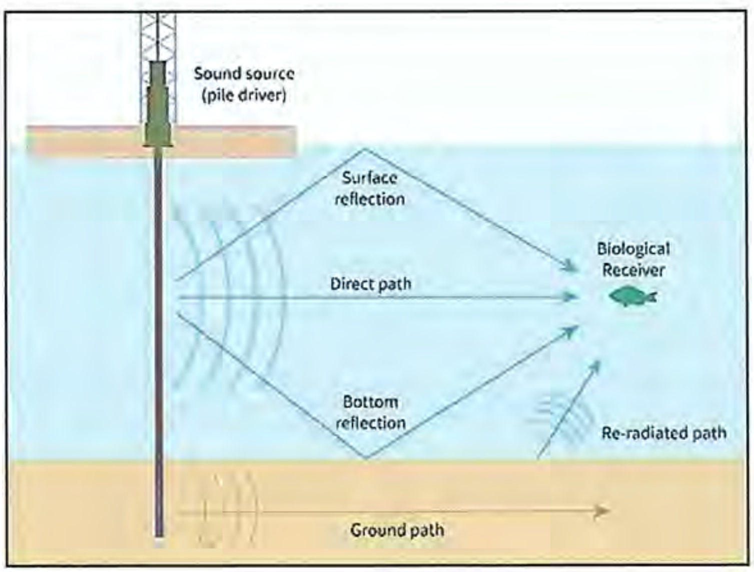

Figure 4. Sound propagation paths associated with pile driving (adapted from Buehler et al., 2015), from BOEM [8].

Since the seabed has a higher sound speed compared to ocean water, acoustic energy traveling through the seabed (the ground path) and re-emerging into the ocean water through refraction can

18 NMFS uses TL and PL interchangeably but they are technically distinct acoustical processes.

arrive at a distant location before the direct-path acoustic peak transmitted through the water. Additionally, acoustic energy that propagates through the seabed can circumvent noise mitigation technologies, such as bubble curtains. The interval between the arrivals of acoustic impulses through the ground path and the direct path widens with distance. This disparity can significantly and adversely affect the 90-percent root mean square (RMS) measurements utilized by NMFS.

2.4 Metrics

Table 1 lists those acoustic terms typically found in regulatory documents and acoustics-related ISO standards including ISO 18405 [19] which addresses underwater acoustics. All terms are unweighted unless weighting is noted.

Table 1. Summary of terminology.

ISO Symbol	Term used in this report	Description
p	P	Sound pressure, Pa
p_0	Pref	Reference sound pressure, Pa (1 uPa)
p_{peak}	Ppk	Peak sound pressure, Pa
$p_{pk\text{-}pk}$	Ppk-pk	Peak to peak sound pressure, Pa
$L_{p,0\text{-}pk}$	Peak, Lpk	Peak sound pressure level, dB re 1 uPa
-	Peak-to-peak, Lpk-pk	Peak to peak sound pressure level, dB re 1uPa
L_p	SPL	Sound pressure level, dB re 1 uPa
$L_{p,rms}$	RMS*	Root mean square SPL, dB re 1 uPa
L_E	SEL*	Sound exposure level, dB re 1 uPa^2s
$L_{E,w}$	SEL,w	Weighted SEL (e.g. LF, PW)
-	cSEL	Cumulative SEL, dB re 1 uPa^2s
L_S	SL	Source level, dB re 1 uPa
-	RL	Received level, dB re 1uPa
r	r	Distance from source, meters
ΔL_{TL}	TL	Transmission loss, dB
N_{PL}	PL	Propagation loss, dB

** Time durationg is required for RMS level and is referenced for cumulative SEL derived from RMS. RMS time durations include the 200-millisecond duration, and the variable time duration for the 5- to 95-percent "90pct" percentage energy signal duration.*

Terms used in this report include sound exposure level "SEL" and cumulative SEL "cSEL". NMFS evaluates the cumulative SEL for Level A harassment, e.g. the onset of permanent threshold shift (PTS, hearing loss). Level B harassment is defined as the sound level above which temporary threshold shift (TTS, temporary hearing loss) occurs. SEL is expressed in dB re 1 μPa^2s as a quantity of exposure over time.

$$SEL = 10 \cdot \log_{10}\left(\frac{1}{T}\sum_{i=1}^{N} p_i^2\right)$$

Where:

- T is the time duration over which the sound levels are integrated (in seconds).

19 Underwater Acoustics – Terminology, ISO 18405:2017, 2017. https:// www.iso.org/ standard/62406.html

- N is the total number of pressure samples in the given time interval.
- p is the sound pressure value at the i-th sample, usually given in Pascals.

SEL can also be expressed as RMS + 10log(T/1.0), with T equal to the RMS duration in seconds. The relationship of peak, peak-to-peak and RMS is illustrated in Figure 5 below.

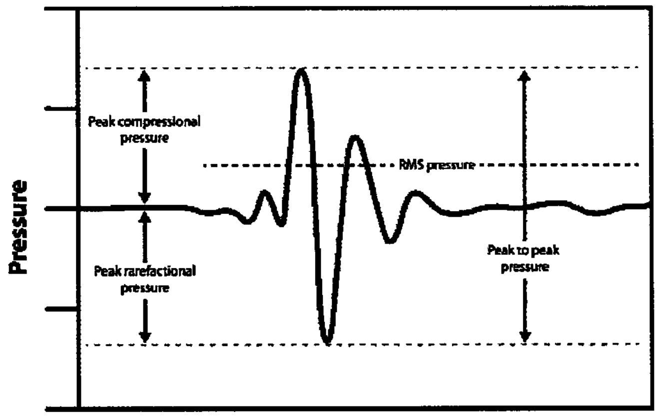

Figure 5. Sound pressure relationship of impulse waveform peak, peak-to-peak, and rms levels.

The peak sound pressure level is the highest sound pressure measured or "held" by the instrumentation depending on its circuitry. The "RMS pressure" is shown as the level integrated over the time period of the pulse, and is always lower than the peak pressure level. The "time period of the pulse" varies depending on waveform shape, complexity, and duration.

The sound pressure level (defined by ANSI as "rms" pressure) has no restrictions on the RMS integration time period. However, the RMS is *sensitive to time period* and the integration time period should always be provided with the sound pressure level when it is reported as RMS. The RMS amplitude value may adequately characterize slow-changing or continuous, non-impulsive noise per NRC 2003 and Madsen 2005 [20,21]. However, the RMS value of an impulsive sound does not reflect the peak energy in the signal. Peak and peak-to-peak sound pressure values are universally preferred over RMS for measuring, characterizing and evaluating impulse sounds.

Depending on the rapidity of the pressure change in impulsive sound, regulation of impulsive sound using RMS values may provide little protection from peak pressures. For reference, in-air impulsive sound limits for hearing damage are not assessed with RMS but rather with peak and peak-to-peak levels (Madsen 2005). When assessing the potential effect of impulsive sounds on the physiology of marine mammals and fishes, the peak sound pressure level Lpk and SEL with

20 National Research Council (US) Committ.ee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals. Ocean Noise and Marine Mammals. Washington (DC): National Academies Press (US); 2003. Appendix E, Glossary of Terms. https://www.ncbi.nlm.nih.gov/books/NBK221261/ accessed 6/5/23.

21 Madsen PT (2005), Marine mammals and noise: Problems with root mean square sound pressure levels for transients. The Journal of the Acoustical Society of America (JASA), 117(6), 3952–3957. https://doi.org/10.1121/1.1921508, accessed 6/28/23.

frequency weighting are used [22]. The disparity between RMS and peak pressures underscores long-standing professional acoustic concerns about the suitability of using RMS levels for protection from impulsive noise sources. The RMS value does not track the impulsivity associated with startle and sudden hearing loss. As Madsen summarized in 2005,

> "*Current mitigation levels for noise transients impinging on marine mammals are specified by rms pressures. The rms measure critically relies upon choosing the size of averaging window for the squared pressures. Derivation of this window is not standardized, which can lead to 2–12 dB differences in rms sound pressure for the same wave forms. rms pressure does not represent the energy of the noise pulse and it does not prevent exposure to high peak pressures. Safety levels for transients should therefore be given by received peak–peak sound pressure and energy flux density instead of rms sound pressure levels.*"

Madsen 2005 noted further,

> "*Ears of terrestrial mammals generally integrate sound intensity over a time window of some 200 ms (Plomp and Bouman, 1959; Green, 1985), and the same appears to be the case for cetaceans at low frequencies (Johnson, 1968). It seems therefore reasonable to use 200 ms as the maximum integration time from a detector or sensation point of view (Madsen et al., 2002).*"

For impulsive sounds traveling in a highly reverberant environment, Madsen 2005 found that impulse waveforms were lengthened and densified due to reverberation and reflections, with RMS duration necessarily extended thus lowering the RMS value, concluding,

> "*long, fixed averaging times for calculation of rms sound pressures can yield very short safety radii around a noise source. Unless there is a specified protocol for determining the duration, it is possible to manipulate the rms level by varying the averaging window: the longer the averaging time, the lower the rms level. Measures for mitigation of sound exposure should not leave room for such analytical freedom.*"

Madsen 2005 recommended,

> "*apply a conservative approach and provide energy flux density integrated both over the entire pulse duration and with a 200 ms integration time if the actual duration is longer than that. Such measures should additionally be accompanied by a figure of the wave form, and information about the recording bandwidth and the duration used for integrating the pressure squared.*"

<u>RMS</u>: RMS time durations analyzed in this report include the 200-millisecond duration, and the variable time duration for the 5- to 95-percent "90pct" percentage energy signal duration while using a 1-second dataframe. The 0.125-second RMS value was also computed using a modified

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22 Southall, B. et al, Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects, Aquatic Mammals 2019, 45(2), 125-232, DOI 10.1578/AM.45.2.2019.125.

version of the approach from the 2019 Block Island Wind Farm study [23], and the data are included in Appendix D. The 90-percent effective signal duration was also computed for comparison to the 90-percent percentage energy signal duration, and the data are reviewed in Appendix D. The report conclusions rely on the 200-milliseond and 90-percent percentage energy signal duration RMS metrics outlined in Madsen 2005.

SEL: Energy flux density and sound exposure level metrics quantify the energy content of sound. The energy flux density quantifies the energy passing through a unit area, while SEL equals the total energy accumulated over a time period. The units are identical (uPa^2s). The SEL is calculated from the RMS level plus 10log(T). SEL values are listed in this report for 200-millisecond and 90-percent RMS.

Cumulative SEL: Sound exposures leading to PTS and TTS may be assessed with the cumulative sound exposure over time (cSEL). The cumulative operational sound exposure level cSEL was integrated over dozens of hammer blows during continuous pile driving for a time T at each location and adjusted using 10log(T/1.0) to an effective 1-second operational SEL integrating total pile driving impulse and vessel propulsion and thruster noise.

Weighted SEL: The unweighted and weighted (LF, MF, HF, PW) sound exposure level SEL was computed using the RMS,200 and RMS,90pct analysis timeframe for each hammer blow at the six measurement locations from 0.57 to 4.1 NM (1.06 to 7.59 km) when pile driving was occurring. MF and HF weightings filtered out the low-frequency hammer blow energy, resulting in data which could not be assessed for peaks and were not analyzed further in this report.

2.5 Underwater Thresholds for Noise Impact Assessment

NMFS is an office of the National Oceanic and Atmospheric Administration (NOAA) within the Department of Commerce. NMFS is charged with protecting marine species and their habitats in the United States. NMFS published guidance related to underwater noise and the potential impacts on marine mammals can be found in NMFS' "Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing." This document, often referred to as the "NOAA Technical Guidance," was published in 2016, 2018 v 2.0, and again in 2020 v 2.2.

NOAA defines impulsive and non-impulsive (continuous) noise as follows [24]:

Continuous sound: A sound whose sound pressure level remains above ambient sound during the observation period (ANSI 2005).

Impulsive sound: Sound sources that produce sounds that are typically transient, brief (less

23. S. Bruce Martin, David R. Barclay; Determining the dependence of marine pile driving sound levels on strike energy, pile penetration, and propagation effects using a linear mixed model based on damped cylindrical spreading. J. Acoust. Soc. Am. 1 July 2019; 146 (1): 109–121. https://doi.org/10.1121/1.5114797

24 National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p. https://www.fisheries.noaa.gov/action/2018-revision-technical-guidance-assessing-effects-anthropogenic-sound-marine-mammal-hearing accessed 6/30/23.

than 1 second), broadband, and consist of high peak sound pressure with rapid rise time and rapid decay (ANSI 1986; NIOSH 1998; ANSI 2005). They can occur in repetition or as a single event. Examples of impulsive sound sources include: explosives, seismic air guns, and impact pile drivers.

Non-impulsive sound: Sound sources that produce sounds that can be broadband, narrowband or tonal, brief or prolonged, continuous or intermittent) and typically do not have a high peak sound pressure with rapid rise time that impulsive sounds do. Examples of non-impulsive sound sources include: marine vessels, machinery operations/ construction (e.g., drilling), certain active sonar (e.g. tactical), and vibratory pile drivers.

The NMFS Summary of Marine Mammal Acoustic Thresholds [25] states the following with respect to behavioral harassment,

"*Marine mammals are considered harassed when exposed to elevated sound levels that may lead to mortality, temporary or permanent hearing impairment (threshold shift), non-auditory physical or physiological effects, and behavioral disturbance. Using the best available science, NMFS has developed acoustic thresholds that identify the received level of underwater sound from explosive and non-explosive sources above which exposed marine mammals would be expected to:*

- *be behaviorally disturbed or incur a temporary threshold shift (TTS), both of which qualify as Level B harassment under the Marine Mammal Protection Act (MMPA), or*
- *incur a permanent threshold shift (PTS) of some degree or lung or gastrointestinal (g.i.) tract injury, both of which qualify as Level A harassment.*"

Level A harassment thresholds for marine mammal species are tabulated from the NMFS technical guidance document [26] in the Vineyard Wind IHA Table 6, shown in Figure 6 below.

25 NMFS Summary of Marine Mammal Acoustic Thresholds, https://www.fisheries.noaa.gov/s3/2023-02/MMAcousticThresholds_secureFEB2023_OPR1.pdf, 2/24/23, accessed 8/11/23.

26 National Marine Fisheries Service. 2018. 2018 Revisions to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commerce, NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 p. accessed 6/5/23.

Table 6. Summary of relevant PTS onset acoustic thresholds (NMFS 2018a).

Hearing group	PTS onset thresholds* (received level)	
	Impulsive	Non-impulsive
Low-frequency (LF) cetaceans	L_{pk}, flat: 219 dB $L_{E,LF}$, 24h: 183 dB	$L_{E,LF}$, 24h: 199 dB
Mid-frequency (MF) cetaceans	L_{pk}, flat: 230 dB $L_{E,MF}$, 24h: 185 dB	$L_{E,MF}$, 24h: 198 dB
High-frequency (HF) cetaceans	L_{pk}, flat: 202 dB $L_{E,HF}$, 24h: 155 dB	$L_{E,HF}$, 24h: 173 dB
Phocid seals in water (PW)	L_{pk}, flat: 218 dB $L_{E,PW}$, 24h: 185 dB	$L_{E,PW}$, 24h: 201 dB

* Dual metric acoustic thresholds for impulsive sounds: Use whichever results in the largest isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.
L_{pk}, flat–peak sound pressure is flat weighted or unweighted and has a reference value of 1 µPa
L_E - denotes cumulative sound exposure over a 24-hour period and has a reference value of 1 µPa²s
The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting.

Figure 6. IHA Application summary of relevant PTS onset acoustic thresholds (NMFS 2018a) for Vineyard Wind pile driving.

NMFS defines the threshold level for Level B Behavioral Harassment as follows:

> "*120 Decibel (dB) Root Mean Square (RMS) referenced to (re) 1 microPascal (µPa) for continuous noise and 160 dB RMS re 1 µPa for impulsive and non-continuous pulsed noise. The Zone of Influence (ZOI) is the area that is ensonified to those levels and constitutes the area in which take of marine mammals could occur*".

Behavioral harassment criteria are further detailed in project documents using the probability of behavioral response for auditory weighted sound pressure level (SPL, dB re 1 µPa), from Wood 2012 [27]. Project behavioral exposure exposure criteria are provided in the Biological Assessment Table 5.1-2 shown in Figure 7 below.

Table 5.1-2: Behavioral Exposure Criteria (based on Wood et al. 2012)

Marine Mammal Group	Probability of response to frequency-weighted SPL (dB re 1 µPa)				Unweighted (dB root mean square) ᵃ
	120	140	160	180	
Migrating mysticete whales	10%	50%	90%		160
All other species (and behaviors)		10%	50%	90%	160

Source: Adapted from Wood et al. 2012; Pyć et al. 2018

µPa = micropascal; dB = decibel; SPL = sound pressure level

Note: Probability of behavioral response frequency-weighted sound pressure level (SPL dB re 1 µPa); probabilities are not additive.

ᵃ Pyć et al. 2018

Figure 7. Biological Assessment Table 5.1-2, behavioral exposure criteria based on Wood et al. 2012.

Management of marine mammal impacts with the 120-dB threshold for Level B Behavioral Harassment is clearly presented in the 2016 incidental harassment authorization (IHA) to Ocean

27 Wood, J., Southall, B. L., & Tollit, D. J. (2012). PG&E offshore 3 D Seismic Survey Project EIR-Marine Mammal Technical Draft Report.

Wind, LLC (Ocean Wind), "*to incidentally harass, by Level B harassment only, marine mammals during high-resolution geophysical (HRG) and geotechnical survey investigations associated with marine site characterization activities off the coast of New Jersey in the area of the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf (OCS–A 0498) (Lease Area)*" [28]. The Ocean Wind IHA recognizes behavioral harassment due to continuous noise for DP drill ship vessel noise, and prescribes protective radii. The scope of potential harassment and basis for take estimates are outlined in the IHA as follows (emphasis added):

> "*Project activities that have the potential to harass marine mammals, as defined by the MMPA, include underwater noise from operation of the HRG survey sub-bottom profilers and equipment positioning systems,* ***and noise propagation associated with the use of DP thrusters during geotechnical survey activities that require the use of a DP drill ship****. Harassment could take the form of temporary threshold shift, avoidance, or other changes in marine mammal behavior.* ***NMFS anticipates that impacts to marine mammals would be in the form of behavioral harassment*** *and no take by injury, serious injury, or mortality is proposed. ... The basis for the take estimate is the number of marine mammals that would be exposed to sound levels in excess of NMFS' Level B harassment criteria for impulsive noise (160 dB re 1 μPa (rms)* ***and continuous noise (120 dB re 1 μPa (rms.))****.*"

2.6 Auditory Weightings for Sound Exposure

Auditory weightings are considered important for assessing marine species *noise exposure* and susceptibility to noise-induced hearing loss [29]. NOAA Table A10 (shown in Figure 8 below) summaries species auditory weightings parameters and sound exposure level thresholds.

$W(f)=C+10\log_{10}\left\{\frac{(f/f_1)^{2a}}{[1+(f/f_1)^2]^a[1+(f}\right.$						Non-impulsive		Impulse			
						TTS threshold	PTS threshold	TTS threshold		PTS threshold	
Group	a	b	f_1 (kHz)	f_2 (kHz)	C (dB)	SEL (weighted)	SEL (weighted)	SEL (weighted)	peak SPL (unweighted)	SEL (weighted)	peak SPL (unweighted)
LF	1	2	0.20	19	0.13	179	199	168	213	183	219
MF	1.6	2	8.8	110	1.20	178	198	170	224	185	230
HF	1.8	2	12	140	1.36	153	173	140	196	155	202
SI	1.8	2	4.3	25	2.62	186	206	175	220	190	226
OW	2	2	0.94	25	0.64	199	219	188	226	203	232
PW	1	2	1.9	30	0.75	181	201	170	212	185	218

28 Incidental harassment authorization (IHA) to Ocean Wind, LLC (Ocean Wind), 6/8/2017, https://www.federalregister.gov/documents/2017/07/07/2017-14260/takes-of-marine-mammals-incidental-to-specified-activities-taking-marine-mammals-incidental-to-site#p-47

29 Jakob Tougaard, Michael Dähne; Why is auditory frequency weighting so important in regulation of underwater noise? J Acoust Soc Am 1 October 2017; 142 (4): EL415–EL420. https://doi.org/10.1121/1.5008901 accessed 6/29/23.

Figure 8. NMFS 2018a Summary of auditory weighting and exposure function parameters. Highlighting in the table denotes the species evaluated by "Hearing Group" listed in the IHA Application.

During this survey's post-survey analysis, NMFS 2018 auditory weightings were computed and applied to the unweighted audio recordings to evaluate weighted sound pressure levels. Hearing auditory weightings are shown below in Figure 9.

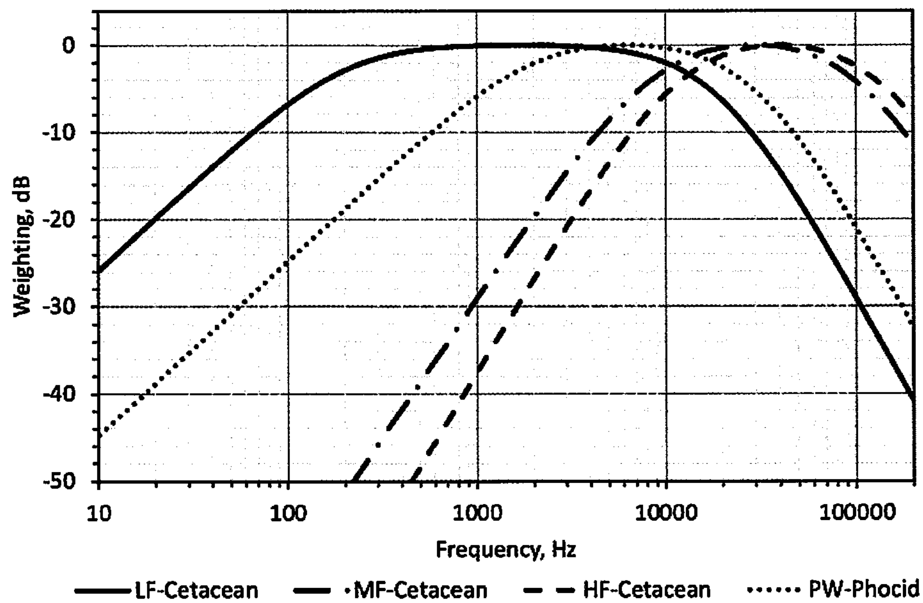

Figure 9. Bode diagram, marine species auditory weightings computed from NMFS 2018.

As noted earlier, MF and HF weightings filtered out the low-frequency hammer blow energy resulting in data which could not be assessed for peaks and were not analyzed further in this report. Species contained in the LF and PW classifications were defined by NMFS in 2016 [30],

> *"LOW-FREQUENCY (LF) CETACEANS: The LF cetacean group contains all of the mysticetes (baleen whales). Although there have been no direct measurements of hearing sensitivity in any mysticete, an audible frequency range of approximately 10 Hz to 30 kHz has been estimated from observed vocalization frequencies, observed reactions to playback of sounds, and anatomical analyses of the auditory system. A natural division may exist within the mysticetes, with some species (e.g., blue, fin) having better low-frequency sensitivity and others (e.g., humpback, minke) having better sensitivity to higher frequencies; however, at present there is insufficient knowledge to justify separating species into multiple groups. Therefore, a single species group is used for all mysticetes.*

30 National Marine Fisheries Service. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing: Underwater Acoustic Thresholds for Onset of Permanent and Temporary Threshold Shifts. U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-55, 178 p.

"PHOCIDS: This group contains all earless seals or "true seals," including all Arctic and Antarctic ice seals, harbor or common seals, gray seals and inland seals, elephant seals, and monk seals. Underwater hearing thresholds exist for some Northern Hemisphere species in this group."

While this analysis utilized the 2018 NMFS auditory weightings, it should be noted that Southall et al. 2019 [31] published a set of modifications to the 2018 NMFS auditory weightings for consideration that are less flattened and closer to audiograms. It appears NMFS is still assessing the Southall 2019 weightings at the time of this writing.

2.7 Measurement Uncertainty

Uncertainties for the acoustic parameters presented in this report were considered in general accordance with United States and international standards [32,33]. Uncertainty considerations apply to the probability of replicating measured sound pressure levels at the same distances at the same location under the same conditions. Acoustic survey measurements can be affected by acoustic propagation and environmental conditions occurring during the survey. Utmost care was taken to minimize environmental effects by selecting a day with the calmest weather conditions available within the weather forecast, using a standardized depth of the dipped hydrophone, and minimizing handling noise of the dipped hydrophone.

System end-to-end calibration before and after the survey found calibration was constant within 0.5 dB. Class 1 digital sound meters have an intrinsic standard uncertainty of +/- 0.5 dB (ISO 1996-2). The remainder of the uncertainty was allocated to the drift distance from the source being measured at each measurement location, estimated at +/-0.5 dB. From ANSI 1996-2, the expanded uncertainty (2σ or coverage probability 95%) of effects on short-term measurements with Class 1 instrumentation (the type used during this survey) is +/-1.6 dB. No uncertainty was introduced by residual/ambient sound levels as they were well below measured pile-driving peak and RMS levels. All reported uncertainties are in the category of Type B evaluation or analysis other than a statistical analysis of repeated observations. While a precise total uncertainty for the offshore measurement survey is not known, the expanded uncertainty appears unlikely to exceed +/-3 dB.

31 Southall et al., "Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects", Aquatic Mammals 2019, 45(2), 125-232, DOI 10.1578/AM.45.2.2019.125. accessed 6/26/23.
32 B.N. Taylor and C. E. Kuyatt, "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," National Institute of Standards and Technology, Gaithersburg, MD, NIST Technical Note 1297, 1994. [Online]. Available http://www.nist.gov/pml/pubs/tn1297/ accessed 8/16/23.
33 ISO/FDIS 1996-2 "Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels", ISO/TC 43/SC 1-2017.

3 Results and discussion

3.1 Pile Driving Sound Pressure Data

Data are presented below for recording locations when the Orion was actively pile-driving. Survey recording for these locations is summarized in Table 2 below.

Table 2. Summary of recording locations and hammer counts.

Distance, NM	**4.10**	**3.17**	**1.98**	**1.34**	**0.86**	**0.57**
Distance, m	7.59	5.87	3.67	2.48	1.59	1.06
Start time	1:36 pm	1:45 pm	1:59 pm	2:09 pm	2:23 pm	2:34 pm
Recording time, mm:ss	3:53	5:30	4:10	5:15	5:50	2:30
Hammer count	126	146	117	143	160	51

Time-series sound pressure charts are shown below in Figures 10 through 15. These charts show the acoustic pressure occurring over time during the recording (x-axis) scaled in Pascals (y-axis). These pressures are unweighted and unaveraged. Each hammer blow has both positive-going and negative-going (compressive and rarefractive) peak pressures arriving at the hydrophone. The more-or-less solid blue section in the core of the chart is dominated by vessel propulsion and DP thruster noise.

Recording time at each location was between 3-1/2 and 5-1/2 minutes except for the last recording at 0.57 NM run which ran for 2-1/2 minutes during which pile driving ended within 2 minutes.

Tables listing summary data at each location are provided in Appendix D along with figures of the peak, RMS and spectrograms for the hammer blows with maximum RMS at each location.

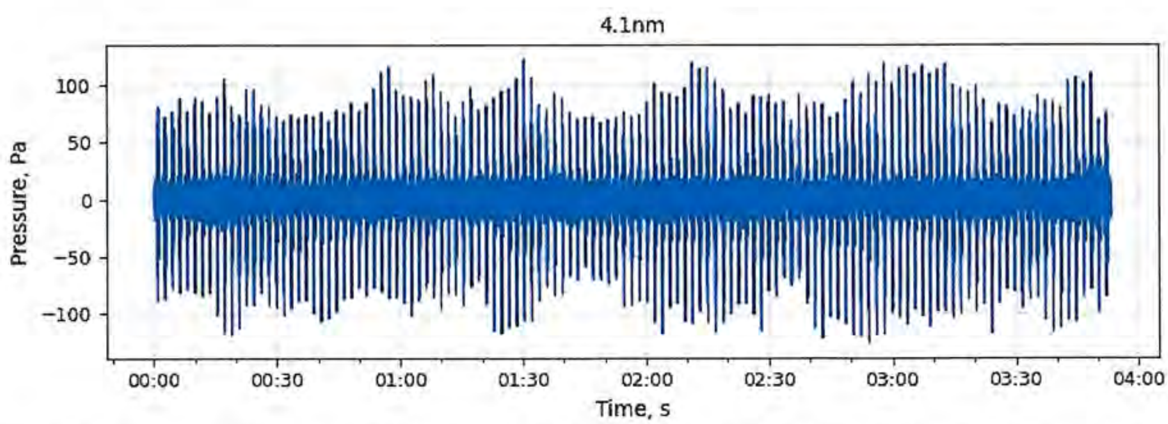

Figure 10. Time series sound pressure, Pa 1:36 pm, 4.1 NM (7.59 km). Pile driving dominant, 126 hammer blows recorded. Orion and support ship propulsion and thruster noise are highly audible (hydrophone through headphones).

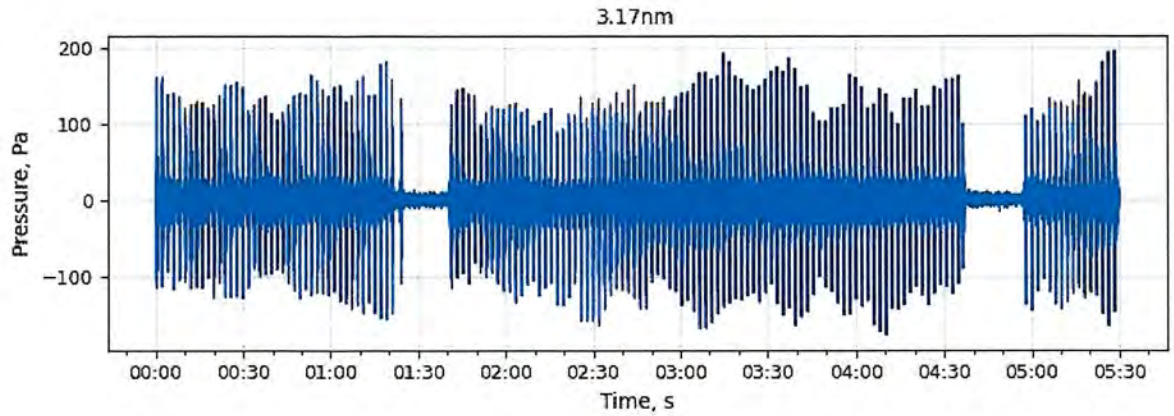

Figure 11. Time series sound pressure, Pa 1:45 pm, 3.17 NM (5.87 km). Pile driving dominant, 146 hammer blows recorded. Orion and support ship propulsion and thrusters are highly audible (hydrophone through headphones). The recording captured two stops with 20-second segments with no hammer blows. Ramp-up was not observed during the two pile driving startups.

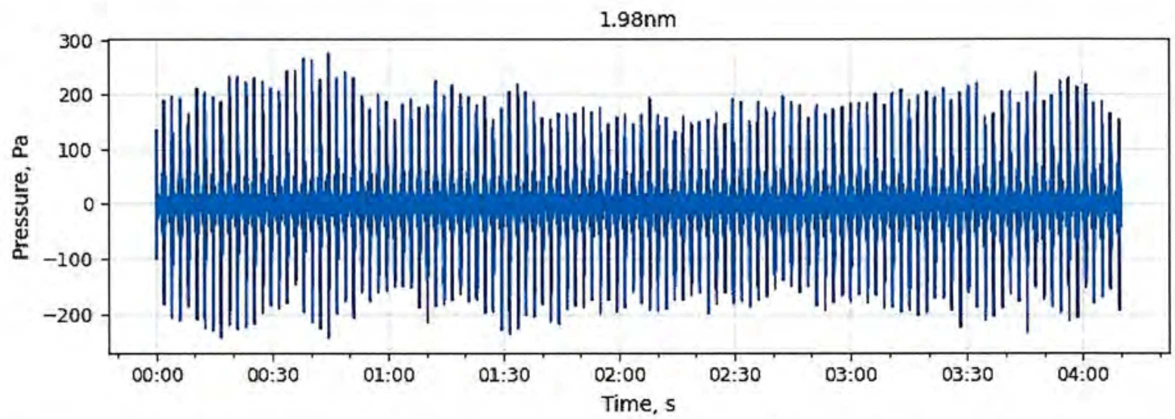

Figure 12. Time series sound pressure, Pa 1:59 pm, 1.98 NM (3.67 km). Pile driving dominant, 117 hammer blows recorded. Orion and support ship propulsion and thruster noise are highly audible (hydrophone through headphones).

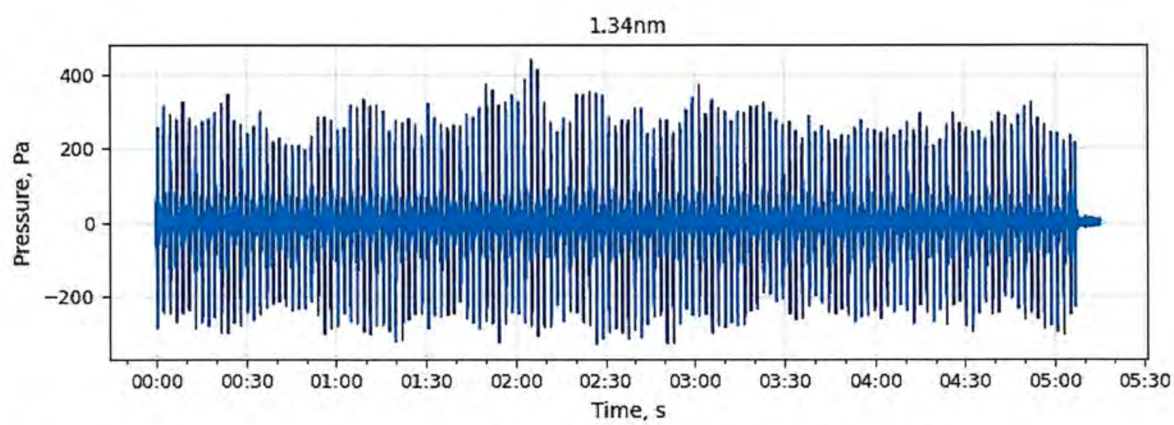

Figure 13. Time series sound pressure, Pa 2:09 pm, 1.34 NM (2.48 km). Pile driving dominant, 143 hammer blows recorded. Orion and support ship propulsion and thruster noise are highly audible (hydrophone through headphones).

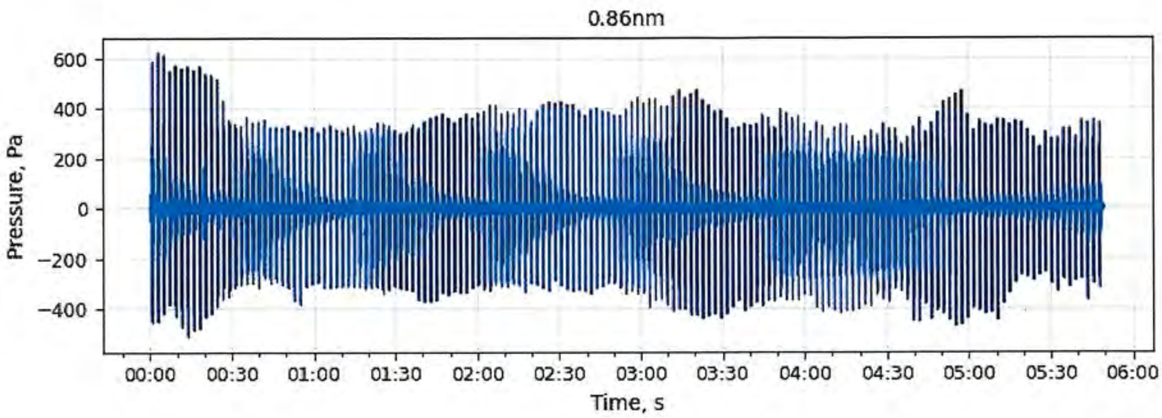

Figure 14. Time series sound pressure, Pa 2:09 pm, 0.86 NM (1.59 km). Pile driving dominant, 160 hammer blows recorded. Orion and support ship propulsion and thruster noise are highly audible (hydrophone through headphones).

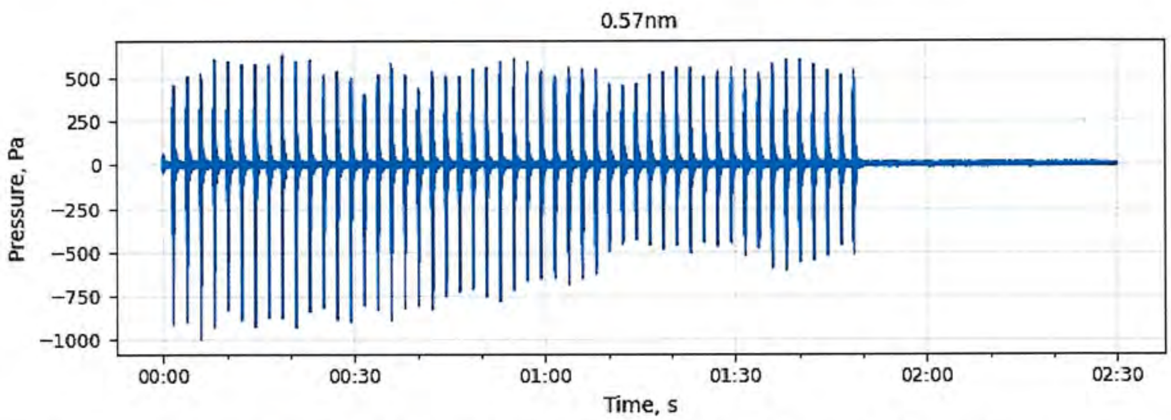

Figure 15. Time series sound pressure, Pa 2:34 pm, 0.57 NM (1.06 km). Pile driving dominant, 51 hammer blows recorded. Orion and support ship propulsion and thruster noise are highly audible (hydrophone through headphones).

Hammer interval is plotted below as a timeline in Figure 16 and with histograms in Figure 17. Interval width varied from 1.68 to 2.38 seconds. Hammer blow count varied from 24 to 34 per minute. Hammer ceased (pile driving completed) at approximately 2:36 PM.

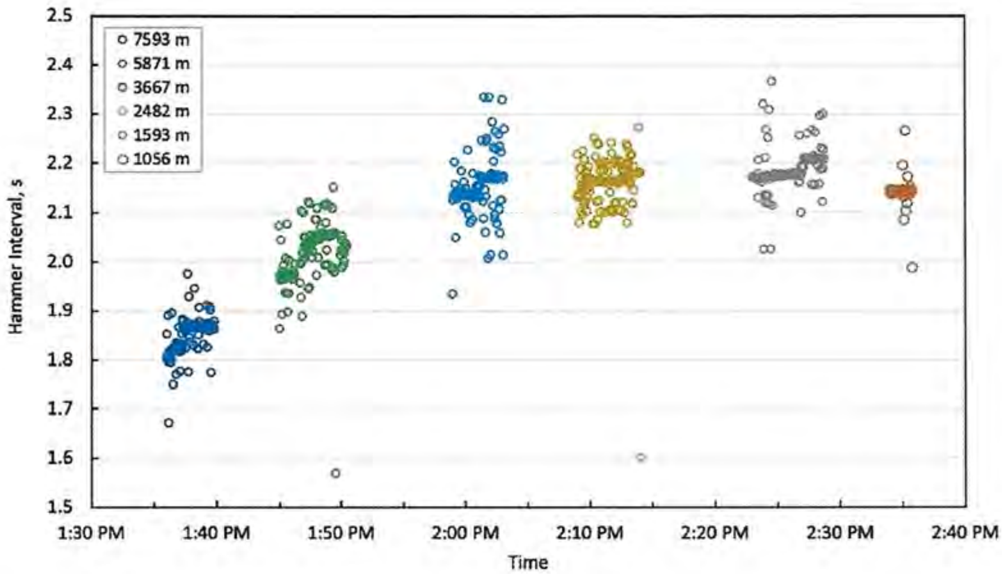

Figure 16. Hammer interval, seconds, for each measurement location. Locations shown by color.

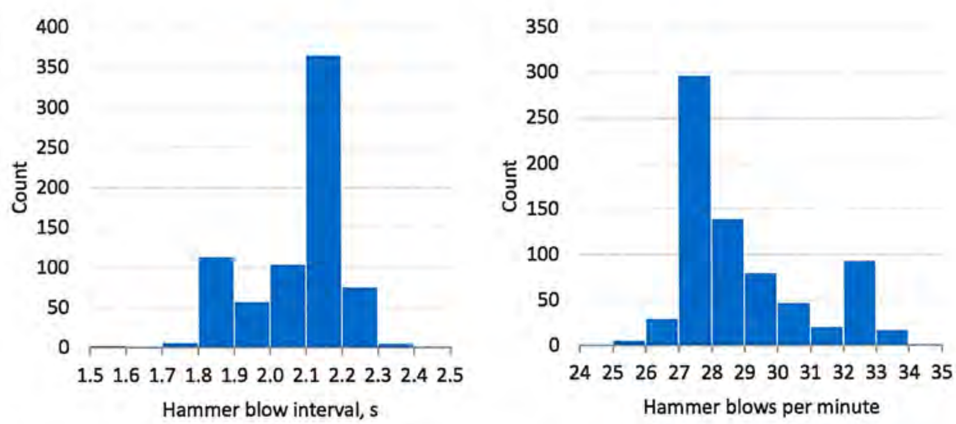

Figure 17. Histograms, hammer blow interval, seconds and blows per minute.

A hammer blow at 0.57 NM is plotted for illustration in Figure 18 below with the peak marked. Pile driving hammer blow pressures were observed generally to be comprised of a primary peak pulse with either positive (compressional) or negative (rarefractional) phase, within a group of pulses of various intensities and phases arriving *before and after* the peak pulse.

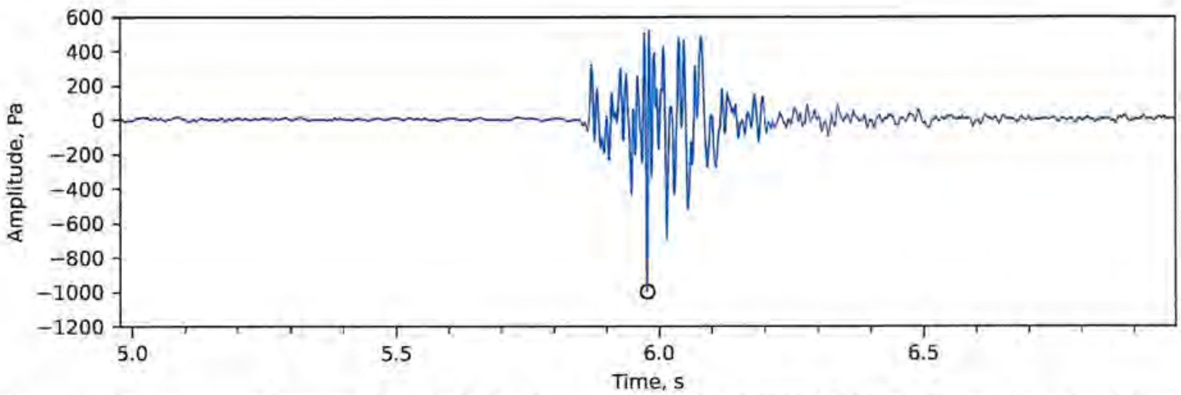

Figure 18. Time series sound pressure, Pa at the highest hammer blow peak at 0.57 NM (1.06 km). Hammer blow signal shows echo/reflection groups and multiple sound speed paths characteristic of reflections off bottom and surface and differing sound speed above and below thermocline.

Multiple pulse components with differing time arrivals are consistent with acoustic path time and strength modifiers:

- Direct path from sparker to hydrophone
- Primary reflections off the water surface and the ocean bottom
- Multiple sound speed paths, above and below thermocline
- Higher speed propagation through the sediment (seabed)
- Focusing, group velocities, and horizontal refraction
- Scattering

The waters in the survey area are shallow (about 35 to 38 meters) compared to open ocean and the distances to recordings (roughly 1 to 8 km). As a result, the water surface and sea bottom channel the acoustic energy horizontally, acting as containing surfaces with varying degrees of reflectivity and absorption from location to location between source and receiver. Hammer blow mach waves penetrate the seabed where the sound speed is faster than in water. If the sound speed also increases with depth in the seabed due to increased density, acoustic waves may bend back up into the water and arrive at the hydrophone before the waterborne acoustic peak.

The observed complex pulse shapes are consistent with Oliveira et al [34], "*Three-dimensional (3D) effects can profoundly influence underwater sound propagation and hence soundscape at different scales in the ocean ... In the particular case of coastal seas, a range of physical oceanographic and geological features can cause horizontal reflection, refraction, and diffraction of sound.*" The shallow 50-meter ocean depth evaluated by Oliveira et al resembles the 35- to 38-meter water depths during this survey.

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34 Oliveira, T., Lin Y.T., Porter, M., Underwater Sound Propagation Modeling in a Complex Shallow Water Environment, Front. Mar. Sci., 15 October 2021.

Data plotted in Figure 19 below illustrate the individual hammer blow sound pressure levels for peak-to-peak, peak, RMS,200 and RMS,90pct metrics.

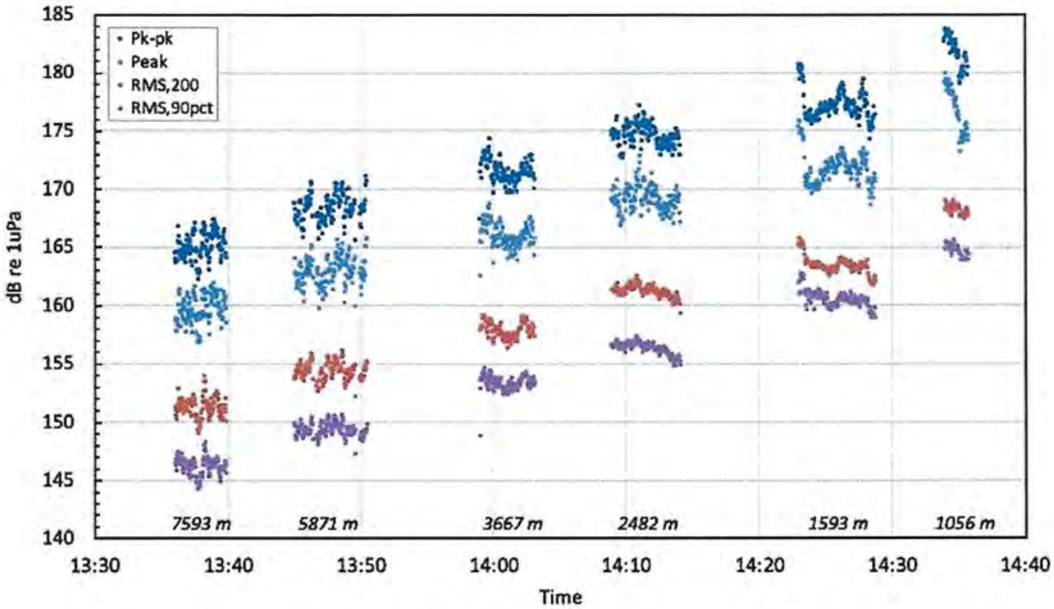

Figure 19. Computed metrics for hammer blows acquired during the survey (n=743).

These sound pressure levels are presented with trends in the following sections.

3.2 Peak Sound Pressure Levels

Peak sound pressure levels are plotted in Figure 20 below.

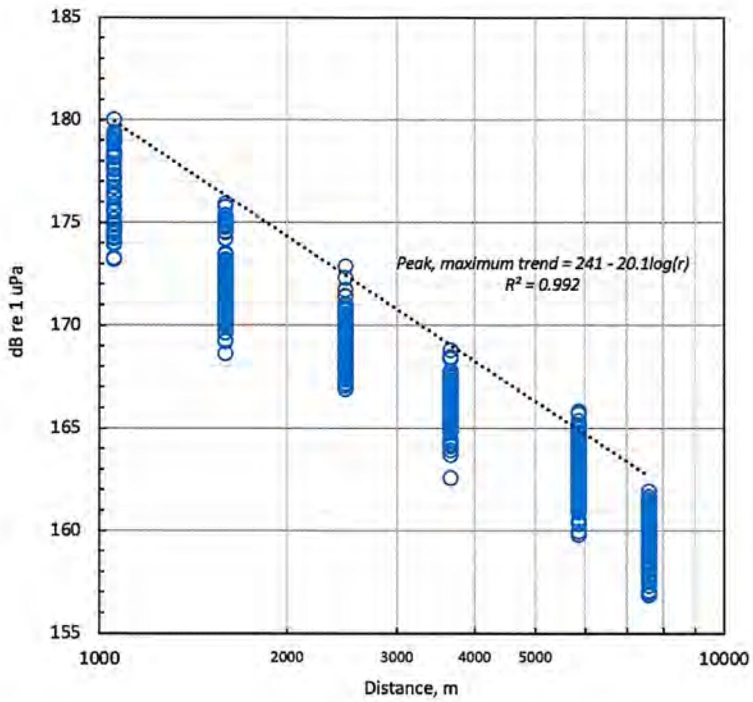

Figure 20. Peak values for all hammer blows during the survey. Lpk Source Level (SLpk) conservatively estimated with highest occurring peaks at each location/.

Peak levels measured up to 180 dB re 1uPa at 1.06 km, during pile driving operations with noise mitigations. The estimated effective source level SLpk is 241 dB re 1 uPa for maximum trend for the far-field range of roughly 1 to 8 km. Propagation loss was 20.1log(r) for the maximum trend, consistent with spherical spreading. Maximum peak values ran about 3 to 4 dB above median peak values. The peak level spread maximum to minimum at each location was 5 to 7 dB.

3.3 Pk-pk Sound Pressure Levels

Peak to peak (pk-pk) sound pressure levels are plotted in Figure 21 below to provide a picture of the total intensity in the hammer blow events.

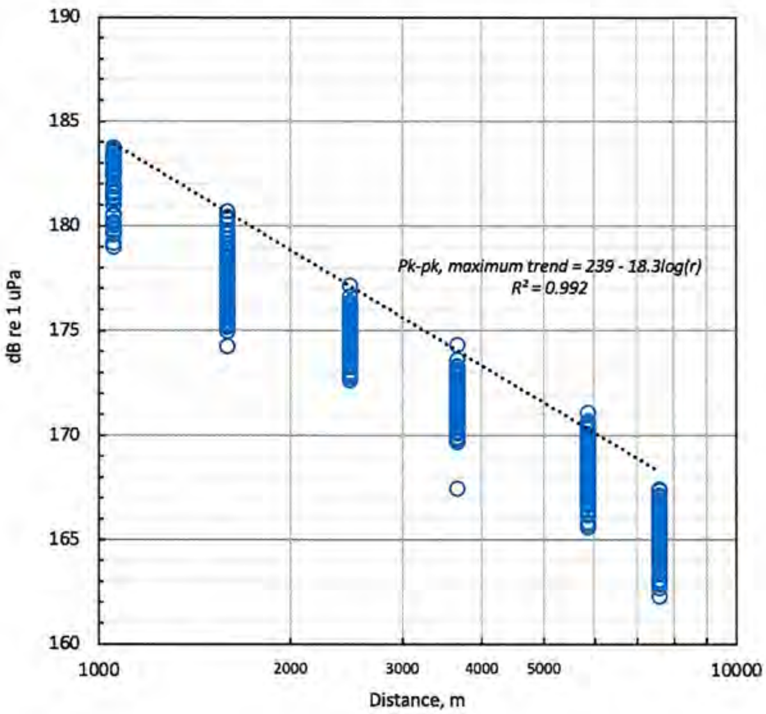

Figure 21. Peak to peak (pk-pk) values for all hammer blows during the survey. Lpk-pk Source Level (SLpk-pk) conservatively estimated with highest occurring peak-to-peak levels at each location.

Peak to peak levels measured up to 184 dB re 1uPa at 1.06 km, during pile driving operations with noise mitigations. The conservatively estimated apparent source level SLpk-pk is 239 dB re 1uPa for the far-field range of 1 to 8 km. Propagation loss was 18.3log(r) for the maximum trend, between spherical and practical spreading. Maximum peak-to-peak values ran about 2 to 3 dB above median values (see Appendix D). The peak-to-peak level spread maximum to minimum at each location was 5 to 7 dB.

3.4 RMS Levels

The RMS,200 is the RMS level computed using 200-millisecond exponential weighting, the recommended maximum fixed RMS time window in Madsen 2005 for mammalian hearing response. RMS,200 sound pressure levels are plotted in Figure 22 below. The NMFS 160 dB Level B harassment threshold is shown for visual comparison.

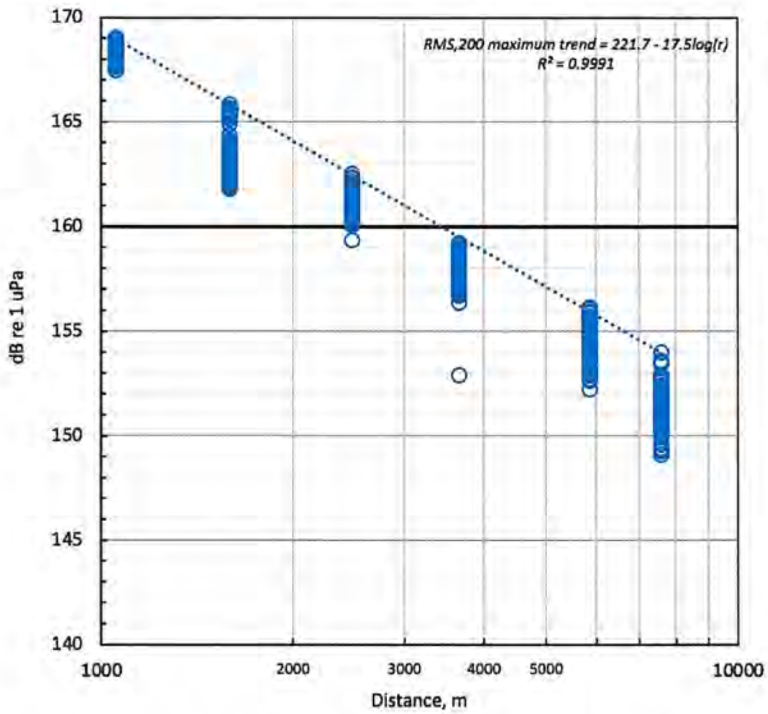

Figure 22. Scatter plot of RMS,200 values for all hammer blows during the survey, with trend of maximum levels for each location.

RMS,200ms levels measured up to 169 dB re 1uPa at 1.06 km, during pile driving operations with noise mitigations. The conservatively estimated apparent source level SL,RMS is 221.7 dB re 1uPa for the maximum trend for the far-field range of roughly 1 to 8 km. Propagation loss PL measured 17.5log(r) for the maximum trend, between practical and spherical spreading. Maximum RMS values ran 1 to 3 dB above median values (see Appendix D). The RMS level spread maximum to minimum at each location was 2 to 5 dB with two "outlier" lower-energy hammer blows. **Pile driving RMS, 200 sound level breach the NMFS 160 dB,RMS Level B harassment threshold out to 3355 meters.**

RMS,90pct sound pressure levels are plotted in Figure 23 below. These are determined with the percentage energy signal duration (between 5% and 95% cumulative energy points) referenced in Madsen 2005 and defined in ISO 18405:2017 (the ISO definition reference is Madsen 2005). The RMS analysis dataframe for each peak was selected at 1 second, previously used in industry pile driving reporting [35]. The 90 percent analysis returns unique 5-95 percent averaging time windows for each peak depending on a number of waveform lengthening and densifying factors including increased numbers of reflections with distance, group velocities, and early energy time arrivals via acoustic waves emitted from the monopile base and refracted out of the seabed. Compared to the RMS,200 mammalian hearing window analyzed in Madsen 2005 and shown in Section 3.4 in this report, the RMS,90pct averaging windows are longer and produce lower RMS levels. The NFMS 160 dB Level B harassment threshold is shown for visual comparison.

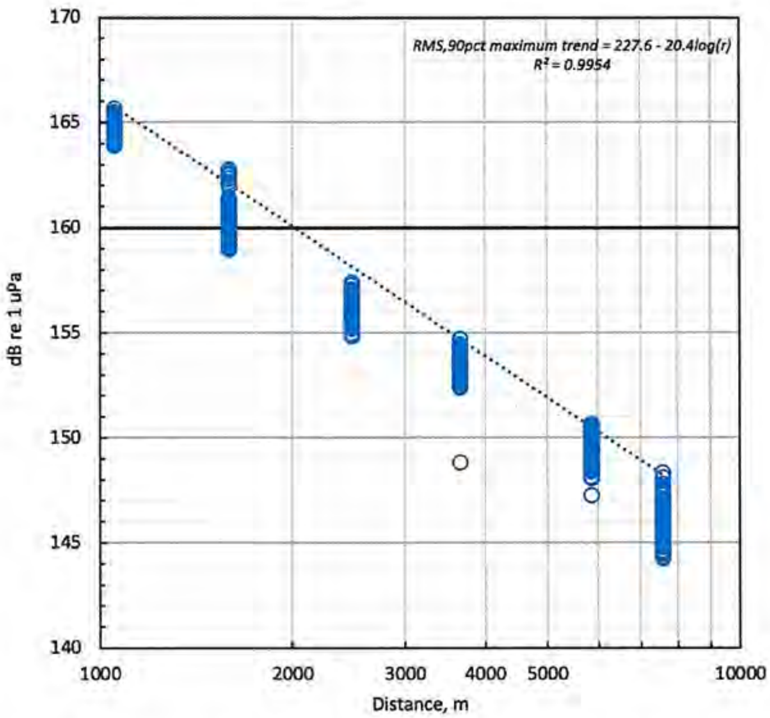

Figure 23. Scatter plot of RMS,90pct values for all hammer blows during the survey, with trend of maximum levels for each location.

RMS,90pct levels measured over 165 dB re 1 uPa at 1.06 km, during pile driving operations with noise mitigations. The estimated apparent source level SL,RMS is 227.6 dB for the maximum trend in the far-field range of roughly 1 to 8 km. Propagation loss PL measured 20.4log(r) for the maximum RMS trend, consistent with spherical spreading. Maximum RMS values ran about 2 to 3 dB above median values (see Appendix D). The RMS spread maximum to minimum at each location was 3 to 4 dB with two "outlier" lower-energy hammer blows. **Pile driving RMS,90pct sound levels breach the NMFS 160 dB,RMS Level B harassment threshold out to just over 2 kilometers.**

Due to the large difference in the computed protective radius to 160 dB, the two RMS metrics were compared. Figure 24 below provides decibel ratio plotting of the RMS,200 (maximum

35 Dominion Energy CVOW Pilot Project – Revised Protected Species Observer (PSO) Monitoring Report and Pile Driving Noise Monitoring Report for WTG Construction and Observations, Document no.: JDN1823.REP.62.32, 28 November 2020.

recommended mammalian hearing window, Madsen 2005), and the RMS,90pct (RL_{90}, Madsen 2005) referenced in NFMS and BOEM documents reviewed for this report.

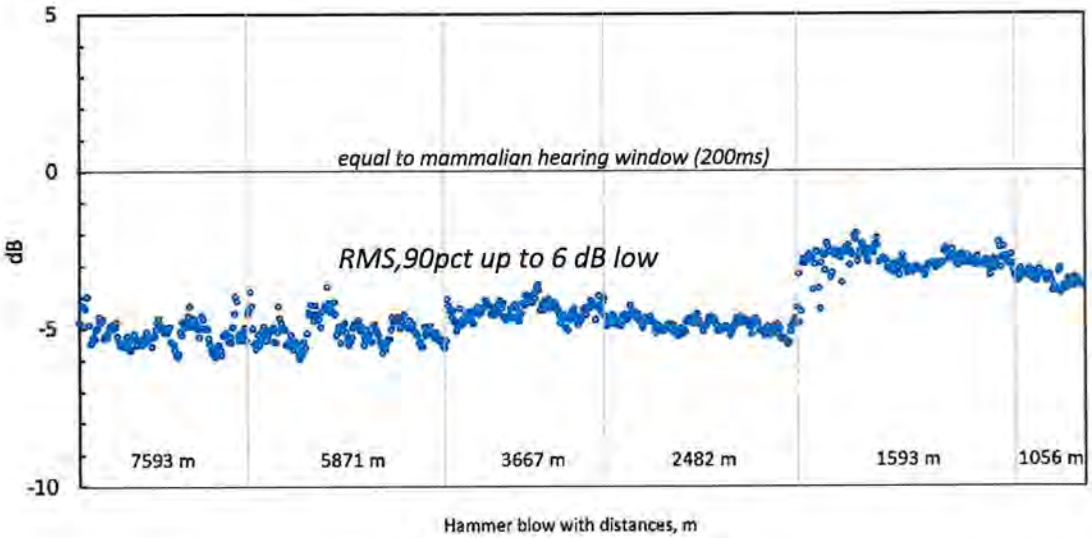

Figure 24. Computed difference of RMS,200 and RMS,90pct for all hammer blows during the survey (n=743). RMS,90pct underestimates the RMS computed for the mammalian hearing window by 2 to 6 dB.

The RMS,90pct is 2 to 6 dB below the 200-millisecond mammalian hearing window RMS. Underestimates were largest in the range of 2482 to 7593 meters from pile driving. The RMS,90pct reductions from mammalian hearing window appear related to the impulse waveforms lengthening and becoming more complex with reflections and group velocities in far-field distances, and increasing time differences between the waterborne peak and pre-peak acoustic waves arriving earlier having traveled faster through the seabed, resulting in larger averaging windows and lower RMS levels.

The results are not surprising and they are consistent with the cautions in Madsen 2005 and general acoustics practice. Longer RMS analysis windows produce lower RMS levels. The RMS,90pct necessarily using the 1-second analysis window to capture the full waveform ensemble underestimates the RMS levels associated with the energy occurring in the mammalian hearing window where detection and response would be expected to occur.

This leads to a professional caution. The 90-percent RMS should not be considered conservative for best practice acoustics planning to prevent adverse noise impacts on marine mammals. A protective setback radius based on the 90-percent RMS and spherical spreading results in a shortage of as much as a *halving* [36] of the regulatory radius required for protection based on the maximum recommended 200ms mammalian hearing window in Madsen 2005.

36 For spherical spreading 20log(r), the change in distance for a drop of 6 dB can be determined using R1 = 10^(RMS/20) and R2 = 10^((RMS-6)/20). For any RMS, the distance R2 for RMS-6, dB will be one half the distance R1 associated with RMS, dB.

3.5 Pile Driving Sound Spectra

Piling one-third octave band sound spectra were analyzed in Spectraplus-SC. Spectrum acquisition on the 192KHz hydrophone recordings was decimated to obtain octave band analysis down to the 10 Hz ANSI one-third octave band, using a 16384 point FFT and Hanning weighting. ANSI S1.11 one-third octave band spectra were acquired using single-shot linear sampling triggered on the peak pile driving hammer blows arriving every 2 seconds. A 150-millisecond pre-delay was engaged to include portions of the hammer blow energy arriving prior to the peak time, traveling faster through the ocean seabed than the direct waterborne pulses and accompanying multiple reflections. Spectrum logs were imported into Excel and processed into box plots for each measurement location using macros from Peltier Tech [37].

One-third octave band analysis results show overall RMS pile driving levels ranged from 165 to 147 dB,RMS re 1uPa from 0.57 to 4.1 NM. The one-third octave pulse spectra contain a low-frequency acoustic signature. Pile driving spectra show acoustic energy principally below 160 Hz, and exhibit attenuation above 160 Hz resembling a 2nd-order 12dB per octave lowpass filter.

At 3.17 and 4.1 NM, one-third octave bands below 31.5 Hz exhibit larger amplitude scatter than at closer distances to the pile driving. This is judged to be due to increased reflections and variations in sound channeling and increased times between refracted pre-arrivals and the acoustic peaks at those distances from the Orion pile driving.

37 Peltier Tech. https://peltiertech.com/documentation/box-whisker-charts-box-plots/

One-third octave RMS spectra for 51 pile driving hammer blows are shown in Figure 25 below in box plot format per band for the 0.57 NM distance (1.06 km).

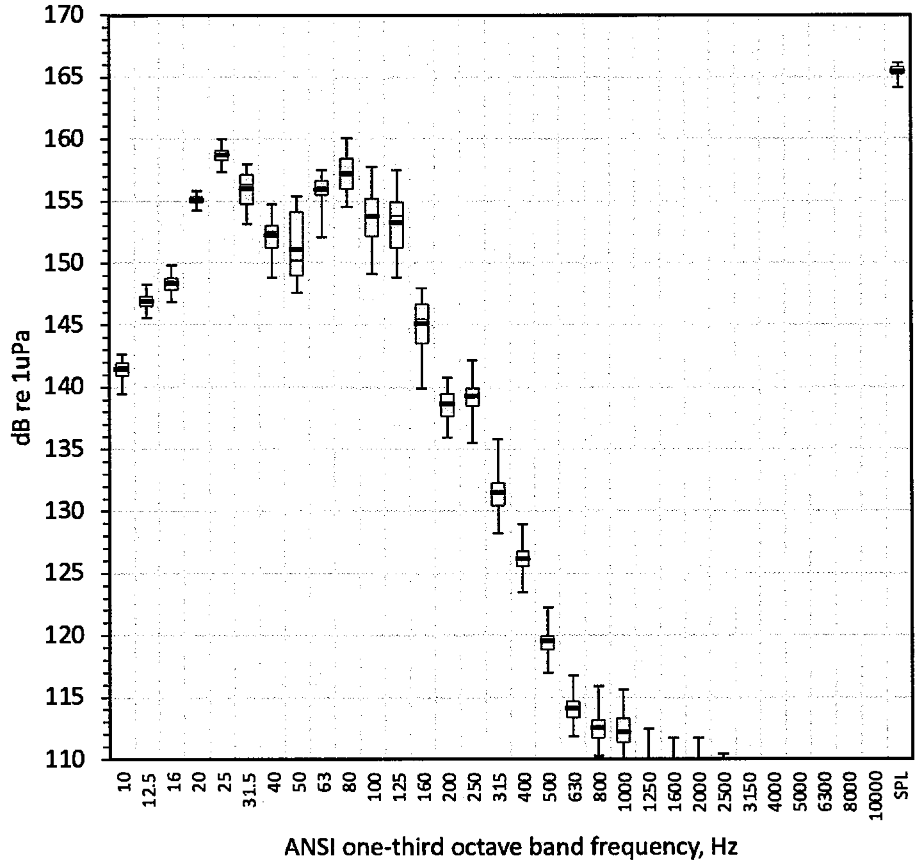

Figure 25. Box plot of one-third-octave band levels at 0.57NM (1.06 km).

One-third octave RMS spectra for 160 pile driving hammer blows are shown in Figure 26 below in box plot format per band for the 0.86 NM distance (1.59 km).

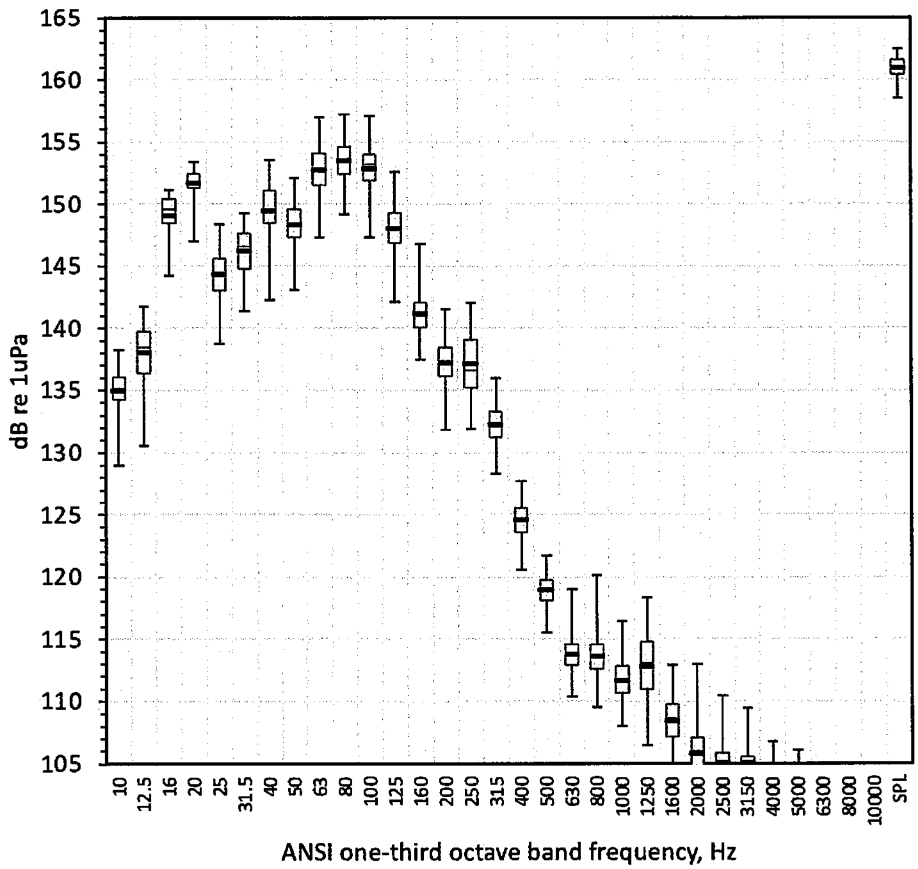

Figure 26. Box plot of one-third-octave band levels at 0.86NM (1.59 km).

One-third octave RMS spectra for 143 pile driving hammer blows are shown in Figure 27 below in box plot format per band for the 1.34 NM distance (2.48 km).

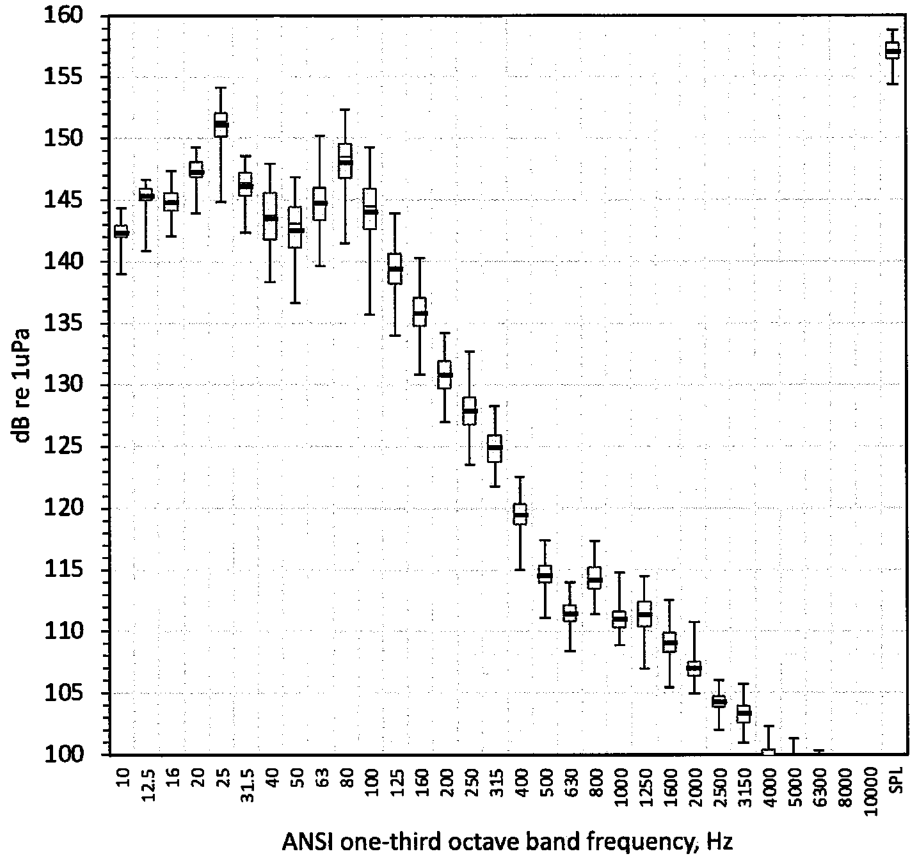

Figure 27. Box plot of one-third-octave band levels at 1.34NM (2.48 km).

One-third octave RMS spectra for 117 pile driving hammer blows are shown in Figure 28 below in box plot format per band for the 1.98 NM distance (3.67 km).

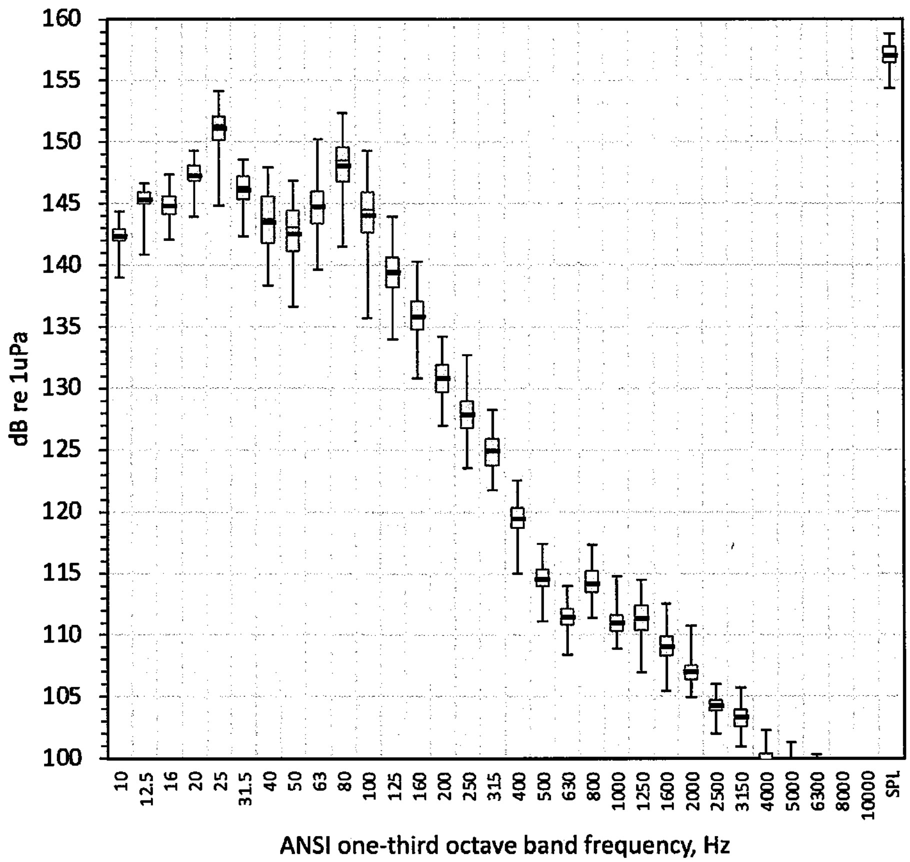

Figure 28. Box plot of one-third-octave band levels at 1.98NM (3.67 km).

One-third octave RMS spectra for 146 pile driving hammer blows are shown in Figure 29 below in box plot format per band for the 3.17 NM distance (5.87 km).

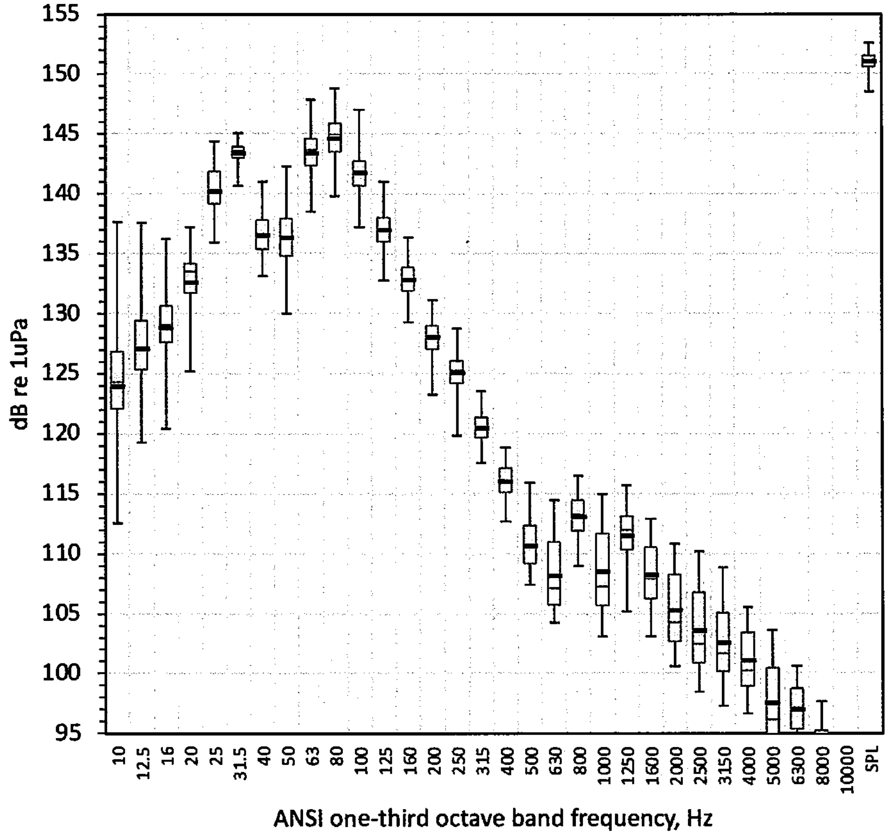

Figure 29. Box plot of one-third-octave band levels at 3.17NM (5.87 km).

One-third octave RMS spectra for 126 pile driving hammer blows are shown in Figure 30 below in box plot format per band for the 4.1 NM distance (7.59 km).

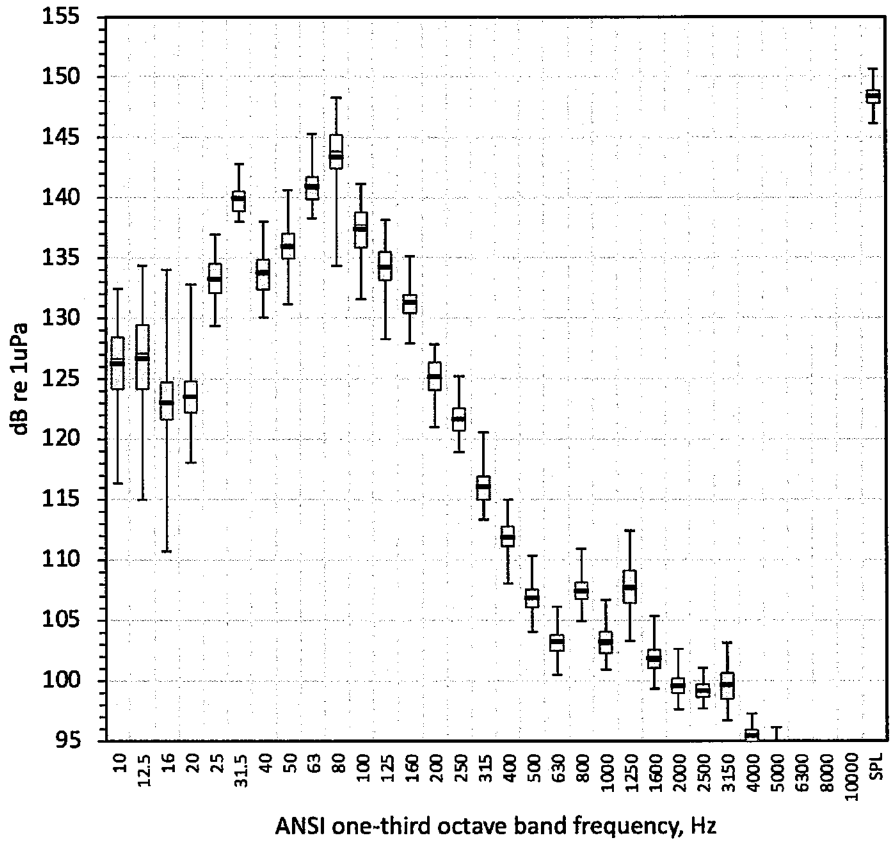

Figure 30. Box plot of one-third-octave band levels at 4.1NM (7.59 km).

3.6 SEL, Unweighted

Unweighted sound exposure level (SEL) was computed for each hammer blow using the measured RMS,200 and the 200-millisecond fixed window width for each hammer blow. The results are shown in Figure 31 below. SEL levels measured over 162 dB re 1uPa^{2}s at 1.06 km. Propagation loss PL measured 17.5log(r), falling between practical and spherical spreading.

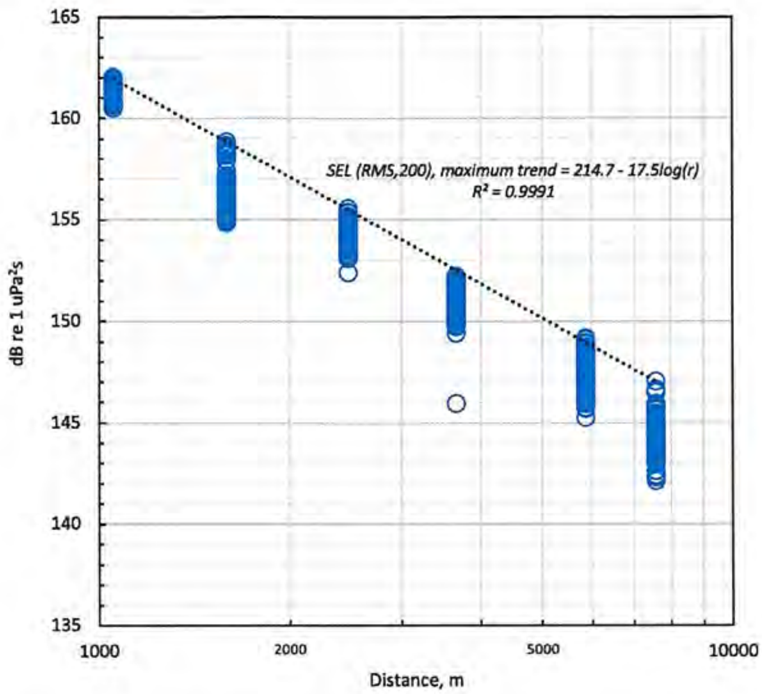

Figure 31. Sound exposure SEL values for all hammer blows acquired during the survey. The SEL values are calculated from the RMS,200 levels with fixed 0.2 second window width. SEL source level (SL) is conservatively estimated for maximum values at each location.

Unweighted sound exposure level (SEL) was computed for each hammer blow using RMS,90pct and the 90 percent window width for each hammer blow. The RMS 5-percent to 95-percent window width was computed within the selected RMS analysis dataframe of 1 second. The results are shown in Figure 32 below. SEL levels measured over 162 dB re 1uPa^{2}s at 1.06 km. Propagation loss PL measured 17.4log(r), falling between practical and spherical spreading. Each peak had a unique RMS time window in milliseconds based on the points where the 5- and 95-percent cumulative RMS sum was determined within the 1-second analysis window. Summary statistics for those values are provided in Appendix D.

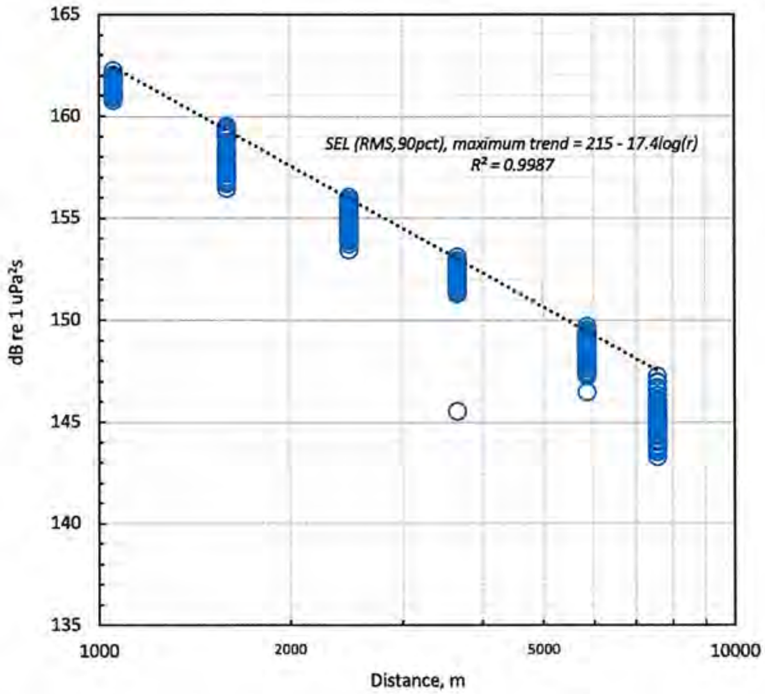

Figure 32. Sound exposure SEL values for all hammer blows acquired during the survey. The SEL values are calculated for the RMS,90pct levels and window width for each hammer blow. SEL source level (SL) is conservatively estimated for maximum values at each location.

3.7 Weighted (LF,Cetacean) RMS and Species Avoidance Response

LF-weighted RMS values are plotted in Figure 33 for each measurement location using the 200-millisecond mammalian hearing window (Madsen 2005). A severity scale of probabilistic behavioral responses to noise exposures between SPLs of 120-140, 140-160, and 160-180 decibels (dB) is shown corresponding to response thresholds listed in the BOEM Biological Assessment, March 2019, Table 5.1-2 for migrating mysticete whales (reference Wood 2012). These thresholds are listed in Wood 2012 Table 3.9 to define Level B behavioral responses. The thresholds reflect the behavioral response analysis method used by BOEM which "*applies frequency-weighted sound pressure levels for hearing groups (Wood et al. 2012) to estimate behavioral responses based on a gradual increase, or step function, that estimated a greater number of responses at higher SPLs and fewer adverse responses at lower SPLs farther from a sound source. This method applies a wider sound exposure range with different percentages of animals responding to noise exposure at each step between SPLs of 120-140, 140-160, and160-180 decibels (dBs) (Table 5.1-2).*"

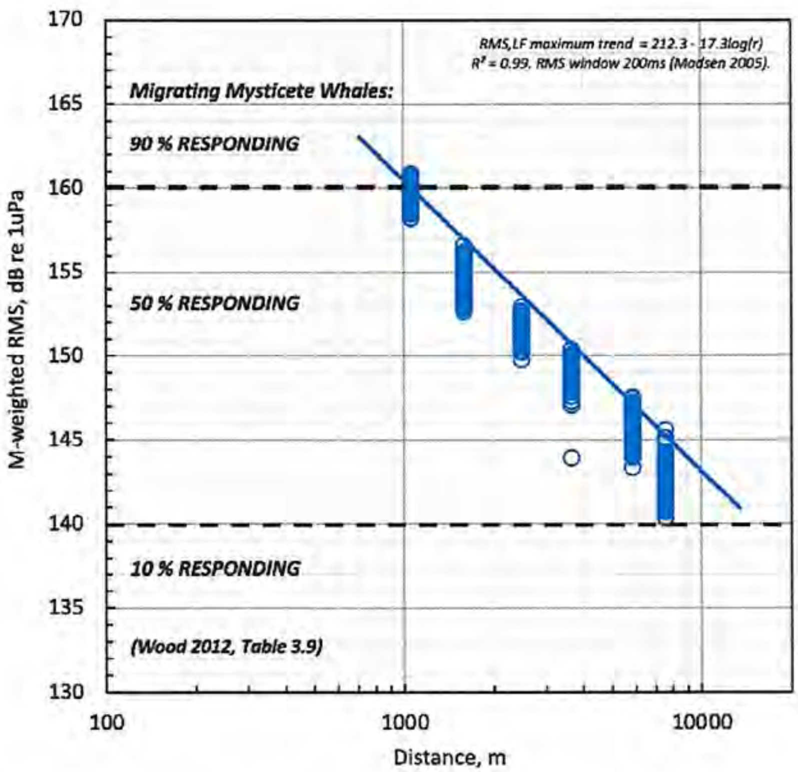

Figure 33. Scatter plot of RMS,LF values for all hammer blows during the survey. The trend for the highest RMS sound pressure levels over distance is shown with the propagation loss equation. BOEM 2019 thresholds for percentage mysticetes responding are shown for consideration.

RMS,LF levels computed from 200-millisecond fixed RMS windows measured up to 161 dB re 1uPa at 1.06 km. Ninety percent of mysticetes are expected to respond within 1 kilometer, with RMS sound levels exceeding 160 dB. Fifty percent of mysticetes are expected to respond behaviorally beyond 10 kilometers, with RMS sound levels exceeding 140 dB out to 14.5 km.

3.8 Weighted SEL for LF and PW Marine Species

The *effective far field* SEL during continuous pile driving was calculated for LF and PW marine species by computing total cumulative SEL sound levels over recording time T ranging from 111 to 248 seconds and 51 to 160 hammer blows per location, then normalizing those values to a 1-second SEL value by subtracting 10log(T/1.0) for each location. These normalized one-second SEL values enable the estimation of noise exposure over time by using using the sound expsoure factor 10log(T) during continuous pile driving. The extended dataset collected at 3.17 nautical miles offered a duration for analysis comparable to the other five sites, specifically between two operational cessation periods (refer to Figure 11).

Regarding the LF Cetacean Hearing Group, guidance from Southall (2019) [31] highlights the need for considerable caution due to the lack of direct hearing data for these species, which impacts the ability to predict their hearing capabilities and assess the vulnerability of their hearing to noise exposure. A prudent approach entails examining the unweighted linear SEL (SEL,Unweighted) to initiate an evaluation of potential hearing sensitivity to noise exposure.

SEL trends were established via logarithmic curve fit, with R^2 goodness of fit exceeding 0.98 with Unweighted, LF(Cetacean) and PW(Phocids) SEL data. MF and HF species weighting filtered hammer blow impulse data below useable range and were not evaluated further in this report. Figure 34 illustrates the effective SEL for unweighted SEL and LF and PW auditory weightings.

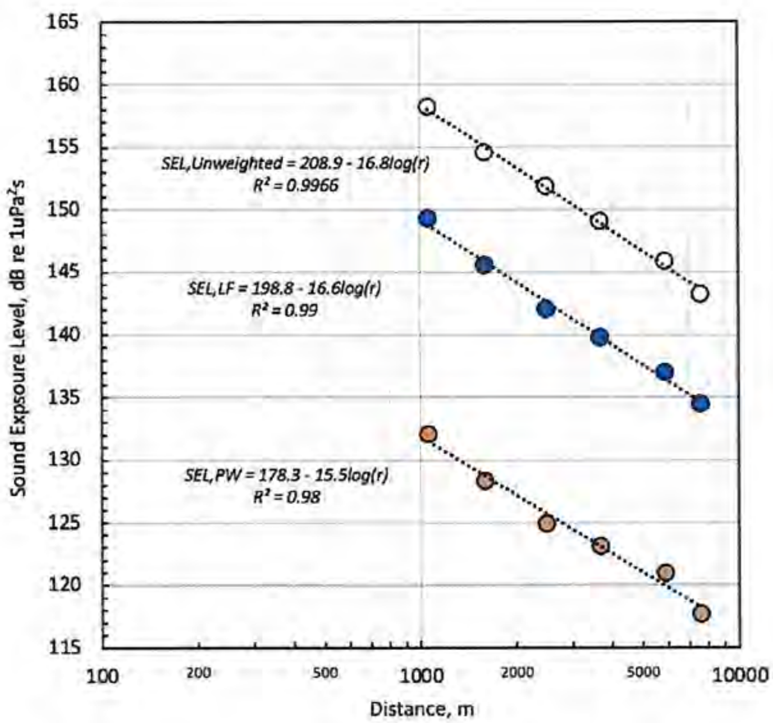

Figure 34. Sound exposure SEL values for unweighted, LF and PW weightings.

SEL,Unweighted measured 158.2 dB re $1uPa^2s$ at 1.06 km. The estimated source level is 208.9 dB re $1uPa^2s$. Weighted SEL measured 149.3 and 132.1 dB re $1uPa^2s$ at 1.06 km for LF and PW species weighting, respectively. The estimated source level is 198.8 and 178.3 dB re $1uPa^2s$ for LF and PW species weighting, respectively.

Propagation loss PL for unweighted SEL was measured at 16.8log(r), close to practical spreading. Similarly, PL measured 16.6log(r) and 15.5log(r) for LF and PW species weighting, respectively, also close to practical spreading. Notably, assuming spherical spreading 20log(r) during sound exposure modeling would significantly underestimate SEL versus distance.

Notably, the LF weighting reduces the sound exposure level relative to unweighted SEL by approximately 9 dB at all locations from 1 to 8 km. With the absence of hearing data for mysticetes acknowledged by all parties and cautioned in Southall 2019, assuming SEL exposure for mysticetes as a function of LF weighting could significantly underestimate the actual, yet unknown noise impact on marine mammals.

3.9 Cumulative SEL and Level B and Level A Harassment Thresholds

The cumulative sound exposure level cSEL is computed by summing exposures to sound levels versus time. Higher sound levels and longer durations result in higher cSEL values. Drawing on extensive expertise in statistical audio noise dosimetry within power plant operations and acoustic evaluations of sonar survey vessels [38,39], questions emerged regarding the temporal durations necessary to exceed the NMFS Level B and Level A acoustic thresholds delineating the onset of temporary and permanent threshold shifts (TTS and PTS) in marine species.

The weighted cSEL was estimated for a range of distances and times assuming fixed source and receiver distances. Figure 35 below provides a log-log plot showing exposure times for the LF Cetacean marine species at Level A (PTS) and Level B (TTS) thresholds, 183 dB and 168 dB re 1 μPa^2s, respectively. The measured transmission loss of 16.6log(r) was employed. The results match calculations using the NMFS User Spreadsheet Version 2.2 (2020) Tab 'E' (Stationary).

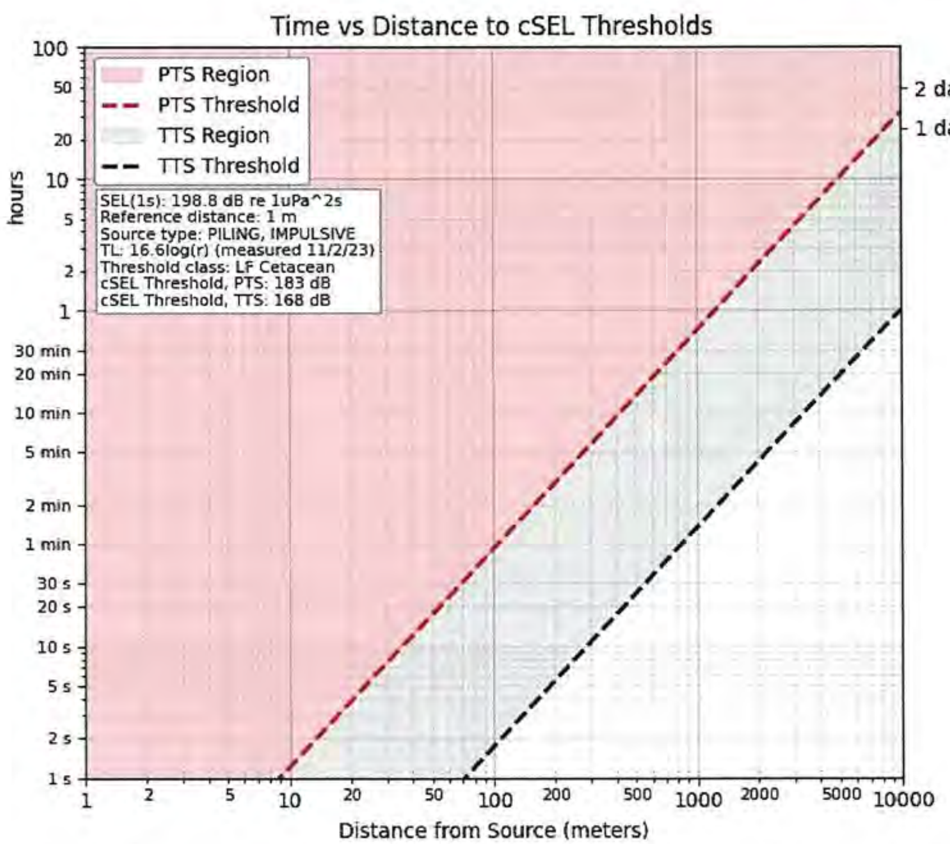

Figure 35. Log-log plot showing exposure times associated with Level B (TTS) and Level A (PTS) thresholds for the LF Cetacean marine species, 168 dB and 183 dB re 1uPa^2s, respectively, assuming exposure at a fixed position.

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38 Teplitsky, AM, Bradley, WE, Rand, RW and Suuronen, DE, "Statistical Audio Dosimetry Methodology", American Speech-Language-Hearing Association, November 1984. Research and work products were developed under contract with the New York Empire State Electric Energy Corporation (ESEERCO).

39 Rand, R.W., "Sonar Vessel Noise Survey", Rand Acoustics, LLC, 22 September 2023.

For LF Cetacean species (whales), a pile driving sound exposure of 13 minutes at 500 meters, 45 minutes at 1000 meters, or 2 hours at 1800 meters, yields a cumulative SEL exceeding the PTS threshold (onset of permanent hearing loss). A sound exposure of 2 minutes at 1200 meters, 5 minutes at 2200 meters, and 10 minutes at 3200 meters yields a cumulative SEL exceeding the TTS threshold (temporary threshold shift, hearing impaired).

Figure 36 below provides a log-log plot showing exposure times for the PW Phocid marine species at Level B (TTS) and Level A (PTS) thresholds, 170 dB and 185 dB re 1uPa^2s, respectively. The measured transmission loss of 15.5log(r) was employed. The results match test calculations using the NMFS User Spreadsheet Version 2.2 (2020) Tab 'E' (Stationary).

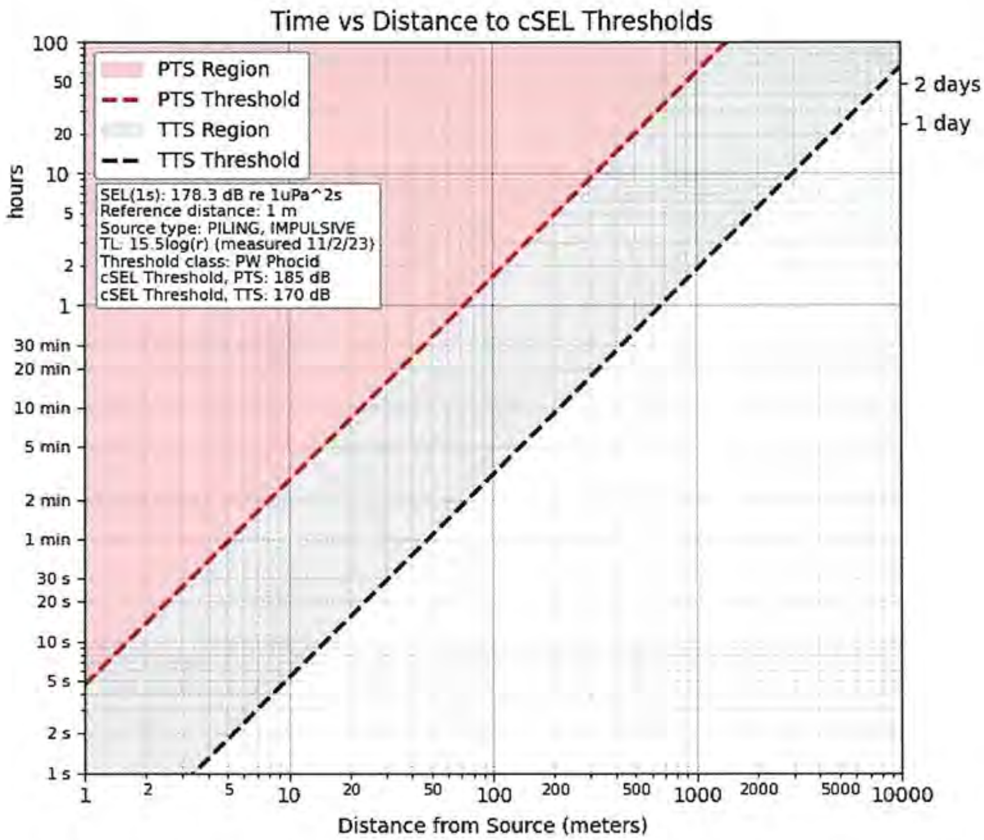

Figure 36. Log-log plot showing exposure times associated with Level B (TTS) and Level A (PTS) thresholds for the PW Phocid marine species, 170 dB and 185 dB re 1uPa^2s, respectively, assuming exposure at a fixed position.

For PW Phocid species (seals), a sound exposure of 1-3/4 hours at 100 meters yields a SELcum exceeding the Level A PTS threshold (onset of permanent hearing loss). A pile driving sound exposure of 40 minutes at 500 meters, or 2 hours at 1 kilometer, yields a SELcum exceeding the TTS threshold (temporary threshold shift, hearing impaired).

3.10 Reverberation

Reverberation time in the shallow littoral waters (depth 35-38 meters) was estimated with T20 decay estimation and Schroeder backward integration on selected portions of the audio recording at 0.57 NM, employing the Orion pile driving peak pulses as pulse source. Reverberation was estimated by averaging three RT60 tests, the highest peak at 5.98 seconds, the last peak, and a random peak at 21.1 seconds. The average RT60 measured 1.3 seconds at 40 Hz and 0.75 seconds at 250 Hz. Operational noise between hammer blows appeared elevated by several dB compared to the continuous noise observed from vessel-only noise emissions after hammer blows ceased at 1:49 elapsed time of recording. The elevated background between hammer blows is consistent with acoustic properties in a reverberant environment.

3.11 Vessel and ambient background sound levels

Vessel propulsion and DP thruster noise was highly audible on headphones out to 8 NM. Ambient sound levels were predominantly controlled by continuous vessel noise within 8 NM during the survey. Sounds heard included propulsion and DP thruster noise which were tonal. Continuous popping and rattling sounds were consistent with cavitation from DP thrusters and propulsion.

Vessel propulsion noise analyzed at 3.17 NM (5.87 km) with 10-second RMS averaging included prominent tones, as shown in Figure 38 below in the recording segment between pile driving at 1:26 to 1:36 mm:ss. Along with low-frequency noise from 50 to 100 Hz consistent with thrusters, tones were observed above 200 Hz, including 390, 780, and 1170 Hz, with higher harmonics. Total vessel noise from 40 to 10000 Hz measured 123 dB RMS.

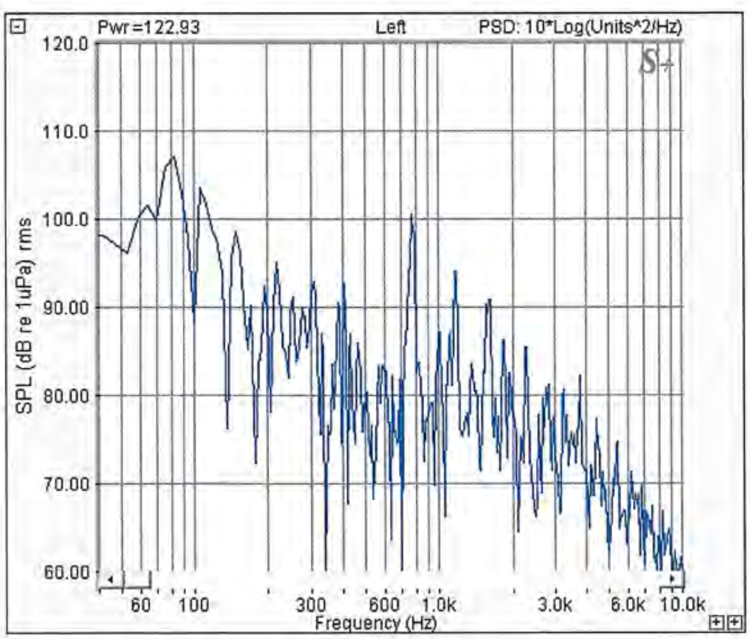

Figure 37. RMS spectrum plot, 3.17NM, between pile driving, recording segment at 1:26 to 1:36 mm:ss. Total RMS level measured 123 dB re 1 uPa from 40 to 10000 Hz.

Vessel propulsion noise analyzed at 0.57 NM (1056m) with 10-second RMS averaging included prominent tones as shown in Figure 39 below in the recording segment from 1:52 to 2:02 mm:ss. Along with low frequency emission in the 50 to 100 Hz consistent with thrusters, tones were observed at 200 Hz and above. Broadband noise included repetitive clattering sounds consistent with cavitation. Total vessel noise from 40 to 10000 Hz measured 127 dB (RMS,10-second).

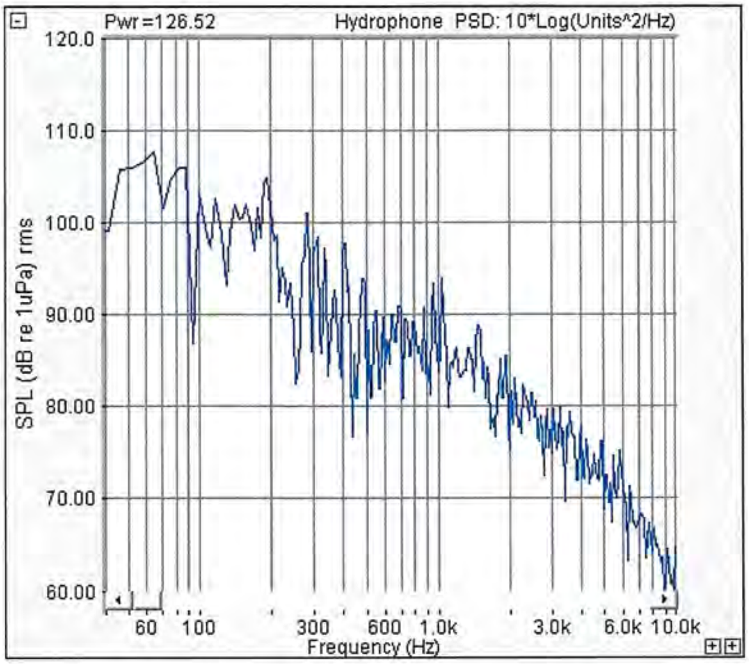

Figure 38. RMS spectrum plot, 0.5NM, between pile driving, recording segment at 1:52 to 2:02 mm:ss. Total RMS level measured 127 dB re 1 uPa from 40 to 10000 Hz.

The spectra at 0.57 and 3.17 NM were markedly different. At 3.17 NM, the outer support vessel was in line of sight and audible on headphones. At 0.57 NM, the outer bubble curtain was between the outer support vessel and the recording location, and likely acted as an acoustic barrier for that vessel's higher frequency noise.

Ambient RMS sound levels dominated by vessel noise and without pile driving were some 20 to 30 dB below pile driving RMS noise levels at all locations.

4 Discussion

4.1 Pile driving and seismic air guns

Pile driving and seismic air guns are impulsive sound sources with predominantly low frequency sound spectra. Seismic air gun source level data were reviewed from Ruppel et al 2022 [40] and compared to the pile driving sound data discussed in this report. The pile driving apparent source level was estimated from far-field sound levels from 1 to 8 kilometers during this survey at 241 dB re 1uPa @1m. This peak source level (SL) estimate is noted with a red arrow in Figure 40 below. Airgun peak SL levels within a 2 dB margin of the measured pile driving SL are outlined in the figure. Even with best available noise controls in place, the peak sound levels at the Vineyard Wind 1 project site are consistent with seismic airgun peak source levels for the highest output Tier 2, airgun arrays (2-36) and for Tier 1, airgun array surveys with total volume of 1500 in^3 or greater and/or 12 airguns or more.

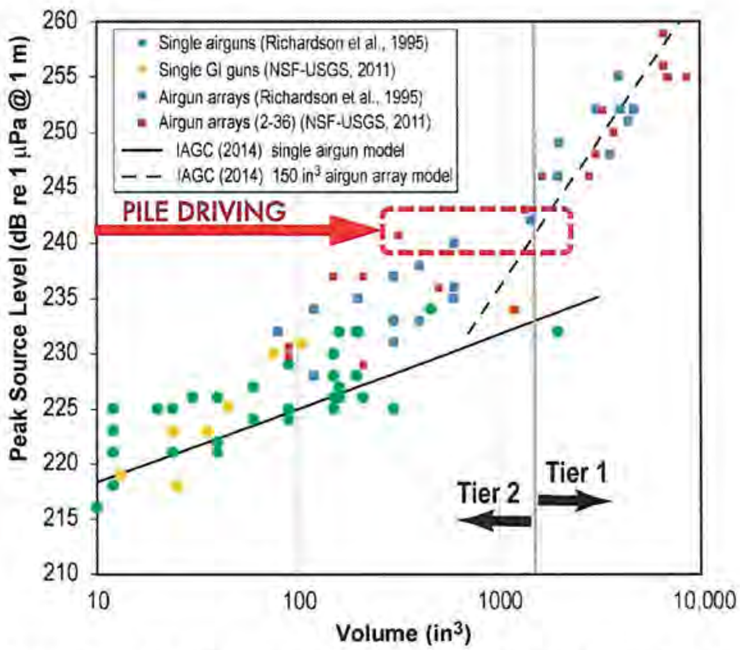

Figure 39. Comparison of 10.3-meter pile driving peak source level with compilation of source-level data on single airguns and airgun arrays from [40]: "The black solid and dashed lines correspond to modeled values for single airguns and an array of 150 in3 airguns, respectively. Tier 1 indicates airgun surveys with total volume of 1500 in^3 or greater and/or 12 airguns or more. All other airgun surveys are designated as Tier 2. Note that rms source level has no physical meaning for impulsive sources such as airguns, so the peak metric is used."

4.2 Caution on "90 percent" RMS for protecting endangered species

RMS is sensitive to the time window over which it is computed. The primary reference for RMS computation is Madsen 2005 which is cited for the 90-percent RMS computation in NMFS and

40 Ruppel, C.D.; Weber, T.C.; Staaterman, E.R.; Labak, S.J.; Hart, P.E. Categorizing Active Marine Acoustic Sources Based on Their Potential to Affect Marine Animals. J. Mar. Sci. Eng. 2022, 10, 1278. https://doi.org/10.3390/ jmse10091278.

BOEM documents. Madsen 2005 provides a comprehensive analysis of the sensitivity of the 90-percent RMS calculation to time window width, and cautions that "*it is possible to manipulate the rms level by varying the averaging window: the longer the averaging time, the lower the rms level. Measures for mitigation of sound exposure should not leave room for such analytical freedom.*"

Here is the basic problem for using the 90 percent window to evaluate pile driving at distance. In the 90 percent RMS algorithm, an analysis integration window must be selected that is wide enough in time to capture the waveform. The algorithm computes the cumulative sum from 5 to 95 percent of the energy within the integration window. The timespan between the 5- and 95-percent times forms the RMS window from which the RMS is determined.

For a 5-95 percent RMS measurement close in to a noise source such as a sparker or mammal click, the background is quiet, the impulse is brief, and the RMS measure is relatively insensitive to integration time. As Madsen found, "f*or short, well-defined transients such as odontocete clicks with good SNR, the rms measure is quite robust and not very sensitive to the criterion used to establish the integration window.*"

However, in the far-field from the pile-driving operation, the situation is different. Pile-driving is a complex noise source. On hammer impact, a shock wavefront travels down the monopile at the speed of sound in steel, acoustic mach waves radiate out the monopile into the water, the impact shock encounters the monopile base and radiates into the seabed, where acoustic energy propagates faster than in water, arriving at the hydrophone earlier than the direct water-borne peak. Meanwhile the shock wavefront is reflected back up the monopile and radiates more mach waves out into the water. Multiple reflections, path lengths, and group velocities and reverberation contribute to the now complex acoustic waveform measured in many tenths of seconds with distance. A 1-second dataframe may capture most of the signal and prevent including energy from the previous or following hammer blow (hammer blows averaged about 2 seconds between blows, with the minimum being 1.6 seconds).

Because the waveform is lengthened and complex due to the factors already discussed, the 90-percent RMS window is much longer than the maximum recommended time window of 200ms for mammalian hearing and reaction listed in Madsen 2005. This survey found the 90-percent RMS underestimates the RMS intensity in the mammalian response window by 2 to 6 dB. The 90-percent RMS is clearly unrepresentative of the intensity detected by mammalian hearing and cannot be considered a conservative metric.

Relying on the 90-percent RMS translates to smaller protective radii around pile driving operations by substantial distances. A 6-dB underestimate with spherical spreading is equivalent to *halving* the distance [36]. This results in a 50% reduction in the protective radius and a 75% reduction in protective area for the critically endangered North Atlantic Right Whale and other marine mammals.

5 Conclusions

This paper presents the methodology, analysis, and results of an independent investigation of underwater noise levels from pile driving by the crane ship Orion utilized as a pile driving vessel in the Vineyard Wind BOEM Lease Area OCS-A 0501 southwest of Nantucket Island, Massachusetts. The pile driving operations included double bubble curtains and hydro damper net for noise controls. Nonetheless, the survey results find pile driving impulsive sound levels are similar to seismic airgun arrays and raise concerns about heightened adverse noise impacts on marine mammals.

1. Peak levels measured up to 180 dB re 1uPa at 1.06 km. The calculated source level SL,pk is 241 dB with noise reduction mitigations employed. Despite double bubble curtains and hydro damper, *pile driving peak levels are comparable to seismic airgun arrays*. Propagation loss was 20.1log(r), consistent with spherical spreading.

2. NMFS relies on the RMS sound level for setting protective radii around impulsive pile driving. There are several different RMS computation methods. RMS was analyzed by applying two methods per Madsen 2005, with a 200ms window consistent with the limits of the mammalian hearing window, and a 90pct window using the 5- to 95-percent effective signal duration. The 90-percent RMS consistently *underestimated by 2 to 6 dB* the 200ms RMS for mammalian hearing response recommended in Madsen 2005. This disparity is consistent with the observations in Madsen 2005 and of the waveforms acquired in this survey that show lengthening with distance, increased numbers of reflections and pre-peak impulse arrivals of impulse energy through the sediment. It is concluded that at distances of 1 to 8 kilometers in waters of these depths the 90-percent RMS currently used by NMFS should not be considered a conservative metric for establishing protective radii for mammalian hearing and behavioral response.

3. The calculated sound exposure level weighted for LF Cetacean species is 198.8 dB re 1 $\mu Pa^2 s$. Pile driving sound exposures of 13 minutes at 500 meters, 45 minutes at 1000 meters, or 2 hours at 1800 meters, yields a cSEL exceeding the PTS threshold (onset of permanent hearing loss). A sound exposure of 2 minutes at 1200 meters, 5 minutes at 2200 meters, and 10 minutes at 3200 meters yields a cSEL exceeding the TTS threshold (temporary threshold shift, hearing impaired). It appears PTS exposure is possible for Cetaceans at significant distances.

4. The calculated sound exposure level weighted for PW Phocid species (seals) is 178.3 dB re 1 $\mu Pa^2 s$. Pile driving sound exposures of 1-3/4 hours at 100 meters yields a cSEL exceeding the Level A PTS threshold (onset of permanent hearing loss). A pile driving sound exposure of 40 minutes at 500 meters, or 2 hours at 1 kilometer, yields a cSEL exceeding the TTS threshold (temporary threshold shift, hearing impaired).

5. Propagation loss for Weighted SEL measured 16.5log(r) and 15.5log(r) for LF and PW weightings respectively. These propagation loss constants are consistent with practical spreading. Regulators assuming spherical spreading would underestimate sound exposure levels and resulting impacts including Level B and possibly Level A Harassment.

6. Level A Harassment appears feasible depending on time periods occupied at various distances to the pile driving. Further assessment using unweighted SELs (from cautions in Southall 2019) finds much larger setbacks are needed. It is unclear that the mitigation methods set in place are adequate to protect the NARW and other ESA-listed mammals and marine species.

7. The distance to the unweighted 160 dB,rms isopleth distance for Level B Harassment is 3355 meters, using the RMS,200ms time weighting for mammalian hearing (Madsen 2005). Whereas the IHA Authorization listed a distance of 2739 meters with 12 dB reduction.

8. The IHA Application and Authorization omit noise impact assessment for exposure at each step between SPLs of 120-140, 140-160, and 160-180 dB listed in the BOEM Offshore Wind Energy Project Biological Assessment Method 2 (Wood 2012). Whereas weighted (LF) RMS sound levels compared to the BOEM step table show ninety percent of mysticetes responding (avoidance response) within 1 kilometer, and fifty percent respomding out to 14.5 km.

9. The IHA Application and Authorization did not evaluate continuous vessel propulsion, DP thruster or combined noise levels by vessel operations in the lease area. The IHA documents including the Authorization treat the Orion and support vessels as silent. Ambient sound levels without pile driving were dominated by Orion and support vessel propulsion and thruster noise including cavitation, despite double bubble curtains surrounding the Orion. Orion and support vessel sound levels with pile driving off measured 127 dB RMS re 1uPa at 0.57 NM (1.06 km) and 123 dB RMS at 3.17 NM (5.87 km) from the Orion.

10. NMFS appears to have abandoned evaluation of its Level B behavioral harassment threshold at 120 dB,rms which leaves insufficient protections in place for marine species behavioral harassment. To meet the NMFS 120 dB,rms behavioral harassment threshold for the operation's continuous noise only, the distance required is estimated at over 6 km.

11. The data acquired during the survey and subsequent review of project and regulator documents raise concerns of sufficient NOAA review methods and mitigation distances to protect the critically endangered North Atlantic Right Whale (NARW) and other marine species from behavioral harassment and hearing loss impacts from pile driving.

Limitations

No information was available on hammer blow strike strengths (kJ) or specifics of noise controls used, including hydro sound damper materials and optimizations, bubble curtain air pressures, and bubble sizes produced during the survey. As a result, peak, RMS, SEL, and source level SL estimations from the far field measurements could under-estimate pile driving noise occurring during higher hammer strike strengths or reduced noise reduction performance.

Sound attenuation with distance underwater could differ from the results found during this survey depending on factors including absorption and scattering, winter versus summer sound speed gradients, thermocline strength, sea state, and sea bottom absorption and reflectivity.

Declaration of Conflicting Interests

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this report. INCE Members are required by professional ethics to ensure compliance with regulatory requirements and hold paramount the safety, health and welfare of the public. The author extends the same professional commitments to marine species.

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6 Appendices

Appendix A. Vineyard Wind Bubble Curtain Technology.

Source: https://maritime-executive.com/article/vineyard-wind-tries-bubble-curtain-system-to-cut-pile-driving-noise

Vineyard Wind Tries "Bubble Curtain" System to Cut Pile-Driving Noise

Twin curtains of bubbles surround this pile-driver during turbine foundation installation (Vineyard Wind)

PUBLISHED MAY 15, 2023 10:27 PM BY THE MARITIME EXECUTIVE

Vineyard Wind, the first wind farm to begin construction in U.S. federal waters, is beginning a trial of bubble curtain technology to reduce the subsea noise impact of pile-driving during installation of wind turbine foundations.

With $5 million in funding from Vineyard Wind's own Industry Accelerator Fund, run by the Massachusetts Clean Energy Center, survey contractor ThayerMahan will provide acoustic mitigation services using the Hydrotechnik-Luebeck "Big Bubble Curtain" technology. ThayerMahan will be moving its headquarters for this product line to the Foss Marine Terminal in New Bedford to support the project, and will be hiring and training locally to staff the operation. It will be the first bubble-curtain service in the U.S. offshore wind industry, according to Vineyard Wind.

The bubble curtain system consists of two concentric rings of perforated hoses laid on the bottom around the work area. Before piledriving begins, the hoses are inflated using special-purpose clean air compressors. The perforations leak a continuous stream of bubbles around the work site. The bubbles absorb and reflect sound energy, creating a barrier that reduces noise transmission from activity inside of the curtain. According to one European contractor which uses the technology, it can cut noise outside of the curtain by 90 percent.

Note: A "90 percent" noise reduction is approximately 10 dB. Noise reduction is frequency dependent. Bubble curtain noise reduction performance is better at higher frequencies.

Appendix A. Vineyard Wind Bubble Curtain Technology (continued)

Source: https://www.eenews.net/articles/blowing-bubbles-offshore-winds-new-strategy-to-save-whales/ (portions excerpted)

Blowing bubbles: Offshore wind's new strategy to save whales
By **Heather Richards** | 12/13/2023 01:24 PM EST

...
To create the bubble curtains, steel encased, perforated, rubber hoses are sunk to the seafloor in two concentric rings around a monopile. As sound waves pulse out during pile driving, that sound energy must travel through the two walls of air, greatly reducing their impact.
...
ThayerMahan vessels carry a suite of powerful air compressors to create the bubbles. At Vineyard, a crew of just under 30 – including union deck crews based in New England – ramp up about 30 minutes before pile driving begins. That's how long it takes to create suitable air barriers. Throughout the pile driving, the vessels are also monitoring the sound levels to gauge how much sound is getting thorough the curtain.
...
Pioneered in Germany to protect marine life in the North Sea, bubble curtains are most effective in shielding animals that rely on lower frequencies to communicate, like baleen whales. ... The bubble curtain technology is also somewhat effective for high frequency sound mitigation, helping mammals like porpoises and dolphins.
...
ThayerMahan is partnered with the world leader in bubble curtain technology, the Germany company Hydrotechnik Lübeck, to bring the industry to the U.S.
...
Big bubble curtains are not specifically required in the U.S., but they are an accepted option to meet federal sound control requirements set by the Bureau of Ocean Energy Management.
...
Vineyard said it has experimented with different sound-dampening options and found that a double bubble curtain like ThayerMahan's can be combined with a hydro sound damper – a related sound system that uses nets – to get the strongest result. That approach is being used on its 62 turbines off the coast of Martha's Vineyard.

Appendix A. Vineyard Wind Bubble Curtain Technology (continued)

Source: https://www.hydrotechnik-luebeck.de/portfolio-items/compressed-air-hydro-sound-mitigation/

How the compressed air hydro sound attenuation works

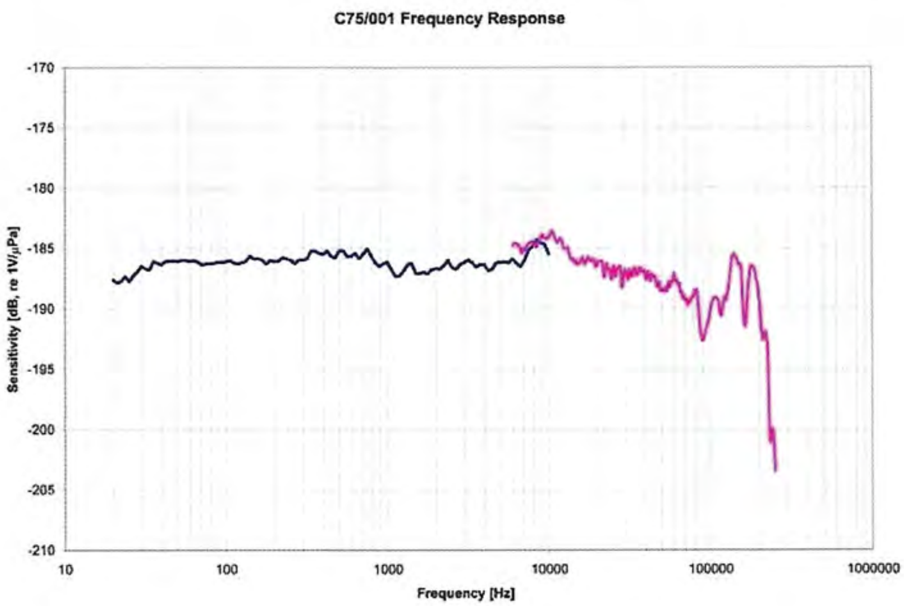
A flexible hose system with special nozzle openings is used. It is laid at a sufficient distance around the location of the sound generation on the seabed. Depending on the nature of the sea bed and the water current, up to two hose rings can be used. A ship equipped with special compressors is connected to the hose system and presses air into the hose system with up to 10 bar while the sound is generated. The compressed air escapes through the nozzles provided. The steadily rising air bubbles create a bubble veil. It changes the physical properties of the water. Sound waves are broken several times, reducing the volume by up to 95%.

The hose system is recovered after each use with the help of specially developed hose winches. The Big Bubble Curtain is independent of other trades and does not leave any traces on the water's bottom.

The maximum sound attenuation that has been achieved so far is 15 dB with one hose ring and 18 dB with two hose rings. The deployment and use of the Big Bubble Curtain depend in different ways on wind strength, wave height, water depth, current, and the environmental conditions of the respective construction site.

Note: A "95 percent" noise reduction is approximately 13 dB. Noise reduction is frequency dependent. Bubble curtain noise reduction performance is better at higher frequencies.

Appendix B Cetacean Research hydrophone frequency response (manufacturer test).



Appendix C. GRAS Model 42AG Acoustic Calibrator calibration certificate.

Calibration Chart

GRAS 42AG Multifunction Sound Calibrator, Class 1

Serial No.	281474
Calibration date	14. Feb. 2023
Operator	ZBA

Environmental calibration conditions

Temperature	23 °C
Relative humidity	44 %
Barometric pressure	1030 hPa

	Nominal Frequency [Hz]	Measured SPL [dB re. 20 uPa]	Measured Frequency [Hz]	Measured THD [%]	Measured THD + Noise [%]	Status
Tolerance		±0.20	±0.30	1.5	2.0	
Uncertainty		±0.08	±0.02	±0.1	±0.1	
94 dB	251.19	94.00	251.20	0.08	1.03	Pass
114 dB	251.19	114.02	251.20	0.13	0.23	Pass
94 dB	1000	94.02	1000.00	0.01	1.47	Pass
114 dB	1000	114.02	1000.00	0.02	0.13	Pass

Calibration

The performed tests refer to the sections 5.2, 5.3 and 5.5 in IEC 60942 (2003): Electroacoustics - Sound Calibrators. The calibrator has been tested ad described in Annex B of the IEC 60942 standard.

Approved by

Quality Manager

14. Feb. 2023

Date

GRAS Sound & Vibration

GRAS Sound & Vibration A/S
Skovlytoften 33, 2840 Holte, Denmark
Email support@gras.dk · gras.dk

Appendix C (continued). BRC hydrophone adapter calibration certificate.

BRC
Engineering

21870 Eighth St. E
Unit # C-4
Sonoma, CA 95476

Tel: 707-226-3332
Fax: 707-236-8964
E-Mail: brcnorcal@aol.com

CALIBRATION CHART for TYPE HADP42AG-C75 S/N: 65506

Hydrophone Adapter for Calibrator Type # 42AG used to

Calibrate CETACEAN Hydrophone Type # C75

Pressure Correction Factor: 0 dB +/- 0.5 dB at reference conditions.

Nominal Frequency: 250 Hz

There is no pressure correction factor for the HADP42AG-C75. The sound pressure level inside the adapter is determined by the pressure level chosen on the G.R.A.S. 42AG, either

1 Pa or 94 dB re 20 microPa or 120 dB re 1 microPa

or

10 Pa or 114 dB re 20 microPa or 140 dB re 1 microPa

Note: 250 Hz preferred for best accuracy

Reference Conditions:

Ambient Temperature: 14.7 C
Ambient Static Pressure: 101.0 kPa
Relative Humidity: 64%

Reference Equipment:

Calibrator Type: G.R.A.S. # 42AG
Microphone Type: LD Type 377B02
Hydrophone Type: C-75

Approved by: Richard Craig

Signature: Rich L. Craig

Date: May 3, 2023

Appendix D. Summary Data

This appendix delineates summary data for each measurement location, accompanied by visual representations of peak values, RMS levels, and spectrograms for hammer blows yielding maximal RMS at each site.

The RMS sound pressure level (defined by ANSI as "rms" pressure) contains no restrictions on the RMS integration time window. Nonetheless, the RMS is inherently *sensitive to the duration of its time window*. The integration time should always be provided with the sound pressure level when it is reported as RMS. In contrast, peak and peak-to-peak sound pressure values are universally preferred over RMS for measuring, characterizing and evaluating impulse sounds.

RMS assessments in this document include the 200-millisecond RMS, which Madsen 2005 recommends as the uppermost fixed interval for evaluating mammalian auditory responses. The 90-percent percentage energy signal duration, delineated as the interval between the 5-percent and 95-percent cumulative energy thresholds in Madsen 2005 and defined in ISO 18405:2017 [41], is also considered. This duration is contingent upon the overall analytical timeframe T, within which these cumulative levels are identified. The T dataframe spans 1 second, a duration established for this analysis to encompass the majority of the impulse at far-field measurements. The RMS window from 5 to 95 percent fluctuates with each impulse and escalates as the distance from the emission point to the measurement site increases, reflecting the influence of acoustic reflections and peak pre-arrivals refracted from the seabed. Consequently, the 90-percent RMS level differs for each peak, typically registering significantly lower than the RMS calculated using the fixed 200-millisecond window that Madsen 2005 advises as the conservative threshold for mammalian auditory analysis.

Figures 41 and 42 present triple plots illustrating data for the most intense hammer strike (centralized) at 0.57 NM (1056 meters or 1.06 km) and at 4.1 NM (7593 meters or 7.59 km), respectively.

In each instance, plot (a) exhibits the sound pressure in Pascals, with each pile driving hammer blow apex demarcated by an encircled highlight. The sound pressures are rendered in blue ink, and red ink illustrates the span wherein the RMS,90pct for the hammer blow is computed—ranging from 5 to 95 percent of cumulative energy as delineated by ISO 18405. The 1-second timeframe selected for the RMS computation is depicted by two dashed red lines flanking each peak.

Plot (b) delineates the continuous RMS level calculated with the 200ms exponential window (in black ink), as stipulated in Madsen 2005 for mammalian auditory response assessments. Additionally, plot (b) depicts the 90 percent RMS, derived from the 5 to 95 percent cumulative sum, as a 'boxcar' (in red ink). The lateral edges of this boxcar correspond to the 5 and 95 percentile points within the cumulative RMS sum, with the upper edges matching the RMS,90pct decibel value.

Plot (c) provides a spectrogram measured in dB re 1 uPa/√Hz, with time on the x-axis and frequency on the y-axis. The sound pressure level is computed via a 4096-point FFT employing

41 Underwater Acoustics – Terminology, ISO 18405:2017, 2017. https://www.iso.org/standard/62406.html

Hanning weighting and 99 percent overlap, standardized to 1 Hz, with color-coded intensity levels indicated in the accompanying colorbar. White dashed lines underscore the peak time location within the plot.

At the 0.57 NM measurement position (1.06 km northeast of the Orion), variations in the temporal signatures and intensities of hammer strikes were relatively subdued. Peaks presented a negative phase pressure characteristic. Energy from hammer blows was observed preceding the peaks and extending beyond them. The majority of this energy was concentrated below 200 Hz, with the peak hammer energy discernible on the spectrogram up to 400 Hz. Both 200-millisecond and 90-percent RMS metrics exceeded the NMFS Level B harassment threshold of 160 dB re 1uPa.

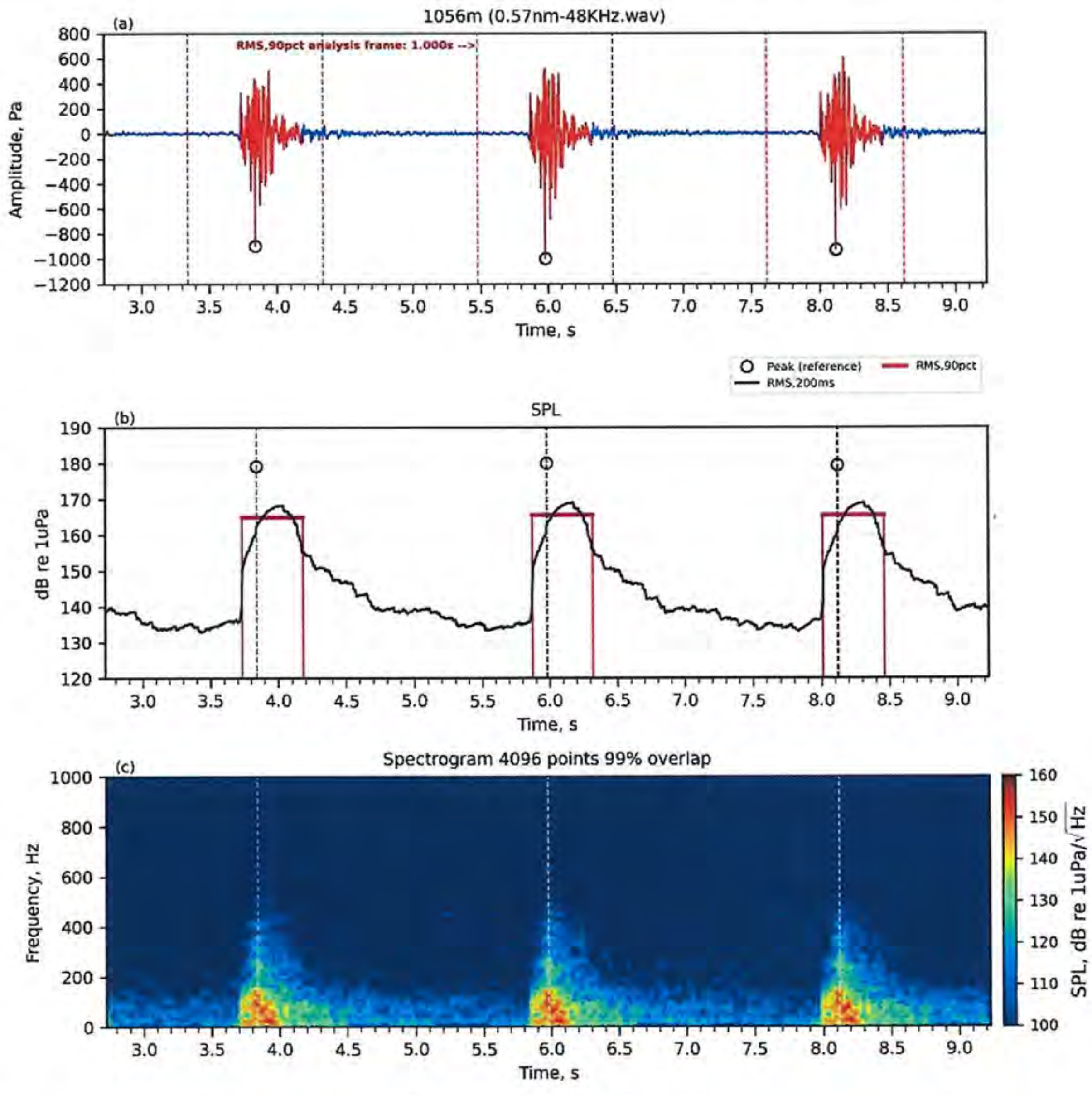


Figure 40. Unweighted sound pressure at 0.57 NM (1056 m), three peaks.

At the 4.1 NM measurement locale (7.59 km northeast of the Orion), hammer blow time signatures and intensities diverged significantly from those at 1.06 km. Hammer blow energy was observed arriving before peaks and lingering afterward. Oscillatory pressures in plot (a) were evident before peak arrival. Peaks displayed both positive and negative phase pressures. Energy from hammer blows primarily spanned below 100 Hz, with energy at the peak detectable on the spectrogram up to 300 Hz. The RMS_90pct's 1-second data frame, indicated by red lines in plot (a), largely contains the trailing energy signature post-peak but does not include pre-peak pressure oscillations appearing 0.5 to 0.9 seconds before the peak. The 200-millisecond and 90-percent RMS levels did not exceed the NMFS Level B harassment threshold of 160 dB re 1uPa.

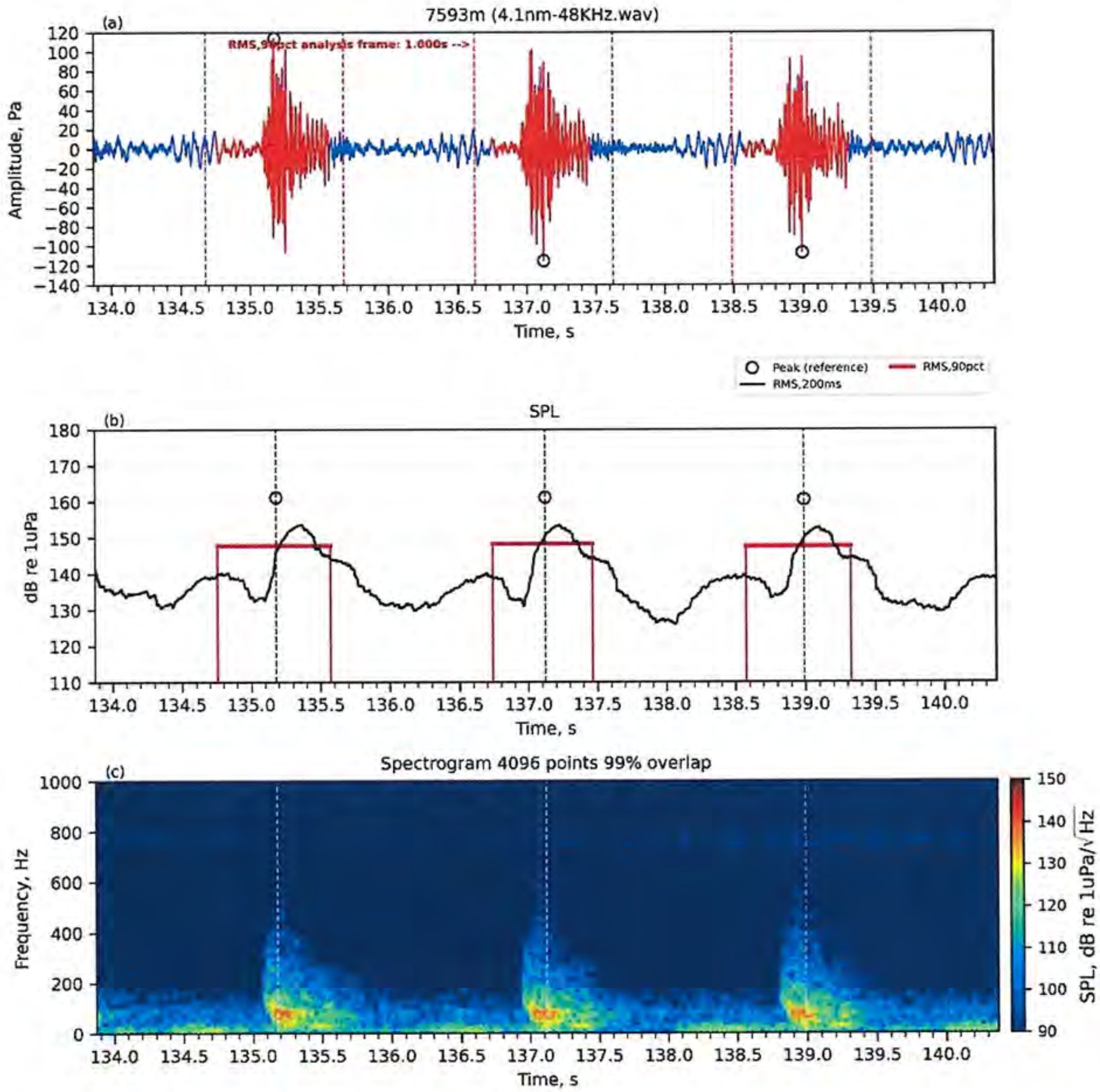


Figure 41. Unweighted sound pressure at 4.1 NM (7593 m), three peaks.

Appendix D (continued). Single Peak Waveform Plots

The nest six pages feature plots of the highest RMS_200 values at each measurement site, with waveforms and data pertinent to pile driving operations. The diagrams detail both the 90-percent duration RMS and the 200-millisecond RMS as per Madsen 2005. Spectrograms at increased distances reveal vessel noise at 390 and 780 Hz, implying acoustic shielding by bubble curtains at nearer distances. The 90-percent RMS consistently records significantly lower than the 200-millisecond RMS, while SEL findings remain consistent within 1 dB across both methodologies.

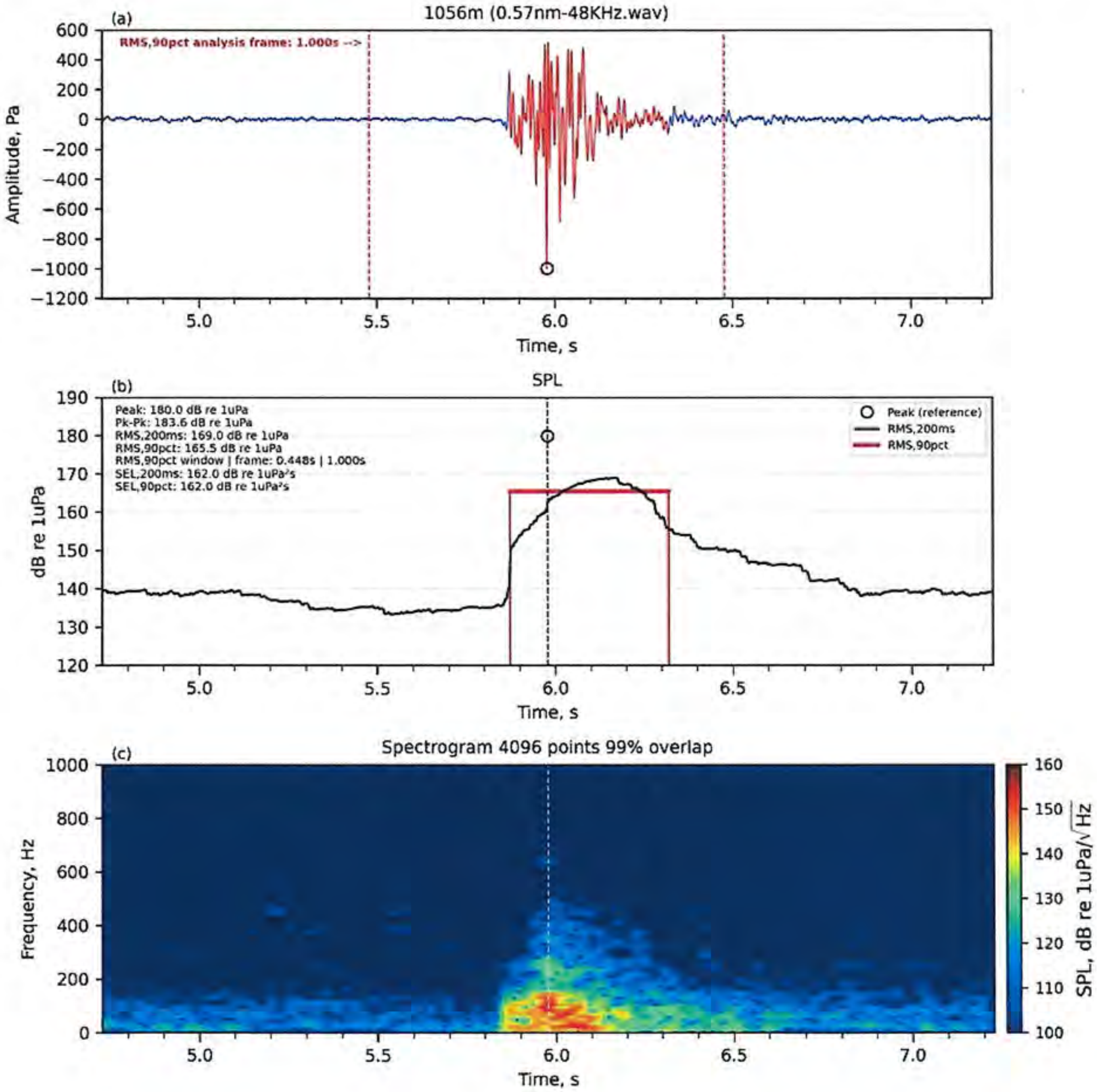


Figure 42. Unweighted sound pressure waveform, RMS levels, and spectrogram at 0.57 NM (1056 m).

Appendix D (continued). Single Peak Waveform Plots

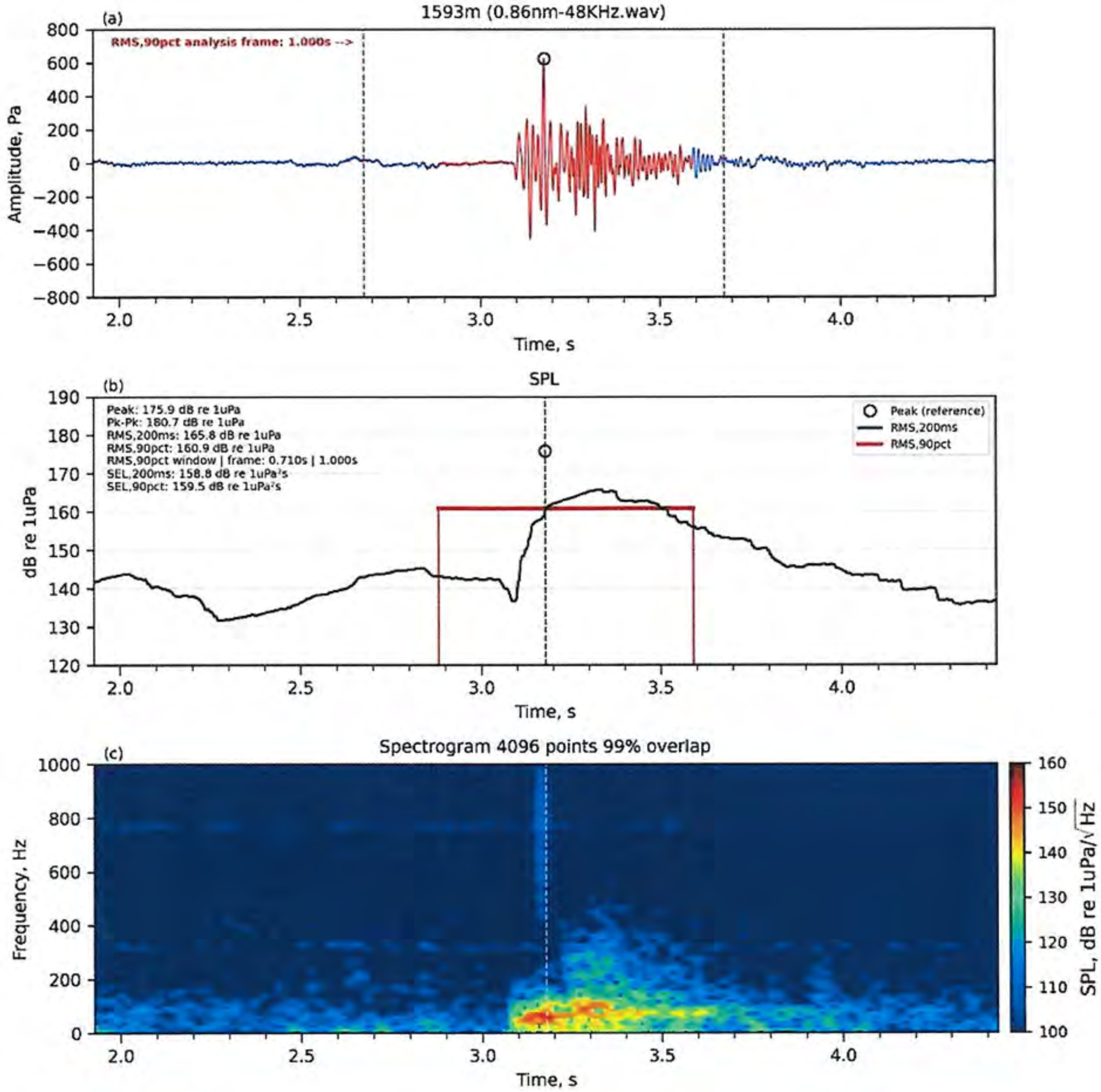


Figure 43. Unweighted sound pressure waveform, RMS levels, and spectrogram at 0.86 NM (1593 m).

Appendix D (continued). Single Peak Waveform Plots

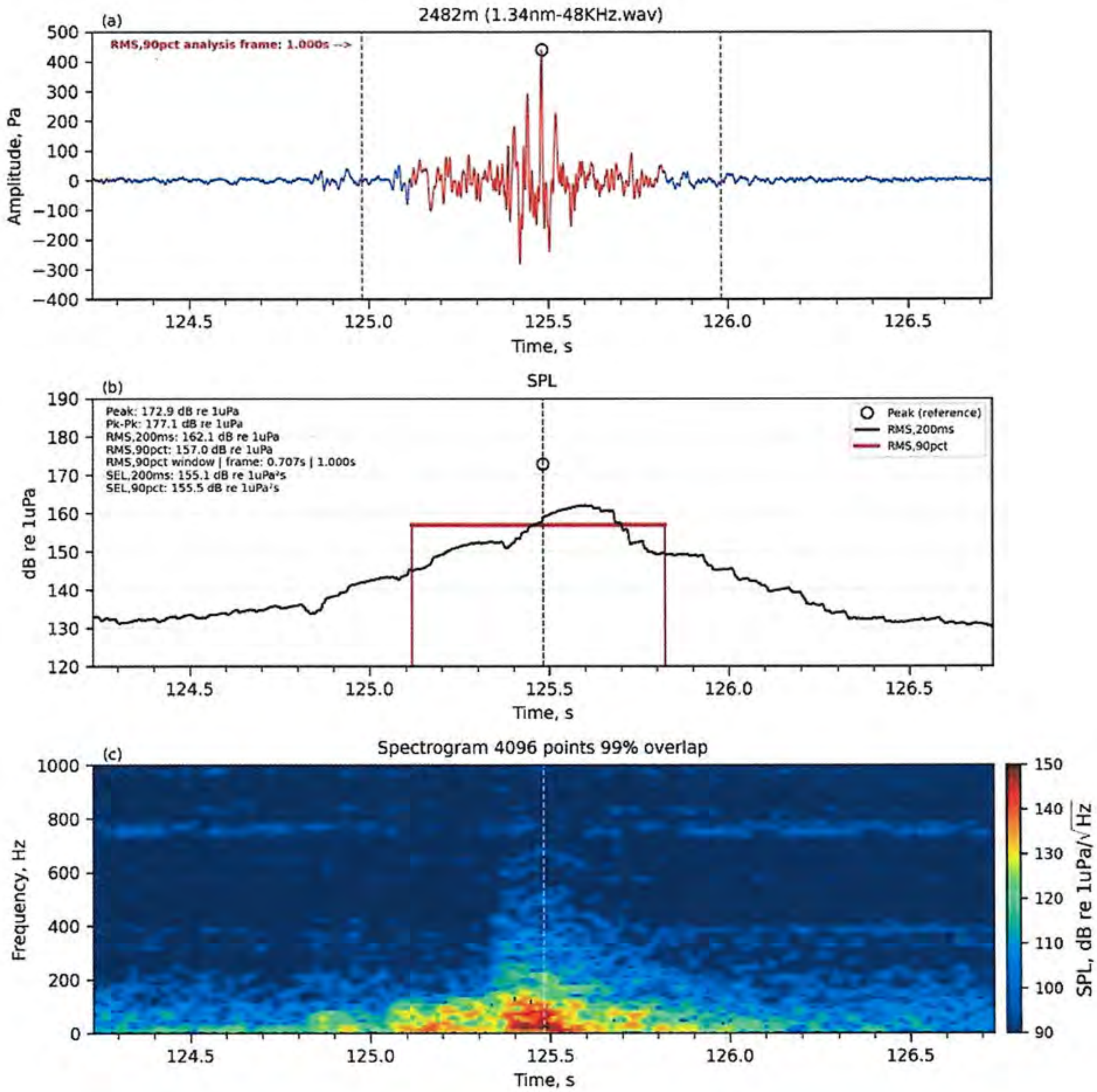


Figure 44. Unweighted sound pressure waveform, RMS levels, and spectrogram at 1.34 NM (2482 m).

Appendix D (continued). Single Peak Waveform Plots

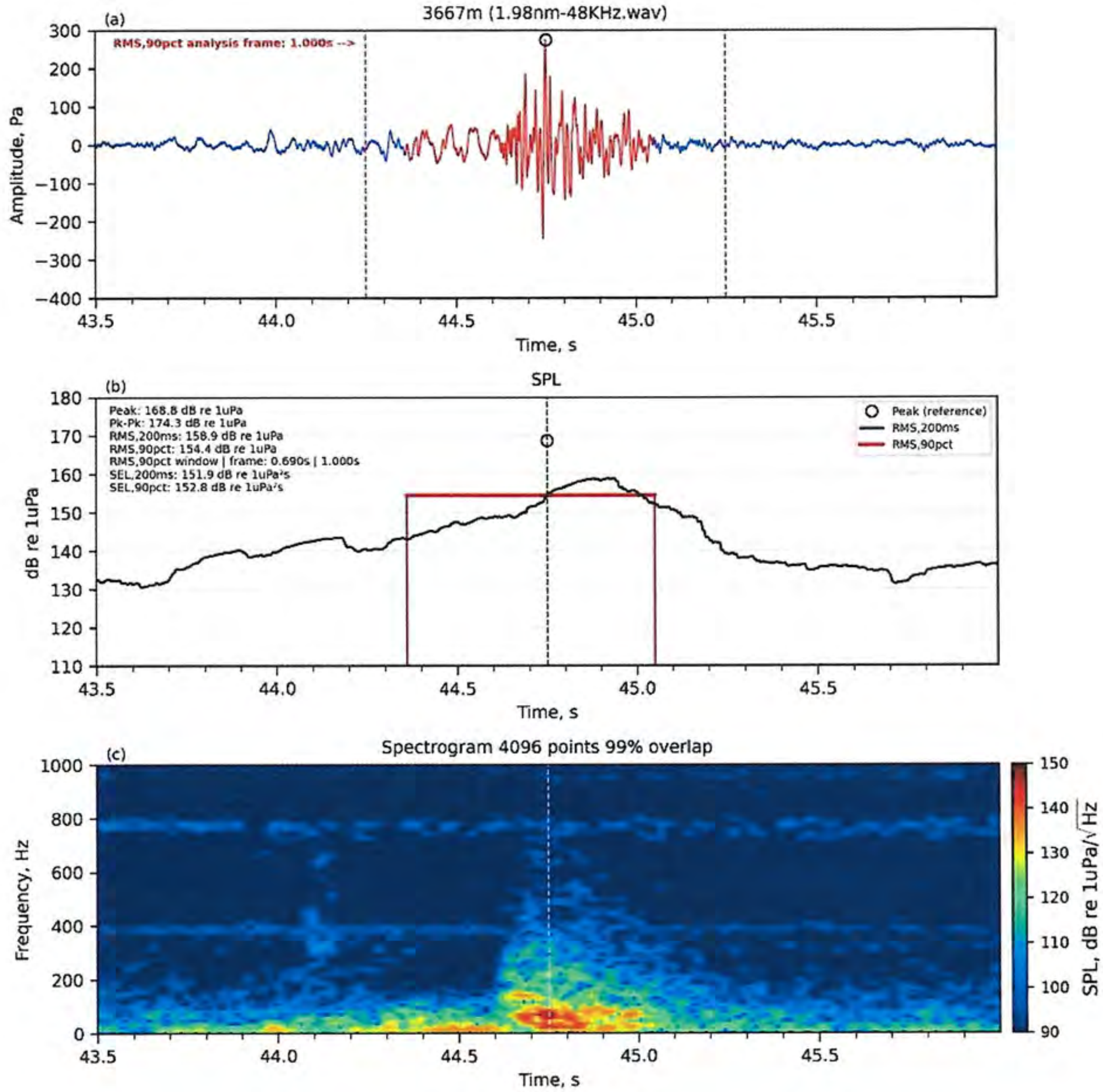


Figure 45. Unweighted sound pressure waveform, RMS levels, and spectrogram at 1.98 NM (3667 m).

Appendix D (continued). Single Peak Waveform Plots

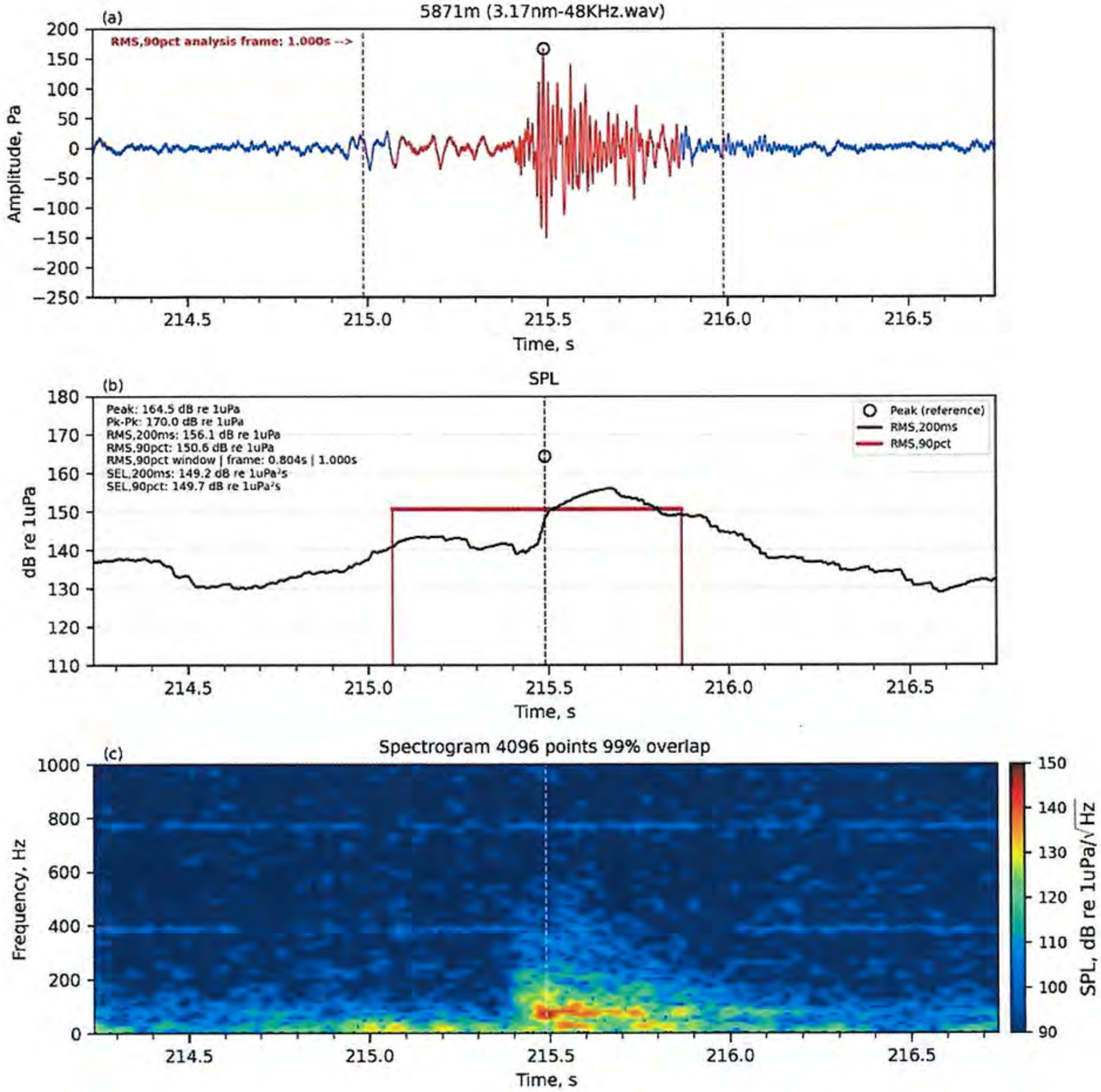


Figure 46. Unweighted sound pressure waveform, RMS levels, and spectrogram at 3.17 NM (5871 m).

Appendix D (continued). Single Peak Waveform Plots

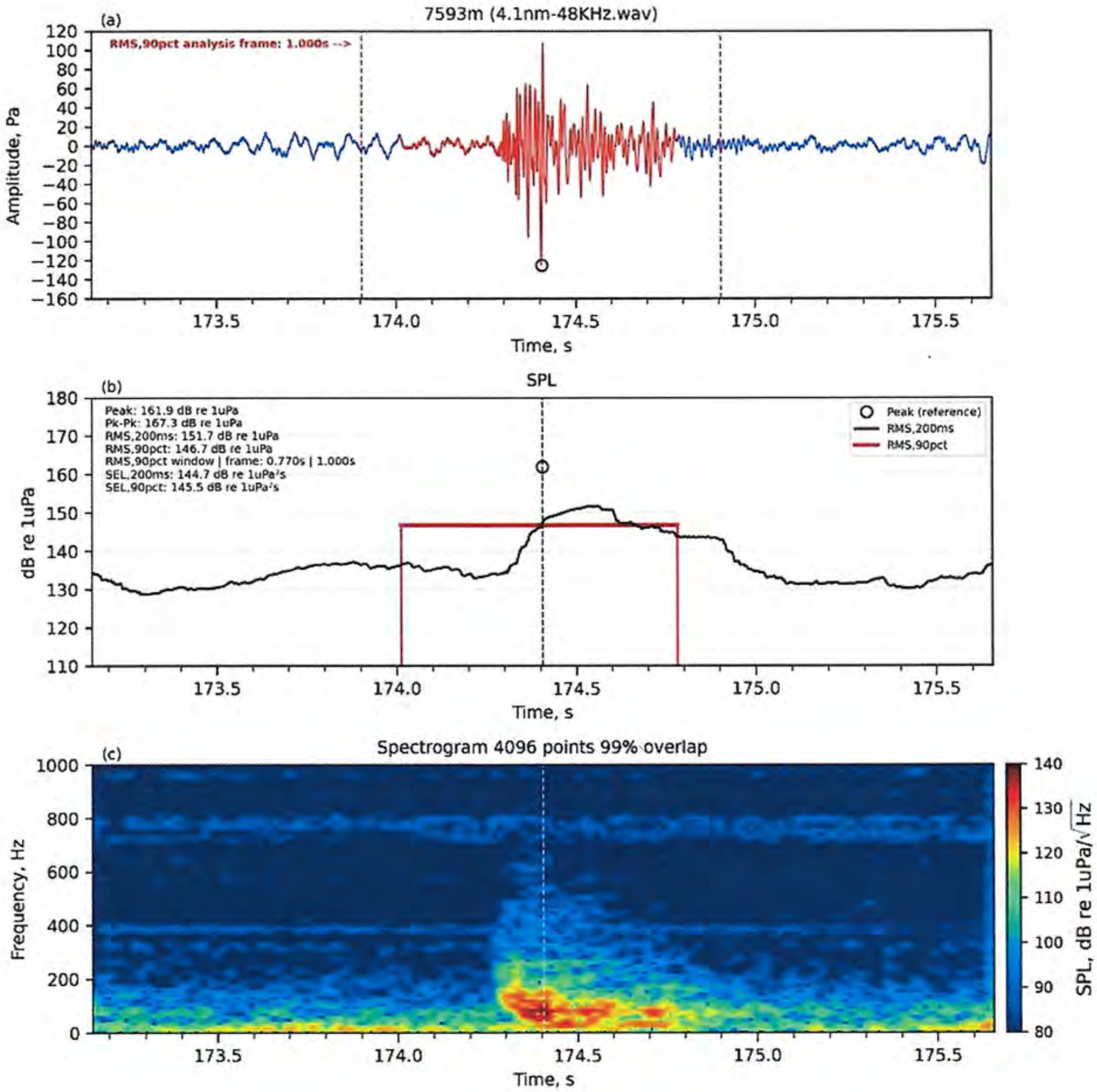


Figure 47. Unweighted sound pressure waveform, RMS levels, and spectrogram at 4.1 NM (7593 m).

Appendix D (continued).

Summary Tables

The subsequent tables encapsulate data procured from the six measurement locales during pile driving, delineated for both unweighted and weighted (LF, PW) datasets. Included metrics are "RMS_200" (200-millisecond RMS per Madsen 2005) and "RMS_90pct" (termed "RL_{90}" in Madsen 2005, and denoted as "effective signal duration" *Teff*, dB in ISO 18405 Section 3.5.1.3). Additionally, data encompass "RMS_125" (ANSI "Fast" 125-millisecond weighting) and "RMS_10dB" (-10dB 90-percent computation, termed "RL_{10dB}" in Madsen 2005, and designated as "threshold exceedance signal duration" *Ty*, dB in ISO 18405 Section 3.5.1.4).

Within these tables, "_CF" appended terms indicate the Crest Factor, defined as the ratio in decibels between peak and RMS levels. Terms suffixed with "_window_secs" refer to the RMS window duration in seconds. The "RMS_125" and "RMS_200" are computed using fixed windows of 125 and 200 milliseconds, respectively.

The "RMS_90pct" (reported as "RMS,90pct") utilizes a 1-second analysis frame, aligning with contemporary industry standards for pile driving noise monitoring [30]. The "RMS_10dB" is analyzed within a 1.5-second frame to encompass the broadest window without intersecting with adjacent peak waveforms, as the average interval between hammer blows was approximately 2 seconds and never less than 1.6 seconds. The "RMS_10dB" is calculated by identifying the furthest pre- and post-peak times at which the level in pascals is at 10 percent of the peak value (denoted as "10dB" level in Madsen 2005). The 90-percent RMS is derived by computing the RMS sum within these two time points.

Both "RMS_10dB" and "RMS_90pct" computations yield variable window lengths for each peak, contingent upon the specific impulse waveform and the acoustic conditions at the time of the peak—factors include reverberation, reflections, and pre-arrivals of early impulse energy.

At a range of 1.06 kilometers, the "RMS_10dB" computations rendered window sizes roughly equivalent to those of the "RMS_90pct". With increasing distance, the "RMS_10dB" windows expanded, occasionally reaching the 1.5-second frame limit beyond 5 kilometers.

A parallel analysis evaluated the "RMS_90pct" ("effective signal duration") within a 1.5-second frame, as used for the "RMS_10dB" ("threshold exceedance signal duration"). The deduced "RMS_90pct" levels were marginally lower (~1 dB) than those computed with a 1-second frame. Notably, the "RMS_90pct" window widths extended significantly with distance when analyzed with a 1.5-second frame, which in turn, drew down the RMS levels and steepened the propagation loss above the spherical spreading rate. These findings affirm the sensitivity of the 90-percent computation to window width selection, a central point of caution in Madsen 2005. This underscores the critical need for meticulous selection of averaging window sizes and thorough review of the resultant data to ensure the validity of acoustic impact assessments on mammalian hearing over extensive distances.

Appendix D (continued).

Table 3. Unweighted sound pressure.

NM	meters	Metric	Count	Maximum	Mean	Median	Minimum
0.57	1056	peak_dB	51	180.0	176.8	177.0	173.2
0.57	1056	peak_to_peak_dB	51	183.7	181.7	181.9	179.0
0.57	1056	RMS_125	51	170.3	169.4	169.4	168.5
0.57	1056	RMS_125_CF	51	9.7	7.4	7.6	4.5
0.57	1056	RMS_200	51	169.0	168.2	168.2	167.4
0.57	1056	RMS_200_CF	51	11.0	8.6	8.8	5.5
0.57	1056	RMS_10dB	51	166.8	164.6	164.7	162.3
0.57	1056	RMS_10dB_CF	51	14.0	12.1	12.2	10.2
0.57	1056	RMS_10dB_window_secs	51	0.741	0.494	0.477	0.315
0.57	1056	RMS_90pct	51	165.6	164.7	164.7	163.9
0.57	1056	RMS_90pct_CF	51	14.5	12.0	12.1	8.7
0.57	1056	RMS_90pct_window_secs	51	0.521	0.470	0.462	0.436
0.57	1056	SEL_125	51	161.3	160.3	160.4	159.5
0.57	1056	SEL_200	51	162.0	161.2	161.2	160.4
0.57	1056	SEL_10dB	51	162.3	161.5	161.5	160.8
0.57	1056	SEL_90pct	51	162.2	161.4	161.5	160.7

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
0.86	1593	peak_dB	160	175.9	171.7	171.7	168.6
0.86	1593	peak_to_peak_dB	160	180.7	177.2	177.0	174.2
0.86	1593	RMS_125	160	166.4	164.0	164.0	162.2
0.86	1593	RMS_125_CF	160	9.6	7.7	7.8	5.9
0.86	1593	RMS_200	160	165.8	163.5	163.4	161.8
0.86	1593	RMS_200_CF	160	10.1	8.3	8.4	6.4
0.86	1593	RMS_10dB	160	162.7	159.8	159.7	157.6
0.86	1593	RMS_10dB_CF	160	16.0	12.0	12.0	9.6
0.86	1593	RMS_10dB_window_secs	160	1.178	0.651	0.655	0.454
0.86	1593	RMS_90pct	160	162.7	160.5	160.5	159.0
0.86	1593	RMS_90pct_CF	160	15.0	11.2	11.3	8.5
0.86	1593	RMS_90pct_window_secs	160	0.710	0.531	0.537	0.443
0.86	1593	SEL_125	160	157.4	155.0	155.0	153.2
0.86	1593	SEL_200	160	158.8	156.5	156.4	154.8
0.86	1593	SEL_10dB	160	159.5	157.9	157.9	156.5
0.86	1593	SEL_90pct	160	159.5	157.8	157.8	156.4

Appendix D (continued).

Table 3. Unweighted sound pressure.

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
1.34	2482	peak_dB	143	172.9	169.1	169.1	166.9
1.34	2482	peak_to_peak_dB	143	177.2	174.6	174.6	172.7
1.34	2482	RMS_125	143	163.4	162.2	162.2	160.1
1.34	2482	RMS_125_CF	143	9.6	7.0	7.0	5.0
1.34	2482	RMS_200	143	162.5	161.3	161.3	159.3
1.34	2482	RMS_200_CF	143	10.8	7.9	8.0	5.9
1.34	2482	RMS_10dB	143	156.9	155.0	155.0	153.4
1.34	2482	RMS_10dB_CF	143	16.2	14.2	14.2	12.1
1.34	2482	RMS_10dB_window_secs	143	1.220	1.032	1.025	0.735
1.34	2482	RMS_90pct	143	157.4	156.3	156.4	154.8
1.34	2482	RMS_90pct_CF	143	15.9	12.8	12.8	10.2
1.34	2482	RMS_90pct_window_secs	143	0.797	0.730	0.726	0.694
1.34	2482	SEL_125	143	154.4	153.2	153.2	151.0
1.34	2482	SEL_200	143	155.5	154.3	154.3	152.4
1.34	2482	SEL_10dB	143	156.1	155.1	155.2	153.6
1.34	2482	SEL_90pct	143	156.0	155.0	155.0	153.4

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
1.98	3667	peak_dB	117	168.8	166.0	165.9	162.6
1.98	3667	peak_to_peak_dB	117	174.3	171.5	171.4	167.4
1.98	3667	peak_pos_pa	117	274.379	189.758	186.886	131.485
1.98	3667	peak_neg_pa	117	-100.974	-187.547	-187.259	-244.707
1.98	3667	RMS_125	117	160.2	158.5	158.4	154.0
1.98	3667	RMS_125_CF	117	9.8	7.5	7.4	6.0
1.98	3667	RMS_200	117	159.2	157.8	157.8	152.9
1.98	3667	RMS_200_CF	117	10.4	8.2	8.1	6.9
1.98	3667	RMS_10dB	117	153.6	151.9	152.0	147.6
1.98	3667	RMS_10dB_CF	117	16.3	14.1	14.0	12.7
1.98	3667	RMS_10dB_window_secs	117	1.363	1.081	1.074	0.694
1.98	3667	RMS_90pct	117	154.7	153.4	153.4	148.8
1.98	3667	RMS_90pct_CF	117	15.0	12.6	12.5	11.1
1.98	3667	RMS_90pct_window_secs	117	0.793	0.742	0.743	0.464
1.98	3667	SEL_125	117	151.2	149.5	149.4	144.9
1.98	3667	SEL_200	117	152.2	150.8	150.9	145.9
1.98	3667	SEL_10dB	117	153.2	152.3	152.3	146.0
1.98	3667	SEL_90pct	117	153.1	152.1	152.1	145.5

Appendix D (continued).

Table 3. Unweighted sound pressure.

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
3.17	5871	peak_dB	146	165.8	163.0	162.9	159.8
3.17	5871	peak_to_peak_dB	146	171.1	168.3	168.3	165.6
3.17	5871	RMS_125	146	157.2	155.4	155.5	153.3
3.17	5871	RMS_125_CF	146	9.9	7.6	7.6	5.7
3.17	5871	RMS_200	146	156.1	154.4	154.5	152.2
3.17	5871	RMS_200_CF	146	10.7	8.6	8.6	6.5
3.17	5871	RMS_10dB	146	149.4	147.6	147.6	145.6
3.17	5871	RMS_10dB_CF	146	17.8	15.4	15.5	13.5
3.17	5871	RMS_10dB_window_secs	146	1.499	1.286	1.288	0.949
3.17	5871	RMS_90pct	146	150.6	149.3	149.3	147.3
3.17	5871	RMS_90pct_CF	146	16.3	13.6	13.8	11.1
3.17	5871	RMS_90pct_window_secs	146	0.854	0.802	0.811	0.629
3.17	5871	SEL_125	146	148.2	146.4	146.5	144.3
3.17	5871	SEL_200	146	149.2	147.4	147.5	145.2
3.17	5871	SEL_10dB	146	149.9	148.7	148.6	146.8
3.17	5871	SEL_90pct	146	149.7	148.4	148.3	146.4

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
4.1	7593	peak_dB	126	161.9	159.7	159.6	156.9
4.1	7593	peak_to_peak_dB	126	167.4	165.1	165.0	162.3
4.1	7593	RMS_125	126	155.0	152.3	152.3	150.0
4.1	7593	RMS_125_CF	126	9.9	7.4	7.3	5.5
4.1	7593	RMS_200	126	154.0	151.3	151.4	149.1
4.1	7593	RMS_200_CF	126	11.1	8.4	8.3	6.3
4.1	7593	RMS_10dB	126	146.3	144.4	144.4	142.3
4.1	7593	RMS_10dB_CF	126	18.2	15.3	15.3	13.3
4.1	7593	RMS_10dB_window_secs	126	1.499	1.352	1.384	1.093
4.1	7593	RMS_90pct	126	148.3	146.2	146.3	144.3
4.1	7593	RMS_90pct_CF	126	16.5	13.5	13.5	11.0
4.1	7593	RMS_90pct_window_secs	126	0.875	0.807	0.815	0.667
4.1	7593	SEL_125	126	146.0	143.2	143.3	140.9
4.1	7593	SEL_200	126	147.0	144.3	144.4	142.1
4.1	7593	SEL_10dB	126	147.5	145.7	145.7	143.8
4.1	7593	SEL_90pct	126	147.2	145.3	145.3	143.3

Appendix D (continued).

Table 4. Weighted sound pressure, LF (Cetacean).

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
0.57	1056	peak_dB	51	172.7	169.1	170.2	165.0
0.57	1056	peak_to_peak_dB	51	177.3	174.0	174.5	170.8
0.57	1056	RMS_125	51	162.0	160.7	160.8	159.3
0.57	1056	RMS_125_CF	51	11.1	8.4	9.3	5.5
0.57	1056	RMS_200	51	160.9	159.5	159.6	158.2
0.57	1056	RMS_200_CF	51	12.2	9.6	10.5	6.5
0.57	1056	RMS_10dB	51	158.2	156.1	156.2	153.3
0.57	1056	RMS_10dB_CF	51	15.2	13.1	13.5	10.3
0.57	1056	RMS_10dB_window_secs	51	0.696	0.453	0.450	0.314
0.57	1056	RMS_90pct	51	157.3	156.0	156.1	154.4
0.57	1056	RMS_90pct_CF	51	15.9	13.2	14.1	10.2
0.57	1056	RMS_90pct_window_secs	51	0.498	0.454	0.451	0.421
0.57	1056	SEL_125	51	153.0	151.6	151.7	150.2
0.57	1056	SEL_200	51	153.9	152.5	152.6	151.2
0.57	1056	SEL_10dB	51	153.8	152.6	152.6	151.3
0.57	1056	SEL_90pct	51	153.7	152.5	152.6	151.3

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
0.86	1593	peak_dB	160	166.6	163.6	163.7	160.3
0.86	1593	peak_to_peak_dB	160	172.0	169.1	169.0	166.0
0.86	1593	RMS_125	160	156.8	155.2	155.1	153.6
0.86	1593	RMS_125_CF	160	10.7	8.4	8.6	6.4
0.86	1593	RMS_200	160	156.6	154.5	154.4	152.6
0.86	1593	RMS_200_CF	160	11.4	9.2	9.4	6.9
0.86	1593	RMS_10dB	160	153.2	150.8	150.8	148.8
0.86	1593	RMS_10dB_CF	160	15.8	12.8	12.9	10.5
0.86	1593	RMS_10dB_window_secs	160	1.234	0.637	0.636	0.453
0.86	1593	RMS_90pct	160	153.6	151.5	151.5	149.6
0.86	1593	RMS_90pct_CF	160	14.5	12.1	12.3	9.2
0.86	1593	RMS_90pct_window_secs	160	0.651	0.531	0.533	0.448
0.86	1593	SEL_125	160	147.8	146.2	146.1	144.6
0.86	1593	SEL_200	160	149.6	147.5	147.4	145.6
0.86	1593	SEL_10dB	160	150.6	148.8	148.8	147.3
0.86	1593	SEL_90pct	160	150.5	148.7	148.7	147.2

Appendix D (continued).

Table 4. Weighted sound pressure, LF (Cetacean).

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
1.34	2482	peak_dB	143	163.5	160.0	160.0	157.5
1.34	2482	peak_to_peak_dB	143	167.9	165.4	165.5	163.2
1.34	2482	RMS_125	143	153.8	152.3	152.3	150.4
1.34	2482	RMS_125_CF	143	10.2	7.7	7.7	5.9
1.34	2482	RMS_200	143	152.9	151.4	151.3	149.7
1.34	2482	RMS_200_CF	143	11.4	8.6	8.7	6.7
1.34	2482	RMS_10dB	143	147.0	145.1	145.1	143.3
1.34	2482	RMS_10dB_CF	143	16.5	14.9	14.9	13.1
1.34	2482	RMS_10dB_window_secs	143	1.308	1.045	1.026	0.730
1.34	2482	RMS_90pct	143	147.9	146.6	146.6	145.2
1.34	2482	RMS_90pct_CF	143	16.4	13.4	13.5	11.0
1.34	2482	RMS_90pct_window_secs	143	0.773	0.719	0.718	0.686
1.34	2482	SEL_125	143	144.8	143.2	143.2	141.4
1.34	2482	SEL_200	143	145.9	144.4	144.4	142.8
1.34	2482	SEL_10dB	143	146.5	145.3	145.3	144.0
1.34	2482	SEL_90pct	143	146.4	145.1	145.2	143.8

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
1.98	3667	peak_dB	117	160.7	157.5	157.7	154.1
1.98	3667	peak_to_peak_dB	117	165.6	162.9	163.0	158.6
1.98	3667	RMS_125	117	151.2	149.4	149.3	145.1
1.98	3667	RMS_125_CF	117	10.6	8.1	8.1	6.4
1.98	3667	RMS_200	117	150.4	148.8	148.8	143.9
1.98	3667	RMS_200_CF	117	11.5	8.8	8.7	6.7
1.98	3667	RMS_10dB	117	144.2	142.5	142.6	137.9
1.98	3667	RMS_10dB_CF	117	17.2	15.0	15.0	13.2
1.98	3667	RMS_10dB_window_secs	117	1.364	1.119	1.107	0.790
1.98	3667	RMS_90pct	117	145.5	144.2	144.2	139.6
1.98	3667	RMS_90pct_CF	117	16.4	13.4	13.3	11.0
1.98	3667	RMS_90pct_window_secs	117	0.770	0.734	0.738	0.466
1.98	3667	SEL_125	117	142.2	140.4	140.3	136.1
1.98	3667	SEL_200	117	143.4	141.8	141.8	136.9
1.98	3667	SEL_10dB	117	143.9	143.0	143.1	136.9
1.98	3667	SEL_90pct	117	143.8	142.8	142.9	136.3

Appendix D (continued).

Table 4. Weighted sound pressure, LF (Cetacean).

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
3.17	5871	peak_dB	146	158.0	154.7	154.7	150.8
3.17	5871	peak_to_peak_dB	146	163.2	160.1	160.0	156.6
3.17	5871	RMS_125	146	148.7	146.6	146.6	144.5
3.17	5871	RMS_125_CF	146	10.7	8.1	8.0	6.0
3.17	5871	RMS_200	146	147.5	145.7	145.7	143.3
3.17	5871	RMS_200_CF	146	11.7	9.0	9.0	6.9
3.17	5871	RMS_10dB	146	141.3	138.7	138.6	136.2
3.17	5871	RMS_10dB_CF	146	18.3	16.0	16.0	13.9
3.17	5871	RMS_10dB_window_secs	146	1.498	1.317	1.349	0.864
3.17	5871	RMS_90pct	146	142.1	140.6	140.5	138.3
3.17	5871	RMS_90pct_CF	146	17.4	14.1	14.1	11.6
3.17	5871	RMS_90pct_window_secs	146	0.840	0.791	0.802	0.615
3.17	5871	SEL_125	146	139.6	137.6	137.6	135.4
3.17	5871	SEL_200	146	140.5	138.7	138.7	136.3
3.17	5871	SEL_10dB	146	141.1	139.8	139.8	137.6
3.17	5871	SEL_90pct	146	140.9	139.6	139.6	137.4

NM	meter	Metric	Pile Count	Maximum	Mean	Median	Minimum
4.1	7593	peak_dB	126	154.0	151.6	151.5	148.6
4.1	7593	peak_to_peak_dB	126	159.8	157.0	156.8	154.3
4.1	7593	RMS_125	126	146.7	143.7	143.7	141.0
4.1	7593	RMS_125_CF	126	10.6	7.9	7.9	6.1
4.1	7593	RMS_200	126	145.6	142.8	142.8	140.4
4.1	7593	RMS_200_CF	126	11.8	8.8	8.8	6.9
4.1	7593	RMS_10dB	126	137.7	135.7	135.7	133.3
4.1	7593	RMS_10dB_CF	126	19.1	15.9	15.9	13.9
4.1	7593	RMS_10dB_window_secs	126	1.497	1.333	1.348	1.043
4.1	7593	RMS_90pct	126	139.9	137.7	137.8	135.4
4.1	7593	RMS_90pct_CF	126	17.1	13.8	14.0	11.6
4.1	7593	RMS_90pct_window_secs	126	0.849	0.779	0.784	0.636
4.1	7593	SEL_125	126	137.6	134.7	134.6	132.0
4.1	7593	SEL_200	126	138.6	135.8	135.8	133.4
4.1	7593	SEL_10dB	126	138.9	136.9	137.0	134.9
4.1	7593	SEL_90pct	126	138.7	136.6	136.7	134.6

Appendix D (continued).

Table 5. Weighted sound pressure, PW (Phocids).

NM	meters	Metric	Pile Count	Maximum	Mean	Median	Minimum
0.57	1056	peak_dB	51	155.8	152.5	153.5	148.2
0.57	1056	peak_to_peak_dB	51	160.8	157.4	157.9	154.1
0.57	1056	RMS_125	51	145.0	143.5	143.5	141.9
0.57	1056	RMS_125_CF	51	11.7	9.0	9.8	6.2
0.57	1056	RMS_200	51	143.8	142.3	142.4	140.8
0.57	1056	RMS_200_CF	51	12.8	10.2	10.9	7.3
0.57	1056	RMS_10dB	51	140.9	138.3	138.9	133.4
0.57	1056	RMS_10dB_CF	51	16.8	14.2	14.5	11.8
0.57	1056	RMS_10dB_window_secs	51	1.248	0.516	0.461	0.313
0.57	1056	RMS_90pct	51	139.6	138.0	138.0	135.9
0.57	1056	RMS_90pct_CF	51	17.5	14.5	15.3	11.3
0.57	1056	RMS_90pct_window_secs	51	0.646	0.540	0.529	0.450
0.57	1056	SEL_125	51	136.0	134.5	134.5	132.9
0.57	1056	SEL_200	51	136.8	135.3	135.4	133.8
0.57	1056	SEL_10dB	51	136.6	135.3	135.3	134.0
0.57	1056	SEL_90pct	51	136.6	135.3	135.4	134.0

NM	meters	Metric	Pile Count	Maximum	Mean	Median	Minimum
0.86	1593	peak_dB	160	149.4	147.0	147.2	144.0
0.86	1593	peak_to_peak_dB	160	155.4	152.5	152.5	149.8
0.86	1593	RMS_125	160	139.5	138.0	137.9	136.5
0.86	1593	RMS_125_CF	160	11.4	9.0	9.1	7.1
0.86	1593	RMS_200	160	139.1	137.2	137.0	135.5
0.86	1593	RMS_200_CF	160	12.2	9.8	10.0	7.7
0.86	1593	RMS_10dB	160	134.6	131.6	131.5	129.0
0.86	1593	RMS_10dB_CF	160	18.8	15.4	15.2	12.6
0.86	1593	RMS_10dB_window_secs	160	1.495	1.045	0.989	0.544
0.86	1593	RMS_90pct	160	135.1	133.4	133.4	132.0
0.86	1593	RMS_90pct_CF	160	16.2	13.6	13.8	11.5
0.86	1593	RMS_90pct_window_secs	160	0.753	0.652	0.660	0.554
0.86	1593	SEL_125	160	130.5	129.0	128.9	127.5
0.86	1593	SEL_200	160	132.2	130.2	130.1	128.5
0.86	1593	SEL_10dB	160	133.3	131.6	131.6	130.1
0.86	1593	SEL_90pct	160	133.2	131.5	131.5	130.0

Appendix D (continued).

Table 5. Weighted sound pressure, PW (Phocids).

NM	meters	Metric	Pile Count	Maximum	Mean	Median	Minimum
1.34	2482	peak_dB	143	146.3	143.1	143.1	140.9
1.34	2482	peak_to_peak_dB	143	150.8	148.6	148.6	146.6
1.34	2482	RMS_125	143	136.3	134.7	134.7	133.0
1.34	2482	RMS_125_CF	143	10.9	8.4	8.4	6.7
1.34	2482	RMS_200	143	135.3	133.9	133.8	132.4
1.34	2482	RMS_200_CF	143	11.8	9.3	9.3	7.5
1.34	2482	RMS_10dB	143	127.7	126.3	126.3	125.1
1.34	2482	RMS_10dB_CF	143	19.0	16.8	16.9	14.8
1.34	2482	RMS_10dB_window_secs	143	1.500	1.472	1.489	1.179
1.34	2482	RMS_90pct	143	130.2	128.9	129.0	127.6
1.34	2482	RMS_90pct_CF	143	17.0	14.2	14.2	12.1
1.34	2482	RMS_90pct_window_secs	143	0.812	0.766	0.765	0.721
1.34	2482	SEL_125	143	127.2	125.7	125.7	124.0
1.34	2482	SEL_200	143	128.4	126.9	126.8	125.4
1.34	2482	SEL_10dB	143	129.1	128.0	128.0	126.9
1.34	2482	SEL_90pct	143	128.9	127.8	127.8	126.6

NM	meters	Metric	Pile Count	Maximum	Mean	Median	Minimum
1.98	3667	peak_dB	117	144.1	141.1	141.1	138.3
1.98	3667	peak_to_peak_dB	117	149.0	146.5	146.5	144.0
1.98	3667	RMS_125	117	134.0	132.1	132.1	128.3
1.98	3667	RMS_125_CF	117	15.3	9.0	8.9	7.3
1.98	3667	RMS_200	117	133.1	131.6	131.6	127.1
1.98	3667	RMS_200_CF	117	16.4	9.5	9.5	7.8
1.98	3667	RMS_10dB	117	125.3	124.4	124.5	122.1
1.98	3667	RMS_10dB_CF	117	21.5	16.7	16.5	14.6
1.98	3667	RMS_10dB_window_secs	117	1.500	1.487	1.498	0.741
1.98	3667	RMS_90pct	117	127.9	126.8	126.8	123.2
1.98	3667	RMS_90pct_CF	117	20.3	14.3	14.2	12.3
1.98	3667	RMS_90pct_window_secs	117	0.821	0.792	0.796	0.446
1.98	3667	SEL_125	117	124.9	123.1	123.1	119.2
1.98	3667	SEL_200	117	126.2	124.6	124.6	120.1
1.98	3667	SEL_10dB	117	127.1	126.2	126.2	120.8
1.98	3667	SEL_90pct	117	126.7	125.8	125.9	119.7

Appendix D (continued).

Table 5. Weighted sound pressure, PW (Phocids).

NM	meters	Metric	Pile Count	Maximum	Mean	Median	Minimum
3.17	5871	peak_dB	146	141.2	138.4	138.2	136.1
3.17	5871	peak_to_peak_dB	146	146.5	143.8	143.7	141.4
3.17	5871	RMS_125	146	131.4	129.5	129.4	127.8
3.17	5871	RMS_125_CF	146	11.6	8.9	8.9	6.9
3.17	5871	RMS_200	146	130.3	128.6	128.5	127.1
3.17	5871	RMS_200_CF	146	12.2	9.8	9.8	7.8
3.17	5871	RMS_10dB	146	123.0	121.6	121.6	120.4
3.17	5871	RMS_10dB_CF	146	19.8	16.8	16.8	14.9
3.17	5871	RMS_10dB_window_secs	146	1.500	1.494	1.499	1.062
3.17	5871	RMS_90pct	146	125.0	123.6	123.6	122.6
3.17	5871	RMS_90pct_CF	146	17.6	14.7	14.8	13.1
3.17	5871	RMS_90pct_window_secs	146	0.862	0.831	0.833	0.655
3.17	5871	SEL_125	146	122.4	120.4	120.4	118.8
3.17	5871	SEL_200	146	123.4	121.6	121.5	120.1
3.17	5871	SEL_10dB	146	124.7	123.3	123.3	122.2
3.17	5871	SEL_90pct	146	124.2	122.8	122.8	121.7

NM	meters	Metric	Pile Count	Maximum	Mean	Median	Minimum
4.1	7593	peak_dB	126	137.3	135.1	135.1	132.2
4.1	7593	peak_to_peak_dB	126	143.1	140.5	140.5	138.0
4.1	7593	RMS_125	126	129.4	126.5	126.4	123.8
4.1	7593	RMS_125_CF	126	11.2	8.6	8.5	6.7
4.1	7593	RMS_200	126	128.3	125.6	125.6	123.2
4.1	7593	RMS_200_CF	126	12.4	9.5	9.4	7.8
4.1	7593	RMS_10dB	126	120.2	118.4	118.4	116.6
4.1	7593	RMS_10dB_CF	126	19.6	16.7	16.8	14.8
4.1	7593	RMS_10dB_window_secs	126	1.500	1.497	1.498	1.476
4.1	7593	RMS_90pct	126	122.6	120.6	120.6	118.5
4.1	7593	RMS_90pct_CF	126	17.5	14.5	14.5	12.6
4.1	7593	RMS_90pct_window_secs	126	0.853	0.816	0.817	0.764
4.1	7593	SEL_125	126	120.3	117.5	117.4	114.8
4.1	7593	SEL_200	126	121.3	118.6	118.6	116.2
4.1	7593	SEL_10dB	126	121.9	120.1	120.2	118.3
4.1	7593	SEL_90pct	126	121.6	119.7	119.7	117.8