Exhibit 9

Letter in Objection to Project by Environmental Defense Center (EDC) dated July 3, 2009

environmental
DEFENSE CENTER

July 3, 2009

RECEIVED
JUL 03 2009
CALIFORNIA
COASTAL COMMISSION
SOUTH CENTRAL COAST DISTRICT

Bonnie Neely, Chair
California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219

Re: **Goleta Beach**

Honorable Chair Neely and Commissioners:

The following comments are submitted by the Environmental Defense Center (EDC) on behalf of the Santa Barbara Chapter of the Surfrider Foundation, regarding the proposed Goleta Beach permeable pile groin project. The Surfrider Foundation is a non-profit environmental organization dedicated to the protection and enjoyment of the world's oceans, waves and beaches for all people, through conservation, activism, research and education. EDC protects and enhances the environment through education, advocacy and legal action. The Goleta Beach permeable pile groin proposal violates the Coastal Act and sets a precedent in favor of environmentally-damaging structural solutions when benign non-structural solutions are available. Approval of the project would also violate the California Environmental Quality Act (CEQA) because the project would cause significant adverse impacts that can be avoided or substantially lessened through adoption of the Park Reconfiguration Alternative.

EDC and Surfrider submit that substantial evidence supports denial of Santa Barbara County's proposed permeable pile groin project.[1] Even as conditioned the groin structure would violate the Coastal Act provisions governing shoreline erosion control structures, protection of environmentally sensitive habitat areas (ESHA) and fill of coastal waters. The Park Reconfiguration Alternative feasibly protects all park acreage, all park facilities, turf, parking and all utilities while avoiding or substantially lessening significant environmental impacts. Coastal Commission staff finds that the Park Reconfiguration Alternative (Alternative) is feasible and would avoid all down-coast impacts, but rejects this Alternative based only on the false notion that the Alternative could result in a loss of 1.3 acres of turf. EDC submitted evidence to Commission staff and personally advised Commission staff that the Alternative can retain the 1.3 acre area

[1] The Commission should be aware that the Santa Barbara County Board of Supervisors has not approved the groin project. Rather, the County stopped its environmental and permit review process once it determined that the project was within the Commission's original permit jurisdiction.

906 Garden Street Santa Barbara, CA 93101 Phone (805) 963-1622 FAX (805) 962-3152
www.edcnet.org

as turf at the County's sole discretion.[2] Accordingly, given that a feasible alternative avoids significant impacts and protects the entire park as described below, the Commission must deny the coastal development permits (CDPs) for the proposed groin project and instead approve the Park Reconfiguration Alternative to protect Goleta Beach County Park and coastal resources in a manner consistent with the Coastal Act, County local coastal program (LCP) and CEQA.

We therefore urge the Commission to take the following action:

1. Deny CDPs for the permeable pile groin and approve CDPs for the Park Reconfiguration Alternative; OR
2. Defer consideration of CDPs for the permeable pile groin until reliably accurate modeling is completed to ascertain the potential for down-coast sand supply impacts and resulting dredge and nourishment impacts.

I. The groin proposal conflicts with the Coastal Act and must be denied.

As discussed herein, the County's proposed groin project will result in significant adverse effects on the environment and conflict with numerous policies set forth in the Coastal Act and County LCP. Due to concerns about the significant environmental harm that would be caused by the County's proposed groin project, and the precedent that would be set if the Commission were to choose a hard structure solution at Goleta Beach, EDC and Surfrider sought expert advice in evaluating the County's proposal and exploring alternatives that would achieve the same objectives.

In general, the proposed groin is inconsistent with Coastal Act and County LCP policies which seek to avoid interruptions in down-coast sand supply and protect sensitive habitats. For a detailed analysis of the groin's inconsistency with the Coastal Act and LCP, see the attached Policy Consistency Analysis.[3] A short summary follows.

Use of Shoreline Protective Devices

The Coastal Act seeks to protect shorelines by ensuring that projects, including shoreline erosion control structures, minimize interference with sand movement and supply. Coastal Act §30235 only allows groins "when required" to protect coastal dependent uses or protect existing structures or beaches. The groin is not "required" to serve any of these purposes because the feasible non-structural Park Reconfiguration Alternative fulfills the project objectives, protects all turf acreage and avoids significant impacts including all down-coast sand supply and erosion impacts. Therefore approval of the groin would violate Coastal Act §30235.

---

[2] Attachment # 12. June 5, 2009 e-mail from Dr. David Revell, Philip Williams and Associates (PWA) to Brian Trautwein, EDC, forwarded to Coastal Commission staff on June 23, 2009; personal conversation with Steve Hudson, Coastal Commission, June 23, 2009.
[3] Attachment #4. EDC Policy Consistency Analysis. June 2009.

Harm to ESHA

In addition, the proposed groin would be incompatible with and would substantially degrade habitat values in ESHA, in violation of Coastal Act §30240. After storms dislodge sand from the groin, the groin will trap a portion of sand moving down-coast, thereby robbing down-coast beaches of sand in an intermittent but ongoing manner. Evidence in the record from reputable biologists identifies the affected beach area as ESHA.[4] The affected beach ESHA is a significant grunion spawning area and includes the Goleta Slough Mouth. Significant shorebird roosts in trees adjacent to the project construction site add to the significance of the ESHA.[5] The bluff down-coast of the project site supports Coastal Bluff Scrub habitat which is also ESHA. These ESHAs would be directly and indirectly impacted by reduced sand supply, reduced beach width, reduced beach wrack, interference with recolonization process, pile-driving noise effects and bluff erosion. The staff report does not address down-coast ESHA potentially impacted by the project.

Moreover, the groin is not "dependent on the resources of the ESHA." (Coastal Act § 30240(a).) Groins are not dependent on grunion spawning beaches or slough mouths. Therefore the groin which is planned within and adjacent to ESHA violates Coastal Act §30240 and must be denied.

Dredge and Fill of Coastal Waters

The Coastal Act only allows dredge and fill of open coastal waters for a narrowly prescribed set of activities. None of these activities applies to the groin project, which involves placement of fill in the form of piles and dredging a 71 acre sea floor area for the purpose of trapping sand at Goleta Beach. The staff report attempts to bend Coastal Act §30233 by suggesting that the "new structural piles" can be considered a pier built "to provide public recreation." But the pier already exists and provides recreation. The addition of the groin, even with decking to masquerade the groin as an expansion of the pier, does not change the facts: (1) the groin is an erosion control structure proposed only to trap sand at Goleta Beach; and (2) the groin does not provide new recreation on a pier. The project therefore violates the Act's prohibitions on dredging and filling open coastal waters.

The staff report alleges that even if the groin would conflict with §30233, that is acceptable because the groin is consistent with §30235, which is more specific to shoreline structures than §30233. However, §30233 is specific to protecting coastal waters from dredge and fill activities. The groin project must comply with both §30233

---

[4] Attachment #9. Dr. Karen Martin, Pepperdine University, Comments on Draft EIR for Goleta Beach Long-Term Protection Plan; Mark Holmgren, Biologist, Comments on Draft EIR for Goleta Beach Long-Term Protection Plan.

[5] Attachment #14. May 30, 2009 e-mail from Mark Holmgren, biologist regarding new roosting and nesting activity of double-crested cormorants, great blue herons, and great egrets at Goleta Slough adjacent to project site.

and §30235.[6] The project violates §30233 as noted above, and thereby must be rejected. In addition, as noted above, the project also violates §30235 because the groin is not required to serve coastal-dependent uses or to protect existing structure or public beaches.

Parking Fees

The staff report does not analyze the County's plans to charge new Goleta Beach parking fees to help fund groin construction and operation.[7] This project is supposed to protect access and recreation, yet ironically the County's internal e-mails and documents demonstrate that the County is plotting to subsequently charge fees to pay for the expensive groin. This proposal will impose new limitations on public beach access, in violation of Coastal Act §30210 and Article X, §4 of the California Constitution.

As the attached Policy Analysis report demonstrates, the proposed groin project violates numerous Coastal Act and LCP policies pertaining to habitats, shoreline structures, coastal waters, access, recreation and views.

II. CEQA requires that the Commission deny the groin project and approve the environmentally preferable Park Reconfiguration Alternative.

CEQA's fundamental goal is to protect the environment and avoid or minimize adverse impacts where feasible. Therefore, CEQA's substantive mandate requires a lead agency to prevent significant avoidable damage to the environment by requiring the use of alternatives or mitigation measures when the agency finds the changes to be feasible. CEQA Guidelines §15002(a)(3). Moreover, as an agency with a certified regulatory program under CEQA, the Commission must "require that an activity will not be approved or adopted as proposed if there are feasible alternatives or feasible mitigation measures that would substantially lessen a significant adverse effect that the activity may have on the environment." Pub. Res. Code §21080.5(d)(2)(A).

As shown herein, the proposed groin project will result in significant adverse effects that can be avoided or substantially lessened by adoption of the Park Reconfiguration Alternative.

A <u>The groin will cause significant damage to the environment.</u>

The groin would result in several significant adverse effects on the environment. Modeling done by the County in support of the groin was based upon

---

[6] A statute should be construed in the context of the entire statutory system of which it is a part in order to achieve harmony among the parts. *Nickelsberg v. Workers' Comp. Appeals Board* (1991) 54 Cal.3d 288, 298 [285 Cal.Rptr. 86].

[7] Attachment #15. See attached internal County emails and documents regarding County plans for beach parking fees to help fund the groin project.

inaccurate assumptions and underestimated down-coast impacts. See section V of this letter for a discussion of flaws in the County's modeling.

As noted in the reports prepared by Philip Williams and Associates, the groin will reduce the width of down-coast beaches.[8] Reduced beach widths result in a series of significant environmental effects to geology, shoreline processes, biological resources and recreation. In addition, when beaches are narrower there is less sand to buffer against bluff erosion. When bluff erosion is exacerbated this impact cannot be undone or mitigated.

Structures which result in narrower beaches "can have significant negative effects by greatly curtailing the width and complexity of the intertidal zone and habitats."[9] Beach ecologist Dr. Dugan notes that, "I think that narrower beaches will provide less intertidal habitat. Thus habitat loss is an issue to be considered for beach animals of all types (invertebrates, fish, birds) with expected impacts to biodiversity, abundance, biomass, and prey availability as well as spawning, foraging and roosting habitat."[10]

In addition, the proposed groin would result in other significant biological effects which are avoided or substantially lessened by the Park Reconfiguration Alternative. These include impacts related to shorebird habitat, to Goleta Slough mouth dynamics and breaching, to repeated rotational dredging of approximately 71 acres of sandy sea floor habitat[11], and potentially to grunion habitat during groin installation, pile tuning, down-coast beach narrowing and frequent removal of wrack from the piles pursuant to proposed special condition 11.A.(5).[12]

Dr. Dugan informed EDC on May 20, 2009 that the groin will not only reduce down-coast sandy beach habitat, but will also restrict movement and recolonization of

---

[8] Attachment #1. Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008; Attachment #2. Philip Williams and Associates "Final Memo on Goleta Beach Modeling Review" April 15, 2009; Attachment #3. Coastal Tech, Inc. "Comments on Goleta Beach Modeling Review" May 11, 2009; Attachment #13. Dr. Edward Keller, UCSB Geologist "Comments on Long-Term Goleta Beach Protection Plan DEIR" May 10, 2007, p.3; Attachment #18. Philip Williams and Associates Memorandum to California Coastal Commission re: "Goleta Beach Permeable Pile Groin Application No. 4-08-006" July 1, 2009.

[9] Attachment #5. Dr. Jennifer Dugan "Comments Opposing Goleta Beach Seawall" November 26, 2003. While these comments were addressed at a revetment proposed for Goleta Beach, the reduction of beach habitat width caused by the revetment is similar to the down-coast beach narrowing effects of the groin in that both cause narrowing of beach habitats. However the revetment would also narrow the beach in part through direct displacement of the upper beach habitat zone. Dr Dugan confirmed verbally to EDC on May 20, 2009 that narrowing of the beach down-coast of the groin will cause "loss of habitat" and "loss of biodiversity."

[10] Attachment #6. Dr. Jennifer Dugan, Beach Ecologist, May 20, 2009 e-mail to Brian Trautwein, EDC regarding the proposed permeable pile groin's effects.

[11] Acreage calculated based on dimensions presented in proposed final EIR Figure 2.3-2.

[12] Attachment #7. Mark Holmgren, Biologist "Comments on Draft EIR for Goleta Beach Long-Term Protection Plan" May 14, 2007; Attachment #8. Jessie Altstatt, Marine Biologist, Comments on Goleta Beach Long-Term Protection Plan Draft EIR, May 14, 2007; Attachment #9. Dr. Karen Martin, Pepperdine University, Comments on Goleta Beach Long-Term Protection Plan Draft EIR, May 14, 2007.

beach organisms down-coast from the groin through beaches including Hope Ranch. According to Dr. Dugan's May 20, 2009 e-mail:

> "What I think may be of immediate concern would be the loss of upcoast sources of colonists and propagules to replenish the narrowing beaches in the lee of a shore-normal structure. Beaches that are dependent on upcoast sources to regenerate after normal seasonal changes and beach erosion/accretion cycles will not recover very quickly, if at all, if the upcoast sources of colonists (and sand) are cut off by a groin of any type. The longshore dominated beach ecosystems of the Santa Barbara coast appear to be very dependent on a connection to upcoast sources of colonists and propagules (as well as sand) e.g. beaches where animals can survive the winter and then repopulate the rest of the coastline via littoral transport. Goleta beach has the potential to be one of these key source areas if managed to maintain the invertebrate populations and habitat quality over the winter months and its up and down-coast littoral connections."

The proposed groin will also result in adverse effects caused by reducing wrack transport. Currently there is a "huge wrack transport past Goleta Beach."[13] This means that there are a lot of organic marine materials – primarily kelp – that move past Goleta Beach and supply nutrients to down-coast beach ecosystems. Dr. Dugan concludes that the transport of this wrack would be blocked by the tight-knit piles, resulting in reduced wrack transport to down-coast beaches and adverse effects on beach species diversity and abundance, biological productivity and water quality. Wrack accumulation will further decrease pile groin permeability on an ongoing basis, further exacerbating down-coast impacts. Proposed special conditions would require removing wrack from the piles – but only when it becomes "excessive." However the impacts of wrack removal have not been considered. Such impacts include direct disturbance to the beach, and possible use of equipment on the beach and in the water. According to Dr. Dugan, it may be prohibitively expensive, infeasible or unsafe to frequently remove wrack from the groin, particularly in the wave zone. Even if wrack is periodically removed from the groin, there will be ongoing intermittent impacts between cleanings. The biological, safety and other impacts of wrack removal, as well feasibility of this measure, have not been analyzed.

Until it can be removed, wrack accumulation in the groin may impair access along the beach. Narrower down-coast beaches caused by the groin would also reduce the

---

[13] Dr. Jennifer Dugan, personal communication to Brian Trautwein, EDC, May 20, 2009. "... a permeable groin will very likely act to catch large quantities of wrack and other drift material on the upcoast side (west of the pier), not only starving the downcoast beaches of wrack subsidies but creating a potentially undesirable conditions for beach users, fishermen, and marine life in the form of a dense tangled matrix of drift algae and material that will probably decompose in place. This decomposition will lower oxygen content of the water and sediments, creating anoxic conditions that will be harmful to marine life. Our research suggests that input rates of marine macrophytes to beaches is very high in the Goleta beach and UCSB campus area. We estimated a deposition rate of >500 kg wet weight per meter of shoreline per year based on late summer estimates in 2002. This is likely quite conservative." See Attachment #6.

amount of beach area for recreation. Therefore the groin would result in adverse impacts to public beach access and recreation.

The groin will also result in adverse visual impacts, as depicted in the County's visual simulations.[14] The groin would impair views to and along the coast, including views through the existing pier pilings to the bluffs and ocean to the east, west and southerly directions. The County's consultant calls this view impact "Not too pretty to be sure."[15] The ongoing, periodic use of heavy equipment for dredging, nourishment and wrack removal will also degrade the aesthetic experience of beach and park users.

The groin's many inconsistencies with County and Coastal Act policies discussed above and in the attached Policy Consistency Analysis constitute significant land use impacts.[16]

Several other impacts, which have not been addressed in the staff report, will result from the project. For example, the County's plans to charge parking fees to pay for the expensive groin project will result in a significant impact to public beach access and recreation. Failure to analyze the recreational effects of imposing parking fees, where none currently exist, violates one of CEQA's basic tenets to consider the whole of the project and improperly results in piece-meal review of the groin project.[17]

Second, the staff report does not analyze the effects of rip currents that may be caused by the groin. As noted by Dr. David Revell, the groin will force the down-coast current of water around the groin, potentially creating a dangerous rip current.[18] This rip current would cause significant adverse effects on the ecosystem and public safety.

Third, the staff report does not analyze greenhouse gas (GHG) emissions. The proposed project will generate GHG emissions during construction, as well as during long-term dredging and beach nourishment operations. These GHG emissions have not been considered.

Finally, the staff report does not analyze the impact caused by the creation of habitat for invasive exotic species.[19] According to Dr. Dugan:

---

[14] Attachment #11. Visual Simulations of Groin Project and Feb. 1, 2008 e-mail from Chris Webb, Moffett and Nichols to Santa Barbara County.

[15] Feb. 1, 2008 e-mail from Chris Webb, Moffett and Nichols to Santa Barbara County. See Attachment #11.

[16] CEQA Guidelines Appendix G, Evaluation of Environmental Impacts, Section IX(b).

[17] CEQA Guidelines §15378 noting "'Project' means the whole of an action…"

[18] Philip Williams and Associates Memorandum to California Coastal Commission re: "Goleta Beach Permeable Pile Groin Application No. 4-08-006" July 1, 2009. See Attachment #18.

[19] Dr. Jennifer Dugan e-mail to Brian Trautwein, EDC. May 20, 2009. See also Attachment #16. Reports provided by Dr. Jenny Dugan regarding invasive non-native species inhabiting groins and coastal structures.

"Lastly, Groins and other artificial structures may harbor a higher proportion of exotic marine organisms, including algae and invertebrates, than natural structures. This could include the exotic kelp, *Undaria*, and other species of concern. This has been studied in the Mediterranean, some reprints are attached. Santa Barbara Harbor and the offshore oil platforms, including platform holly, harbor numerous exotic/invasive marine species already."

B. The proposed mitigation measures are inadequate to avoid or substantially lessen significant adverse effects caused by the groin structure.

The proposed approach to mitigate down-coast impacts is inadequate because these measures allow impacts to down-coast beaches to occur over a year before mitigation is implemented. The planned mitigation measures (i.e. removing piles to allow more sand to pass through the groin, and beach nourishment) are delayed by over one year from initial impact detection due to (1) the time necessary to detect the impact, (2) the 12-month monitoring period to confirm the erosion trend is continuing, (3) the time required to implement the measures, and (4) the time necessary for sand to move onto and replenish down-coast beaches. Therefore the groin's down-coast beach impacts can ultimately only be partially mitigated after-the-fact.

In addition, the proposed mitigation measures, including dredging and nourishment, would cause impacts of their own. For instance, dredging five to fifteen feet deep within the 71-acre dredge area, even in a rotational manner, results in intermittent, ongoing biological, recreational, air quality and water quality impacts.[20] Beach nourishment results in beach closures classified as Class I significant recreational impacts. Nourishment also degrades water quality and damages coastal strand and sandy beach habitat.[21] Ongoing tuning of the groin (i.e. pile installation and/or removal) will result in periodic pier and beach closures identified as a Class I significant impact.[22] Finally, wrack removal causes impacts to the beach habitat as discussed above.

Commission staff proposes conditions that require monitoring of down-coast beaches to detect impacts. Given the natural variability in sand supply, wave energy and resulting beach widths, it has been difficult for staff, our engineers and the County's engineer to establish a threshold for determining when the groin (as opposed to natural variation) has reduced down-coast beach widths. The 15% threshold in special condition 2.A.(4) is too high in that it allows substantial down-coast beach narrowing to occur before mitigation is triggered. It will be very difficult to accurately determine when the threshold has been exceeded as a result of the groin's sand-trapping effects. As a result, as part of this after-the-fact mitigation, staff proposes an additional year of monitoring

---

[20] Attachment #8. Jessie Altstatt, Marine Biologist, Comments on Goleta Beach Long-Term Protection Plan Draft EIR, May 14, 2007; Proposed FEIR p. 4.1-7 Impact BS-AQ-2; and Proposed Special Condition 2, page 13 noting that dredging and nourishment may be ongoing actions to mitigate down-coast impacts.
[21] Proposed FEIR pp. 4.1-52 – 54 re: beach closures; Proposed FEIR pp. 4.1-62 – 64 re: water quality impacts; Proposed FEIR pp. 4.1-15 – 16 re: impacts to coastal strand habitat.
[22] Proposed FEIR pp. 4.1-52 – 54 re pier and beach closures.

(after the down-coast beach narrowing has been detected) before the impact may be attributed to the groin and before mitigation is triggered.

The groin's interference with recolonization of down-coast beaches by upcoast sources of colonists and propagules is not mitigated by proposed special condition 11.A.(5)'s requirement to remove "excessive" wrack from the groin and move it down-coast. "Excessive" is too vague a term to trigger wrack removal, resulting in inadequate and uncertain mitigation.[23]

Moreover, down-coast bluff erosion that is exacerbated by the effect of the groin cannot be undone or mitigated.

C. <u>The Park Reconfiguration Alternative avoids or substantially lessens the significant damage to the environment caused by the groin.</u>

The non-structural Park Reconfiguration Alternative avoids any potential for adverse down-coast impacts.[24] The non-structural solution avoids all impacts caused by pile installation, operation and maintenance. The Alternative also substantially reduces the quantity and environmental impacts of initial pre-project dredging and beach fill from 500,000 cubic yards to 30,000 yards.[25] Additionally the Alternative substantially lessens the need for future dredging and beach nourishment to mitigate down-coast effects.[26] As a result, the Alternative substantially lessens significant impacts related to water quality (turbidity), recreational diving, beach closures, biological resources and air quality[27] caused by 24 hr by 7 day per week dredging of these volumes.

As noted in the County's proposed (but not certified) EIR, groin construction and operation will result in three significant Class I impacts to recreation: closure of the pier and adjacent beach areas during (1) construction, (2) pile-tuning, and (3) beach

---

[23] Pub. Res. Code § 21081.6(b); CEQA Guidelines, §§ 15091(d), 15126.4(a)(2); *Federation of Hillside and Canyon Assns v. City of Los Angeles* (2000) 83 Cal.App.4th 1252, 1261 (agency must ensure that mitigation measures identified in the EIR will actually be implemented); see also *San Joaquin Raptor Rescue Center v. County of Merced* (2007) 149 Cal.App.4th 645; *Napa Citizens for Honest Gov't v. Napa County Bd. Of Supervisor* (2001) 91 Cal.App.4th 342, 360.

[24] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008; Philip Williams and Associates "Final Memo on Goleta Beach Modeling Review" April 15, 2009; Coastal Tech, Inc. "Comments on Goleta Beach Modeling Review" May 11, 2009; Personal Communication with Steve Hudson, Coastal Commission staff, June 22, 2009; CCC Staff Report for Application No. 4-08-006, page 3.

[25] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008, Table 1, page 14.

[26] Attachment #10. Coastal Tech, Inc. Comments on Draft EIR for Goleta Beach Long-Term Protection Project, May 2007.

[27] Santa Barbara County's proposed final EIR Table 4.1.2-2 identifies over 100 tons per year of smog-producing NOx but is nonetheless deficient. The EIR omits (1) emissions from operational dredge and fill activities required as mitigation for down-coast effects, and (2) evaluation of Greenhouse Gas emissions from construction and ongoing dredge and fill activities.

nourishment.[28] Pile-tuning and nourishment are ongoing intermittent mitigation measures which would close the adjacent beach and pier when implemented. The Park Reconfiguration Alternative avoids all pier closures. This Alternative also avoids all beach closures caused by groin construction and tuning. The Alternative reduces 24 hour x 7 day/week dredging and initial beach nourishment by 90 to 95%.[29]

The Alternative will not starve down-coast beaches of sand or wrack, will not narrow and degrade beach or ESHA, will not threaten down-coast bluff erosion, will not interfere with movement of beach organisms or recolonization of down-coast beaches following winter storms, will not result in pile-driving noises, will not result in pier closures for pile installation or subsequent "tuning," will not cause pile-driving noise impacts, and will not create a need for groin maintenance or wrack removal.

The Alternative also avoids the visual impacts of the groin structure, including the impairment of scenic views through the existing pier. The Alternative also avoids the visual effects caused during groin construction, tuning and maintenance and enhances the Park's appearance by upgrading restrooms, parking lots and other facilities.

Table 1 – Impact Comparison

Impacts:	Groin	Park Reconfiguration
Down-coast beach and bluff erosion	Yes	No
Down coast sandy beach habitat	Yes	No
Down-coast recreation	Less beach	No
Dredging water pollution	550k cubic yards+	30k cubic yards
Pre-fill dredging air pollution	>100 tons NOx	~95% less
Visual impact along shore	Yes	No
Pier and adj. beach closures: construction	Yes	No
Pier and adj. beach closures: pile tuning	Yes	No
Involves structure on Beach	Yes	No
Recreation during dredge and prefill	Yes	~95% less
Recreation during ongoing dredge / fill	Yes	Substantially reduced
Pile-driving noise during construction	Yes	No
Recreation during construction	Yes	Yes

D. <u>The Commission may not approve a CDP for the groin project, and instead should approve a CDP for the Park Reconfiguration Alternative.</u>

---

[28] Like the groin, the Park Reconfiguration Alternative would close the affected beach and park areas during removal of the existing revetments. Facility relocation would also result in short-term, temporary closures of portions of the Park.

[29] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008, page 14 noting pre-fill dredging volumes reduced from 550,000 to 30,000 cubic yards.

Under CEQA Guidelines §15002(h), "when an EIR [or a functional equivalent to an EIR] shows that a project would cause substantial adverse changes in the environment, the governmental agency must respond to the information by one or more of the following methods: (1) changing a proposed project; (2) imposing conditions on the approval of the project;... (4) choosing an alternative way of meeting the same need; (5) disapproving the project..."

As noted above, the groin will cause substantial adverse environmental changes that are not adequately mitigated. These adverse changes include down-coast beach and bluff erosion, impacts to down-coast sandy beach habitat, impacts to recreation, water and pollution from dredging operations, and visual impacts along the shore. The conditions proposed by the Commission staff are inadequate to avoid or substantially lessen such impacts. Disapproving the project, by itself, will not address the Commission's and County's desires to develop a long-term plan for dealing with intermittent erosion at Goleta Beach. Therefore, the Commission should approve the Park Reconfiguration Alternative as an alternative way of meeting the same need as the groin project without incurring the adverse effects.[30]

The Park Reconfiguration Alternative meets the same need of the project because it protects the uses and resources of Goleta Beach County Park, takes into account long-term environmental change, and satisfies the specific project objectives set forth by the applicant.[31] The uses and resources of Goleta Beach County Park are protected under the Park Reconfiguration Alternative as the recreation areas, facilities, turf and beach areas remain enhanced and preserved.[32] Additionally, the Park Reconfiguration Alternative accounts for long-term environmental change by lessening the impact of down coast effects while protecting the park from erosion.[33]

The Park Reconfiguration Alternative also fulfills the project's specific objectives by retaining and enhancing recreational opportunities, natural resources, and park access. The Park Reconfiguration Alternative replaces aging facilities, such as utilities and restrooms, provides shore protection for the restaurant, enhances and maintains the lawn, park facilities, beach areas and sandy beach-turf interface, provides the same number of parking spaces as the status quo, and avoids closures of the pier.[34]

The staff report incorrectly alleges that the Park Reconfiguration Alternative will not maintain the park's turf acreage. Specifically, the staff report claims that the Alternative would convert 1.3 acres of upland area to beach, and that the beach area would eventually erode. These allegations are simply untrue, as we had previously notified staff. Initially, the Park Reconfiguration Alternative will *increase* the park's turf

[30] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008, pg. 16-17.
[31] Proposed FEIR page 2-2 sets forth of the project's objectives.
[32] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008.
[33] Id.
[34] Id. at 16

acreage by .2 acres to 4.2 acres.[35] In addition, as PWA has clarified, the 1.3 acres of turf identified by the Commission staff can be maintained and if needed revegetated with lawn by the County.[36] Therefore, the alleged impact caused by the possible loss of 1.3 acres of turf is illusory. Once that unfounded allegation is taken away, it is clear that the Alternative will not result in any new impacts.

In sum, the Park Reconfiguration Alternative meets the same needs as the proposed groin project while avoiding or substantially lessening the groin's significant adverse effects. Therefore, under CEQA, the Commission may not approve the groin project and instead should approve the Park Reconfiguration Alternative.

III. The Park Reconfiguration Alternative will feasibly protect Goleta Beach Park, complies with the Coastal Act, and should be approved.

A. <u>The Park Reconfiguration Alternative will protect Goleta Beach Park.</u>

EDC and Surfrider hired PWA because of their experience with coastal sand movement, coastal erosion and the Goleta Beach issue. Dr. David Revell completed his Ph.D. work on sand movement along the coast and is considered the leading expert on sand movement along Santa Barbara County's coastline. Moreover, EDC and Surfrider hired PWA because PWA worked for the County developing the Managed Retreat Alternative for the County's EIR and thus has substantial experience with Goleta Beach management issues. Our goal in retaining PWA was to develop a proposal that would avoid the impacts caused by the groin while protecting the entire park and all its facilities.

The Park Reconfiguration Alternative provides a long-term solution at Goleta Beach by relocating restrooms, parking, utility lines and picnic areas north within the Park to avoid future erosion threats. The Alternative maintains all acreage of the County Park including turf acreage, and increases the area available for recreation from 7 to 10 acres.[37] The lawn is increased from 4 acres to 4.2 acres and includes a buffer area that may revert to sandy beach or be retained as turf at the County's discretion.[38] The plan retains 594 parking spaces based on an engineering analysis performed by Philip Williams and Associates as confirmed in your staff report. The restaurant and existing revetments on the east end of the Park are retained.

---

[35] Id. at 14

[36] Attachment #12. June 5, 2009 e-mail from Dr. David Revell, Philip Williams and Associates to Brian Trautwein, EDC. Attachment #18. Philip Williams and Associates Memorandum to California Coastal Commission re: "Goleta Beach Permeable Pile Groin Application No. 4-08-006" July 1, 2009.

[37] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008, Table 1, page 14.

[38] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008, page 9 stating "over time this increase may be reduced to existing levels." June 5, 2009 e-mail from Dr. David Revell, PWA to Brian Trautwein, EDC noting that turf can be retained in the buffer at the County's discretion; Philip Williams and Associates Memorandum to California Coastal Commission re: "Goleta Beach Permeable Pile Groin Application No. 4-08-006" July 1, 2009.

Unlike the modeling performed to support the groin project, the Park Reconfiguration Alternative engineering analysis and design recognize that beach widths oscillate naturally over the course of decades governed by the Pacific Decadal Oscillation.[39] As a result, considering new predictions for sea level rise[40], Goleta Beach County Park would be fully protected by the Alternative during the County's chosen 20-year project life and beyond.

B. <u>The Park Reconfiguration Alternative complies with the Coastal Act.</u>

The Park Reconfiguration Alternative complies with the Coastal Act's preference for soft solutions and protects ESHA, recreation, water quality, views, and beaches. Specifically, the alternative does not involve any construction on the beach and therefore poses absolutely no chance for down-coast impacts to beaches, habitat and recreation. Construction impacts such as water, air and noise pollution from dredging, beach fill and pile groin installation and tuning are substantially lessened or avoided. Unlike the groin which damages views, views are enhanced by the alternative's facility upgrade and doubling of the park's attractive turf-sandy beach interface to 1900 linear feet. The alternative protects access and recreation by minimizing beach closures and avoiding pier closures.

C. <u>Rebuttal of County Criticisms of the Park Reconfiguration Alternative.</u>

Santa Barbara County Parks Department staff refused several requests to meet with EDC and Surfrider to discuss the Park Reconfiguration Alternative. Nevertheless, three concerns were relayed to EDC regarding the Alternative. These concerns are addressed below.

1. <u>Criticism: It will be difficult getting the utility companies (gas, water etc.) to go along with and help pay for relocating utility lines. Relocating lines will encroach into Goleta Slough's buffer.</u>

<u>Responses:</u>

A. The utility lines will have to be moved at some point in the future to protect them from sea level rise and to protect the ocean. It is better to move them sooner while costs are lower rather than later when chances of emergencies and spills rise.
B. The County - not the utility companies - owns the Park. The County can embrace or reject timely utility relocation regardless of the wishes of the utility companies.
C. Even with the cost of utility relocation, the Park Reconfiguration Alternative will cost less than the proposed groin project. Philip Williams and Associates' engineers put the 20-year cost of the Park Reconfiguration Alternative (including

[39] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008.
[40] Philip Williams and Associates and Pacific Institute 2009.

utility relocation) at $8.4M. This is $1.2M less than the 20-year cost of the County's proposed $9.6M groin project.[41]

D. If the County, utility companies, EDC and Surfrider cooperate on utility relocation, we can apply for grants to help fund this element of the Park Reconfiguration Alternative. In fact, the County has already secured some funding for the project. The County acknowledges these funds could be used for whatever alternative the Commission approves.

E. The County has not approved any particular project or alternative. If the Commission approves the environmentally superior Park Reconfiguration Alternative, based on our conversations with County Board members, we believe the County Board of Supervisors will embrace the Park Reconfiguration Alternative.

F. Relocating utility lines, parking and facilities pursuant to the Park Reconfiguration Alternative would not impinge on the Goleta Slough or buffer, and the degraded buffers would be restored.

2. Criticism: Parking under the Park Reconfiguration Alternative is inadequate.

2.a. The County does not plan to remove the ranger houses so there is insufficient room to replace all parking spaces within the Park.

Response:
The County's proposed Final EIR for this project submitted to the Coastal Commission as part of the CDP application packet states that the ranger houses are already planned to be phased out: "It should be noted that there is already a County initiative to phase out onsite Park rangers, but implementation of the Managed Retreat alternative could force this to happen sooner."[42] The FEIR finds replacement of the ranger houses with parking to be feasible and does not identify any impacts or concerns associated with this action.[43] Therefore, this area is available for parking.

2.b. Philip Williams and Associates used an 8-foot width to calculate parking spaces, overstating the parking that can be provided under the Park Reconfiguration Alternative.

Response:

---

[41] Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008, Table 1, page 14. These costs exclude $10.5M expected to be necessary for long term mitigation of the groin's down-coast impacts, and which are unnecessary for the Park Reconfiguration Alternative. We dispute the utility companies' higher utility line cost estimates. Regardless of cost estimates used, costs do not render utility line relocation or the Park Reconfiguration Alternative economically infeasible.

[42] Goleta Beach Long-Term Protection Plan Proposed FEIR page 2-15; Proposed FEIR Appendix A Responses to Comments page 61; See also Proposed Final EIR page 2-12 describing the Managed Retreat Project: "Creation of a new parking area in the location of the existing Park ranger buildings."

[43] Proposed Final EIR pages 2-12 and 2-15.

Commission staff concurs that the Park Reconfiguration Alternative maintains all 594 parking spaces.[44]

Philip Williams and Associates' Park Reconfiguration Alternative uses the same parking plan as the County's Managed Retreat Alternative in the County's Proposed Final EIR. The County's EIR finds that all parking places can be retained onsite using this parking plan.

The County Parking Regulations allow 30% of the parking spaces to be 8' wide for compact cars. Other spaces must be 9 feet wide. Currently parking spaces in the park are 9.5 feet wide. Reconfiguring the parking lot and restriping the spaces to meet County Parking Regulations allows the Park Reconfiguration Alternative to maintain all 594 parking spaces within the Park as determined by our consulting engineers.

2.c. The Park Reconfiguration Alternative relies on the maintenance storage area for future parking, but this maintenance area must be retained.

Response:
The maintenance area can support approximately 20 - 25 parking spaces. If the maintenance storage area cannot be used for parking, these 20 – 25 spaces can be accommodated onsite through restriping, parking lot reconfiguration and utilization of existing landscaped areas within parking lots.[45]

3. Criticism: The Alternative will result in seawater intrusion in Goleta.

Response:
Philip Williams and Associates stated the alternative would not increase seawater intrusion.[46] The park and landform on which the park sits would remain as a barrier to seawater intrusion under the Park Reconfiguration Alternative. The slough mouth would not be altered to allow more seawater into the slough. Therefore the Park Reconfiguration Alternative will not increase seawater intrusion. Reduction in down-coast sand supplies induced by the groin, however, may cause the slough mouth to open more frequently or for longer periods.

IV. Modeling done to support the groin was based on flawed assumptions and is inaccurate and unreliable.

[44] CCC Staff Report, p. 48 noting that EDC and the County agree that versions of Managed Retreat can maintain all 594 parking spaces.
[45] Off-site options also exist but need not be considered, e.g. along Sandspit Road, at UCSB, or by using shuttles from the airport or old drive-in theatre.
[46] Dr. David Revell, Philip Williams and Associates, Personal Communication with Brian Trautwein, EDC, July 1, 2009.

The County's hope that the groin may not cause significant down-coast impacts relies on a model which used flawed assumptions and is not reliable.[47] All County and Commission staff findings regarding groin effectiveness and down-coast effects are based on this flawed modeling.

First, the model input only 4 years of wave energy and sand supply data (during a period of erosion: 2002 - 2006) and therefore did not model recently documented and historically recurring periods of sand accretion tied to the Pacific Decadal Oscillation. Dr. Revell of Philip Williams and Associates identified natural fluctuations in the width of Goleta Beach going back as far as records exist. These fluctuations are driven by the 30-year Pacific Decadal Oscillation cycle which effects alternating periods of El Nino and La Nina dominance. Within the last 4 years a large volume of sand arrived at Goleta Beach, naturally rebuilding the beach width and halting erosion of the park since January 2005.[48] The County's modeling ignored this new information and incorrectly assumed Goleta Beach is continuing to erode.[49]

This flawed assumption resulted in the model favoring a structural solution over the Park Reconfiguration Alternative, which relies on fluctuating periods sand supply found in nature. By running the model with this improperly limited set of 4 years of sand supply and wave energy conditions, the County was able to conclude that only the groin can fulfill the project objectives. However, Philip Williams and Associates and Coastal Tech demonstrate that the modeling is unreliable and that the Park Reconfiguration Alternative is technically feasible and effective at protecting every inch of the park.

PWA's findings regarding the implications of the flawed modeling are summarized below:

1. The feasibility of attaining the desired beach response with the permeable groin is unproven and dubious.

2. The future shoreline evolution predictions are likely erroneous, and misleading.

3. The Beach Stabilization Project is not likely to perform as presented in the MNE and EC reports. The Beach Stabilization Project may induce erosion downcoast; will likely require massive additional sand placement to protect the lawn and other park amenities, and will require extensive resources to adaptively manage the park with structural modifications of unknown effect.

---

[47] Philip Williams and Associates "Final Memo on Goleta Beach Modeling Review" April 15, 2009; Coastal Tech, Inc. "Comments on Goleta Beach Modeling Review" May 11, 2009; Philip Williams and Associates Memorandum to California Coastal Commission, July 1, 2009.

[48] Attachment #17: Philip Williams and Associates; June 29, 2009 e-mail from Dr. David Revell to Brian Trautwein, EDC.

[49] Philip Williams and Associates "Final Memo on Goleta Beach Modeling Review" April 15, 2009; Coastal Tech, Inc. "Comments on Goleta Beach Modeling Review" May 11, 2009.

4. The County's assertion that the project should be permitted on the basis of this technical modeling is not, in our professional opinion, valid: the Permeable Groin is experimental, and the Beach Stabilization Project description is erroneous in terms of effects and effectiveness.

Finally, County modeling done to support the groin pre-dated and failed to consider recent sea level rise projections.[50]

There is ample evidence that modeling done to support the groin project was based on flawed assumptions that resulted in unreliable conclusions. Therefore, the Commission should deny CDPs for the project outright, or at a minimum the Commission should require independent computer and physical modeling utilizing accurate, up-to-date inputs prior to considering issuing CDPs. Specifically, the Commission should first require new modeling which accounts for varying wave energy and sand supply conditions representative of the full spectrum of expected conditions including El Ninos and which accounts for new information regarding sea level rise rates. This modeling is necessary to evaluate down-coast impacts and groin effectiveness.

Conclusion

The proposed groin would set an unnecessary precedent for approving beach structures when non-structural solutions have been proven feasible and effective. The groin violates the Coastal Act protections for ESHA, shorelines and open coastal waters. Contrary to the conclusion in the staff report, there *is* a feasible alternative available, beyond the measures proposed in the staff report, which would avoid or substantially lessen the significant adverse impacts that the project may have on the environment. The feasible non-structural Park Reconfiguration Alternative is based on sound up-to-date science and engineering. This cost-effective Alternative would avoid or substantially lessen significant biological and sand supply impacts and reduce other environmental impacts of the groin such as water turbidity, pier and beach closures, scenic view impairments, air pollution and greenhouse gas emissions.

Modeling performed by the County to justify the groin was based on flawed assumptions identified by Philip Williams and Associates and Coastal Tech. These improper assumptions resulted in inaccurate modeling results favoring the groin and disfavoring the Park Reconfiguration Alternative. The Alternative is a viable option for protecting all of Goleta Beach Park, all turf, all parking, all facilities and all utilities, but unlike the groin the Alternative protects the beach and important coastal resources. Therefore the Commission must deny the groin and instead approve the effective and environmentally superior Park Reconfiguration Alternative.

---

[50] Dave Ward of Santa Barbara County. Personal communication to Brian Trautwein, EDC, and Everett Lipman and Scott Bull, Surfrider. May 21, 2009. County modeling relied on sea level rise projections in July 2008 but predated and does not account for current projections (Pacific Institute and Philip Williams and Associates 2009) which nearly triple earlier projections.

Sincerely,

Linda Krop,
Chief Counsel

Brian Trautwein
Environmental Analyst

Attachments:

- Attachment #1. Philip Williams and Associates "Goleta Beach County Park - Park Reconfiguration Alternative" November 24, 2008.
- Attachment #2. Philip Williams and Associates "Final Memo on Goleta Beach Modeling Review" April 15, 2009.
- Attachment #3. Coastal Tech, Inc. "Comments on Goleta Beach Modeling Review" May 11, 2009.
- Attachment #4. EDC Policy Consistency Analysis, June 2009.
- Attachment #5. Dr. Jennifer Dugan, Beach Ecologist, comments on Draft EIR for Goleta Beach Long-Term Protection Plan.
- Attachment #6. Dr. Jennifer Dugan email to Brian Trautwein, EDC, May 20, 2009.
- Attachment #7. Mark Holmgren, Biologist, Comments on Draft EIR for Goleta Beach Long-Term Protection Plan.
- Attachment #8. Jessie Altstatt, Marine Biologist, May 14, 2007 Comments on Draft EIR for Goleta Beach Long-Term Protection Plan.
- Attachment #9. Dr. Karen Martin, Pepperdine University, Comments on Goleta Beach Long-Term Protection Plan Draft EIR, May 14, 2007.
- Attachment #10. Coastal Tech, Inc. Comments on Draft EIR for Goleta Beach Long-Term Protection Project, May 2007.
- Attachment #11. Visual Simulations of Groin Project and February 1, 2008 e-mail from Chris Webb, Moffett and Nichols to Dave Ward, Santa Barbara County.
- Attachment #12. June 5, 2009 e-mail from Dr. David Revell, Philip Williams and Associates (PWA) to Brian Trautwein, EDC, forwarded to Coastal Commission staff on June 23, 2009; personal conversation with Steve Hudson, Coastal Commission .June 23, 2009.

- Attachment #13. Dr. Edward Keller, UCSB Geologist "Comments on Long-Term Goleta Beach Protection Plan DEIR" May 10, 2007.
- Attachment #14. May 30, 2009 e-mails from Mark Holmgren, Biologist re: double-crested cormorants roosting and nesting at Goleta Slough adjacent to Goleta Slough.
- Attachment #15. County documents regarding County consideration of parking fees to pay for groin project construction and operation.
- Attachment #16: Reports regarding exotic marine species.
- Attachment #17: Philip Williams and Associates; June 29, 2009 e-mail from Dr. David Revell to Brian Trautwein, EDC.
- Attachment #18. Philip Williams and Associates Memorandum to California Coastal Commission re: "Goleta Beach Permeable Pile Groin Application No. 4-08-006" July 1, 2009.

Attachment #1

Goleta Beach County Park
Park Reconfiguration Alternative

Prepared for
The Coastal Fund at UCSB
Surfrider Foundation – Santa Barbara Chapter
Environmental Defense Center

Prepared by

Philip Williams & Associates, Ltd.

November 24, 2008

PWA REF. #1940.00

Services provided pursuant to this Agreement are intended solely for the use and benefit of the Surfrider Foundation and Environmental Defense Center.

No other person or entity shall be entitled to rely on the services, opinions, recommendations, plans or specifications provided pursuant to this agreement without the express written consent of Philip Williams & Associates, Ltd., 500 Kearny St, Suite 900, San Francisco, CA 94108

For planning purposes we have provided estimates of construction costs to allow cost comparison of alternatives. These cost estimates are intended to provide an approximation of total project costs appropriate for the preliminary level of design. These cost estimates are considered to be approximately -15% to +30% accurate, and include a 25% contingency to account for project uncertainties (such as final design, permitting restrictions and bidding climate). These estimates are subject to refinement and revisions as the design is developed in future stages of the project.

TABLE OF CONTENTS

	Page No.
1. PROJECT SUMMARY	**1**
2. INTRODUCTION	**2**
3. FACTORS AFFECTING THE SHORELINE	**2**
4. RECENT SCIENTIFIC STUDIES RELATED TO GOLETA BEACH	**4**
4.1 Conceptual Model for Goleta Beach	6
4.2 Implications for Future Management	7
5. PARK RECONFIGURATION ALTERNATIVE	**7**
5.1 20-year vision of Park Reconfiguration Alternative	8
5.2 Phasing of 20-year Vision	10
6. COMPARATIVE COSTS	**11**
6.1 Park Reconfiguration	12
6.2 Summary of Alternatives and Costs	13
Table 1. Summary of Alternatives	14
Table 2. Detailed Summary and Comparison of Alternatives.	15
7. LIST OF FIGURES	**18**
8. REFERENCES	**19**
9. LIST OF PREPARERS	**21**

1. PROJECT SUMMARY

This project provides a conceptual design of a park reconfiguration alternative at Goleta Beach County Park in Santa Barbara, California. The premise behind this project alternative is to reconfigure the infrastructure and park facilities to allow for natural shoreline processes and realignment. Recent scientific research has shown that the coastal processes operating at Goleta Beach are highly variable and have resulted in fluctuations in beach width over the last 75 years. These changes appear to be caused by cyclic climate phenomena that regulate the direction of waves and storms. Recent research findings also provide insight into an erosion wave that propagated along coast causing the recent erosion at Goleta Beach before migrating down coast affecting Arroyo Burro, Shoreline Park, and currently Ledbetter Beach. This alternative attempts to provide a new vision of Goleta Beach that functions more naturally in light of these recent scientific findings.

The proposed alternative is based upon:

1. Goleta beach has historically fluctuated and has experienced a state of dynamic equilibrium with the most landward extent of erosion being the 1943 back beach.
2. A "coastal processes zone" which is proposed to encompass the likely most landward limit of future erosion corresponding to the 1943 back beach,
3. Park infrastructure within the "coastal processes zone" is proposed to be relocated to the extent practical except for the restaurant and associated buildings which will remain protected by the existing revetment.
4. This alternative reasonably minimizes potential future erosion damage, allows natural beach fluctuations, optimizes the natural beach width, and avoids downcoast impacts associated with the pile groin currently proposed by the County.

This proposed alternative is estimated to cost approximately $4.7 million to construct as opposed to the pile groin alternative which is estimate to initially cost about $8.4 million.

The benefits of this Park Reconfiguration alternative are to reduce the hazards associated with episodic coastal processes while enhancing public recreational opportunities and beach access. This alternative is the lowest cost alternative as well as a long term investment in the park which upgrades facilities and recreational amenities while reducing long term costs. Another important benefit to this alternative is to reduce the potential for downcoast impacts. This contrasts markedly with the likely increases in disruption of longshore sediment transport associated with the County's current proposal which includes a pile groin. By removing potentially threatened infrastructure away from the ocean's edge, this alternative provides a long term vision for Goleta Beach as a unique place to recreate and enjoy a special experience along California's coastline.

2. INTRODUCTION

PWA was commissioned by Environmental Defense Center on behalf of the Surfrider Foundation- Santa Barbara Chapter to provide a conceptual design of a park reconfiguration alternative at Goleta Beach County Park. This task included updating information on recent scientific advances on the historic evolution of the Santa Barbara shoreline and providing visual representations of the alternative. This park reconfiguration alternative provides a contrast with the proposed Santa Barbara County Beach Stabilization / Permeable Pile Groin project submitted to the California Coastal Commission (CDP-4-08-006).

A primary driver for these project alternatives has been erosion at Goleta Beach initiated during the 1997-98 El Niño. During the Goleta Beach Master Planning process, PWA was contracted by Santa Barbara County to examine managed retreat and realignment alternatives (PWA 2005). At the end of this process, another consultant for the county proposed a pile groin as the preferred alternative to undergo environmental review by the county. Although this environmental review was not completed, the pile groin project was submitted to the California Coastal Commission (CDP-4-08-006) prior to certification of the project's Environmental Impact Report.

Accommodation for the beach under this park reconfiguration alternative creates more space for the natural coastal processes to occur. This is the fundamental difference between the reconfiguration alternative proposed here and the proposed pile groin. The pile groin alternative attempts to manipulate the environmental conditions to move the shoreline zone to a new location. Unlike the pile groin proposal, the Park Reconfiguration Alternative works with natural processes to create a stable shoreline and protect down-coast beaches and natural resources.

3. FACTORS AFFECTING THE SHORELINE

The major issue to consider is where the shoreline is located in relation to the rest of the park. Some functions of the park (e.g., the restaurant, parking lots) have to be located landward of the shoreline. Other functions, such as wave dissipation and some ecological and recreational functions have to be located seaward of the line. The long-term management of the park depends on understanding the interaction of the shoreline with the various functions of the park and how these functions will change in the future. Historic changes at the park including the introduction of artificial fill and placement of rock revetments have altered the natural shoreline location and reduced naturally occurring beach widths.

We usually think of the shoreline as a line drawn on a map but this is an artificial line drawn by man. In reality, the shoreline is not static, it is continually moving, and so over time it describes not a single line but a zone. In general, the shoreline represents some time-averaged high water mark and is used to represent an area of wave activity and of the dynamic beach. If set back enough, structures and assets landward of the shoreline zone would not normally be in danger from erosion and flooding.

The shoreline zone responds at a variety of time scales:

- In the short term (days to months), during a storm the shoreline may move landward as sand is dragged offshore to form bars. In calmer weather, sand moves onshore and builds up the beach so the shoreline moves seaward. This rhythmic movement of the shoreline can be clearly seen when comparing summer and winter profiles at Goleta Beach.

- In the medium term (seasons to years), the shoreline may be influenced by particular events. A large amount of sand arriving at that part of the coast due to erosion in the watersheds or elsewhere along the coast may deposit sand widening the beach and moving the shoreline seaward. Changes in wave energy and water levels associated with El Niño and seasonal fluctuations (e.g. winter storms) also cause the shoreline to move.

- In the long term (decades), trends in sea level and tectonic earth movements may cause the shoreline to migrate. In the case of sea level rise, the shoreline will tend to migrate landward, which has been the general history for the last ten thousand years. Tectonic earth movements can result in episodic uplift which tends to move the shoreline seaward. In addition, climatic patterns such as the Pacific Decadal Oscillation a 50-60 year climate cycle which changes phase roughly every 25-30 years affects the location of storm tracks focusing wave energy into and out of the narrow swell window of the Santa Barbara Channel. Finally, reductions in sediment supply from dam, debris basins, and shoreline armoring also influence the shoreline position.

The natural position of the shoreline is not random – it is a response to a number of environmental variables and the beach is continually adjusting itself to accommodate changes in these variables:

- Wave energy – a beach dissipates wave energy in a number of ways by providing a long rough surface over which wave energy is transformed, into breaking waves and converted into sound, heat, sediment transport, and currents. Goleta Beach is relatively sheltered from large northwest wave events by the narrow swell window between Point Conception and the Channel Islands. At a more local scale, wave refraction around Campus Point further reduces wave energy. However, during large wave events, often associated with El Niños, when swell direction is more west, the response of the beach profile is to flatten and erode inland. These profile changes increase the ability of the beach to dissipate wave energy and are part of the natural beach response to storms. The narrowing or truncating of the beach area (e.g. as due to the existing revetment) available for wave energy dissipation can lead to an increase in scour on the fronting beach, and lower the sand levels.

- Sand supply– sand to Goleta Beach comes predominantly from the creeks and rivers to the north and west. Local geologic formations forming the nearby bluffs along Isla Vista only contribute small amounts of sand (Runyan and Griggs 2004) to the beach although the contribution of cobbles is not well understood. Sand arrives along Santa Barbara beaches often during episodic storm events when stream and river discharge pulse sediment into the ocean as deltas. Over time these deltas erode as sand is transported onshore during low wave energy conditions. Proliferation of dams and debris basins have impounded sand and reduced the amount of sand contributed to the beaches of Santa Barbara and Ventura County by about 40% (Willis and Griggs 2003). A reduction or interruption in upland or updrift sand supply is a primary cause of shoreline erosion.

- Sand transport - Sand along the Santa Barbara coast does not just move onshore and offshore, it also moves east along the coast (alongshore). Waves approaching a beach at an angle will tend to move sand along the coast. In general, the larger the incident wave angle and the larger the waves, the greater the transport of sand. The angle the waves approach is governed by the direction of storms and ocean swell waves, the shape of the seabed for several miles offshore and the shelter provided by headlands and islands. The shoreline may be relatively stable even though a large quantity of sand is being transported provided an equal quantity of sand is arriving from further up the coast. Along Goleta Beach to the Santa Barbara Harbor, estimates of the long term average annual alongshore transport is around ~300,000 yds^3(Patsch and Griggs 2007). However given the episodic nature of sediment supply and storm events in this region, the actual transport in a particular year typical differs from the long term average, and can vary with location along the shoreline (described further below).

- Sea level rise – the position of the shoreline is defined where the beach profile and the surface of the sea intersect. With rising sea levels, associated with climate change, the point of intersection will tend to move landward, moving gradually over decades. Relative sea level rise is the difference between global sea level rise rates and vertical land motions affected by local tectonic conditions. Episodic tectonic movements cause the land levels to rise faster than sea level with the result to move the shoreline seaward. Geological dating of the West Bluff at Goleta Beach places the age at ~45,000 years BP and provides some indication that this section of coast is uplifting at about the same rate of sea level rise ~2mm/yr (Keller and Gurrola 2000).

The key is to understand the width and location of the dynamic coastal processes zone in which the shoreline will fluctuate in the future in response to large wave events, changes in sediment supply, and sea level rise, and to accommodate this dynamic coastal processes zone with the other functions of the park.

4. RECENT SCIENTIFIC STUDIES RELATED TO GOLETA BEACH

Substantial research on Goleta Beach has been completed by several authors since the publishing of the PWA report (2005). The most pertinent articles are Revell and Griggs, Revell, Dugan, and Hubbard (in press), and Hapke et al. (2006, in press, 2006). In addition, there are ongoing efforts of the USGS combining long term shoreline and beach change research by Revell with ongoing seasonal monitoring funded in cooperation with BEACON.

In Revell and Griggs (2006), the authors found that the beaches along Goleta have not exhibited a high long term erosion trend, but rather beach widths oscillate apparently in phase with the Pacific Decadal Oscillation. During positive "cool" phases ("El Niño like"), storms come from a more westerly direction (Adams, Inman, and Graham 2008), resulting in a reduced sheltering of Goleta Beach from waves.

During the opposite phase, storms tend to be shifted northward increasing the wave sheltering and reducing wave energy resulting in wider beaches.

These authors also identified significant reductions to beach widths in front of shoreline armoring structures as a result of placement loss and passive erosion. The placement of rock revetments onto the beach reduces the overall beach area available for recreation and habitat while negatively impacting public beach access both vertically and laterally. Another significant impact to Goleta Beach has occurred at the ebb delta to Goleta Slough. The ebb delta was largest in 1938 prior to the development of the Santa Barbara Airport. The decline of this delta has been linked to the reduction in tidal prism as a result of filling of the Goleta Slough to construct the Santa Barbara airport.

The research by Revell, Dugan, and Hubbard (in press) grew directly out of a question that arose during the Goleta Beach Master Planning stakeholder process, "What is the impact of a large El Niño on Goleta Beach?" By combining topographic LIDAR data, historic shoreline change information, and measurements of ecological indicators, the authors examined the physical changes caused by the 1997-98 El Niño and the ecological response including identifying some timelines to beach and ecosystem recovery. The research found that the beaches narrowed by more than 50%, lost more than 60% of sand volumes, and also rotated in response to the El Niño storms. Beach rotation is a natural response of beaches during large storm events (often associated with El Niños) to reduce longshore sand transport and maintain sand on the beach. In this study, the authors identified the causative mechanism for the recent erosion at Goleta Beach - propagation of an erosion wave. After the El Niño, updrift Ellwood Beach remained in a rotated position for at least two years after the event. During this period, sand was naturally impounded at Ellwood, which initiated an erosion wave that migrated downdrift starving Goleta Beach. Historic profiles collected by Coastal Frontiers during monitoring of the Goleta Beach nourishment project, and subsequent seasonal surveys by the USGS, show a pulse of sand arriving at Goleta Beach in 2005. By 2005, the beach at Goleta had largely recovered its ability to buffer erosion. Currently, the erosion wave has continued to propagate downdrift affecting Arroyo Burro, Shoreline Park and is currently located at Ledbetter Beach on its way to the Santa Barbara harbor.

The last pertinent studies to Goleta Beach include examination of long term shoreline changes (1870s to recent) by the USGS and Revell. Both studies, using slightly different techniques, found that average annual long term shoreline change rates for Goleta Beach are less than -7in/yr (Hapke et al 2006, Revell and Griggs 2007). However, the average annual changes detected using a linear trend must be questioned given the oscillations observed in beach widths, and the large variability associated with the episodic nature of large storms and wave events. During this study, Revell identified that the 1943 shoreline was the most landward extent at Goleta Beach observed in the historic air photo record. In 1945, following the 1943 most eroded conditions, human changes resulted in the filling of much of the parkland artificially pushing the park seaward.

4.1 CONCEPTUAL MODEL FOR GOLETA BEACH

The recent measurement and observation of beach oscillations, stable sandy beaches (beaches that always have some sand and hence wider minimum beach widths), the measurement of storm event beach rotations and the historic and current documentation of erosion and accretion waves provide the basis for a revised conceptual model of beach behavior along the Santa Barbara coastline (Revell and Griggs 2006, Revell, Dugan and Hubbard in press, Revell and Griggs 2007). This conceptual model also builds on the discussion of the hook shaped bay presented in PWA 2005.

Along the Santa Barbara coastline, the stable beaches such as Goleta Beach and Ellwood form different sized sand boxes or sand deposits (hereafter referred to as boxes). These boxes are connected by the movement of sand between the boxes as driven by waves. Areas without much sand, such as Isla Vista, are typically stretches of shoreline where transport is more rapid and sand does not remain for long; these are not considered boxes. The sand boxes tend to extend from the base of the cliffs to a moderate depth offshore (~2m). In dune backed boxes, (e.g Ellwood and historically Goleta) these boxes extended well inland to encompass the entire dune system.

During calm wave energy periods, these sand boxes tend to be wide such as those beaches seen during the calm PDO phase in the 1970s (Revell and Griggs 2006) when wave energy was reduced. As each box fills, it must reach a certain level before it cascades sand downdrift making it available to the next box. When this cascading transport of sand is interrupted, (e.g shoreline rotations, or human alterations such as the construction of the Santa Barbara Harbor breakwater) or reduced (e.g. the proposed permeable pile groin), then the downdrift box closest to the impoundment begins to erode. Once that first downdrift box is reduced below the bypass level, then the next box downdrift begins to erode. Conversely as sand is moved around the impoundment, the downdrift boxes fill up again in the order that sand is received. In this example, as Ellwood filled up to the bypass level, sand cascaded downdrift to fill the next box, Goleta Beach.

During a major erosion event such as an El Niño, the boxes lose most of the sand AND the beach changes shape by rotating into the dominant wave direction - generally clockwise in response to large waves from the west. In dune backed boxes, the size of the box can get temporarily larger as sand is eroded from the dunes supplying even more sand to the overall system and thus reducing some of the erosion impacts. During these erosion events, much of the sand volume (>60%) is lost revealing a layer of cobbles that, without the sand on top, changes its behavior (due to increased porosity), and gains elevation providing a dynamic cobble revetment that becomes active during large erosion events. This change of shape and size of the boxes, and coarsening of grain size reduces some of the erosion impacts. It also affects the storage capacity of each box and can increase the recovery time for each box to reach bypass level. Only after a box reaches its unique bypass level will it begin to cascade and fill downdrift boxes. At Goleta Beach, the erosion wave initiated during the 1997-98 El Niño was a result of the lack of input from upcoast sediment sources during the time required to fill the sand box at Ellwood.

Generally most of the sand cascading between boxes occurs during the winter time in higher energy conditions. Since many of the boxes are located near inlets, if there is a flood event, many of these boxes gain sand. However, the sand that is gained is generally deposited offshore in deltas and not immediately used to fill the boxes. These deltas may however reduce rates of longshore sand transport which can result in wider beaches updrift. The deterioration of the ebb delta at Goleta Beach may be enhancing storm erosion impacts. Over time (seasons to years), the sand deposited in the deltas moves landward and fills in the boxes. Disruptions or alterations to the shape or storage capacity of these boxes such as that proposed under the pile groin alternative has the potential to impact downcoast beaches.

4.2 IMPLICATIONS FOR FUTURE MANAGEMENT

1. The oscillation of Goleta Beach appears to be a balance between occasional large pulses of sediment that widen the beaches and erosion periods when the sediment is transported eastward. Wave direction is especially important with most erosion occurring during energetic southerly El Niño conditions – which produces large waves from the west, and a reduction in wave energy during the negative phase of the Pacific Decadal Oscillation – associated with waves predominantly from the north. Recent indications from NASA suggest that we may be entering a negative phase of the PDO (2008).

2. In the event of future erosion waves such as the one that impacted Goleta following the 1997-98 El Niño, nourishment in the erosion wave of appropriate volumes could be conducted to reduce the recovery time and prevent further deterioration of beach buffering capabilities. Following the 1998 El Niño, about 510,000 yds^3 were removed from the beaches from Ellwood to Goleta with Goleta losing approximately 175,000 yds^3 of sand (Revell, Dugan and Hubbard in press). This erosion especially at updrift Ellwood catalyst the erosion wave. In order to offset a similar erosion wave an estimated 175,000 yds^3 of sand would be needed. This volume is of greater quantity than any single nourishment effort following the 1998 El Niño event despite an approximate ~270,000 yds^3 of sand nourished sporadically during the 9 years (~30,000 yds^3/yr) following the event (Moffat and Nichol 2008).

3. Infilling of Goleta Slough and the consequent reduction in the ebb delta has reduced the stability and possibly increased the longshore transport along Goleta Beach.

4. The park reconfiguration alternative will provide additional room for coastal processes to occur.

5. Another pulse of sand arrived at Goleta Beach in fall of 2005, with the corresponding beach widening providing additional erosion protection.

5. PARK RECONFIGURATION ALTERNATIVE

A conceptual design for a park reconfiguration alternative has been developed that considered the goals and outcomes from the Master Planning Working Group process, input from EDC and Surfrider

Foundation, and an understanding of historic and future shoreline evolution. The design consists of a park reconfiguration which allows for natural shoreline realignment along the west end of Goleta Beach and includes beach restoration, removal and refinement of coastal armoring, and the relocation of existing utilities and structures.

The constraints used to shape the alternative include:

- Same number of parking spots as 2008 (594)
- Same number of restrooms and facilities
- Same acreage of lawn as 2008 (4.0 acres)
- Similar acreage of beach as 2008 (3.0 acres)
- No new rock
- No backstop revetment landward of coastal process zone
- Removal of ranger housing and surrounding buildings as a planned
- Maintain restaurant
- Maintain Pier

The philosophy behind the park reconfiguration alternative is to relocate threatened infrastructure from the seaward side of the park and put it on the landward side of the park. This will enable more room along the seaward side of the park for coastal processes to occur naturally, while enhancing the recreational and park amenities on the lawn area between the parking lots and the beach. (Figures 1, 2).

To determine the potential extent of shoreline realignment, a coastal processes zone is herein defined as an area in which storm induced erosion and flooding can cause either an erosion of the shoreline or damage to infrastructure that lies within the zone. The intention is to remove facilities, infrastructure and utilities from this zone (figure 3). Moving utilities and structures landward of this coastal processes zone would provide a setback from the existing shoreline and provide an increase in the area over which natural coastal processes could operate.

The coastal processes zone was defined landward using the 1943 back beach shoreline. The 1943 shoreline is the most landward observed in the past 80 years and pre-dates significant human alterations. The area between the landward edge of the buffer zone and the maximum seaward shoreline measured in 1975 provides the seaward limit of the coastal processes zone (Figure 4).

5.1 20-YEAR VISION OF PARK RECONFIGURATION ALTERNATIVE

Within 20 years, realignment to a stable shoreline position would be allowed to the west of the restaurant as shown in Figures 1 and 2. The restaurant and the parking lot on the spit to the east would remain in place protected by the existing rock revetment[1]. The area from the west bluff to the restaurant

[1] The County may consider re-engineering this revetment given its current condition. While not included in this alternative, the potential exists to reduce the overall footprint of this structure while maintaining existing parking levels. A relocation of the pier restroom would upgrade the park facilities enhancing both public recreation and natural beach area while remaining consistent with the intent of this alternative – reconfigure the park to allow more room for natural processes to occur.

accommodates future coastal evolution within the coastal processes zone. The park reconfiguration alternative shows the coastal process zone as a restored beach area (Figure 1).

Landward of the coastal processes zone is a beach park area that includes the existing park amenities reconfigured for the future shore conditions: space for the same acreage of lawn that currently exists, a playground, barbecue pits, horseshoe pits, picnic tables and group picnic areas, public restrooms and paths that connect the beach to the parking areas. The approximate area of the lawn in the proposed Park Reconfiguration alternative is 4.2 acres with an initial .2 acre gain compared to existing conditions as a result of Parking Lot A relocation. This increase in lawn would be located in the coastal processes zone, so overtime this increase may be reduced to existing levels. This reconfiguration also extends the desirable beach/lawn interface and potential beach access by over 850 feet to a total of 1900 linear feet.

Landward of the beach park area are Parking Areas A and B and maintenance area. The maintenance area and ranger housing would be removed as already planned by the County. In the Park Reconfiguration alternative design, Parking Areas A and B are shown connected to the restored beach area with paths to focus beach access.

Approximately 1000 feet of existing rock revetment at the west end of the park would be removed; this section of revetment is not necessary under the proposed alternative. However, at this time, it is not practical to relocate the existing restaurant, adjacent restroom, and surrounding infrastructure given the economic value and lease arrangements with the restaurant. The existing rock revetment in front of the restaurant and restroom would be extended by 150 feet to the west to protect Parking Area C and the sewer outfall vault. The rock removed from the existing west end revetment would be used to protect the sewer outfall vault. The remaining rock will be stockpiled on site at the County maintenance yard or used to bolster the existing eastern rock revetment.

As the west end and mid park revetments are removed, the underlying fill will be regraded to provide safe public access then covered with sand and vegetated (Figure 5). This area within the coastal processes zone may be subject to episodic erosion which would likely oversteepen or create a scarp in the fill material. Ongoing maintenance in the spring would be required to regard this scarp and renourish with opportunistic sediments.

Ideally, the relocation of utilities and park amenities occurs initially, but it is not required that all the proposed changes in the conceptual design occur at once. Proposed changes could be implemented in a phased manner to accommodate the evolution of the beach and budgetary constraints, and to time work to avoid highest park use periods. It is recommended that relocation of existing utilities and restrooms within the coastal processes zone be completed early in the project, but it is possible to relocate facilities within the coastal processes zone on an as needed basis. This may affect the cost at the actual time of implementation.

5.2 PHASING OF 20-YEAR VISION

For the park reconfiguration alternative, existing utility lines, buildings, and parking lots would need to be reconfigured or removed to accommodate the design. It is anticipated that the coastal processes zone would be eroded at least once in the next 20 years given the trends in long term shoreline changes and the episodic pulses of sediment moving along the coast. While the beach would likely recover from such an erosion event, facilities in the zone may be damaged or lost. Structures and utilities within this zone, such as the restrooms, need not be relocated immediately but as erosion threats warrant and budgets allow. It is recommended a triggering threshold of 20 feet be used to identify when a utility or structure needs to be relocated. Figure 3 shows the elements in which either portions of utility lines or existing structures need to be relocated or removed as part of the park reconfiguration.

The utilities to be relocated include:

- Goleta Water District reclaimed water line
- Goleta Sanitation District pressure sewer line
- Potable water line
- Southern California Gas Line[2] (which lies outside the coastal processes zone)
- Small sewer lines to existing restrooms
- Park irrigation lines

Relocated facilities include:

- Parking Lot A
- Two restrooms
- Ranger housing (planned to be removed by County already)

The initial work includes removing the west end revetment and relocating Parking Area A landward. The next step is to regrade the scarp in the fill material at a 5:1 slope (H:V) and add lawn and sand at the landward extent of the beach (Figure 5). The vertical scarp in the fill that that forms following an erosion event could be a safety issue and also presents a negative image of the park. It is suggested if the scarp is exposed during the spring that the scarp be regraded (at 5:1 slope; H:V) and covered in sand e.g. from the sediment debris basins, and flood control projects located within the Goleta Slough watershed. This sand is already permitted for placement under BEACON's South Central Coast Beach Enhancement Program for opportunistic sediment use permit (SCCBEP). This sand would act as supplemental nourishment of the back beach.

[2] We assume that responsibility for this infrastructure lies with the Utility District since it is a private entity utilizing public lands and is not the responsibility of the County of Santa Barbara. However, we have included this relocation cost for reference only and envision a cooperative approach between the county and utility districts to obtain funding e.g. grants and/or state funds and generate support from various stakeholder groups. This is not included in any of the cost estimating associated with any of the alternatives.

At the western end of the beach, much of the existing parking area would be reconfigured to accommodate Parking Area A. Several existing buildings would be removed or relocated as currently planned - within Parking Area B, including several maintenance sheds and onsite ranger housing. Parking Areas C and D in the proposed design currently exist, but will need to be reconfigured and restriped to compensate for the loss of spaces elsewhere. The total number of parking spaces in the park reconfiguration alternative is based on a uniform parking space dimension of 8 feet wide by 15 feet long as measured in air photos. A rigorous analysis to optimize the parking spaces, including spaces for varied sizes for compact cars and disabled parking, was not conducted as part of this analysis. There are a total of 594 parking spaces based on this estimate which is reported to be the current level of parking. The intent behind the parking analyses is to ensure that there will be equivalent number of parking spaces for the park reconfiguration alternative.

Given the likelihood that there could be another energetic El Niño in the next 20 years, the park reconfiguration alternative includes a one time erosion wave response nourishment of 175,000 yds^3 at some unknown date in the future. Annual maintenance costs for all alternatives would include seasonal monitoring as well as routine maintenance which should be similar for all alternatives. The park reconfiguration alternative would likely have slightly reduced operating costs due to the upgrading of new restroom and parking facilities and thus not require as many repairs.

5.3 ADDITIONAL OPTIONS

Several other options for the park reconfiguration alternative could also be included although these have NOT been cost estimated or incorporated into the proposed park reconfiguration alternative.

One option would be to replace the bathroom on the south side of the pier with a new restroom set inland on the opposite side of the restaurant buildings. This option would create space to enable a realignment of the armoring on the south side of the pier and increase the area available for the natural coastal processes at the most narrow point along Goleta Beach.

Another option to be considered would be the use of impervious pavement for all of the new parking lots. This would serve the purpose of improving local water quality conditions, and providing an educational showcase on one method of low impact development. These additional options could be included in any preliminary design stage if the county decides to move forward with this reconfiguration alternative.

6. COMPARATIVE COSTS

The Park Reconfiguration alternative's costs are PWA's preliminary engineers' estimates of likely construction and operation/maintenance costs. The County EIR's managed retreat and pile groin projects' costs are based upon the recent cost estimates by Moffatt and Nichol Engineers Long-Term Beach Restoration and Shoreline Erosion Management Plan (Moffatt and Nichol, 2002). For comparative purposes all of the cost alternatives are present in 2007 dollars.

For planning purposes we have provided order of magnitude estimates to allow cost comparison of alternatives. These cost estimates are intended to provide an approximation of total project costs appropriate for the preliminary level of design. These cost estimates are considered to be approximately -15% to +30% accurate. These estimates are subject to refinement and revisions as the design is developed in future stages of the project.

6.1 PARK RECONFIGURATION

The Park Reconfiguration alternative: removes and regrades fill from the back beach, replaces fill with sand, provides for major reconfiguration of existing parking lots that currently require reconstruction, removes the western segment of revetment, extends the eastern revetment and relocates restrooms and utilities farther inland. All park improvements (except the lawn) are proposed to be moved inland of a "coastal processes zone" consistent with contemporary research. The width and location of the coastal processes zone have been established to accommodate the likely shoreline fluctuations over the next 20 years and nourishment of the beach is expected only on a contingency basis with a one time nourishment cost estimated in response to a major erosion event. However, based on historic data, erosion into this zone is not anticipated to occur before approximately 2028.

The reconfiguration presented herein is one possible layout that maintains all uses and elements (in terms of function, not existing location) previously identified by County Parks, and included in other alternatives. The precise park configuration is subject to further design and community input.

Removal of 950 feet of rock forming the western revetment is estimated at $209k ($220/ft, modified from Moffatt and Nichol, 2008). The extension of the eastern revetment, in front of parking lot C, by 150 feet is estimated at $0.33M ($2200/ft, updated from Moffat and Nichol, 2002).It is assumed that the removal of rock from the western revetment will be used directly to extend the eastern revetment with the remaining material stockpiled at the County maintenance yard or placed on the existing eastern revetment.

The fill above MHHW would be removed to the seaward edge of the buffer and replaced with sand. Removal cost of the fill would be approximately $11/yd^3 and include excavation and reuse on site during construction of the new parking lots. Sand backfill and fill will be accomplished using upland or opportunistic sand (already permitted under SCCBEP) or offshore sources. The total volume of fill to be removed is approximately 20,000 yd^3 at a cost of $0.22M and replaced with approximately 30,000 yd^3 of sand at a cost of approximately $0.44M. Initial costs would be minimized if the beach fill was left in place; the erosion scarp regraded each spring and then allowed to erode the following winter (Figure 5) This phased approach would then increase the ongoing operations and maintenance cost. Total estimated initial costs considering the total removal of the fill as part of the initial construction is $0.96M.

The beach would then be allowed to fluctuate over the next 20 years in a state of dynamic equilibrium. At measured rates of historic retreat the coastal processes zone will not be eroded until after 2028. Although these rates do not account for the pulses of sediment through the system, the coastal processes zone will enable these natural processes to occur without jeopardizing infrastructure and park facilities. There are also some indications that we may be entering a different phase of the Pacific Decadal Oscillation which would be more conducive to beach accretion (NASA 2008). The utilities and restrooms lie within the coastal processes zone and would not have to be moved until the back beach reached within 20 feet of these facilities zone. The relocation of these facilities should be planned in advance and timed with the availability of funds. Cost for relocating two restrooms including necessary infrastructure is approximately $0.44M (figure estimated by Santa Barbara County Parks and updated to 2007 dollars). The cost of new parking lots is approximately $0.6M using unit costs of $3.60/sf from Moffatt & Nichol Engineers. The new lawn is estimated to be $136K.

A portion of the pressure sewer line has recently been relocated landward out of the coastal processes zone; the cost for relocating the remaining portion of the sewer line inland is estimated to be $58K (figure estimated by Santa Barbara County Parks and updated to 2007 dollars). A larger undertaking is the relocation of 500 feet of the reclaimed water line that lies in the processes zone between the West Bluff and the western restroom. The cost for relocating this portion of the reclaimed water line inland is estimated to be $0.57M ($1000/ft, figure estimated by Goleta Water District and updated to 2007 dollars) Additional utility relocations include 900 ft of electrical and telephone lines at a cost of $57K, 1100 ft of potable water line at a cost of $45K (figures provided by Santa Barbara County and updated to 2007 dollars). A high pressure gas line exists at the site and is assumed to remain in its current location and thus is NOT included as part of the Park Reconfiguration Alternative.

To be thorough, the construction cost for the new high pressure gas line was estimated at $500,000 to $800,000. This estimate is from the presentation by utility companies to the Goleta Beach Park Working Group on March 4, 2004. This was summarized in a letter to Steve Hudson and Jenn Feinberg from Dave Ward, dated 2-15-2008. These costs were updated to 2007 dollars (to match all other dollars in the memo and cost estimate) to arrive at a range of $570,000 to $910,000.

A one time beach nourishment is included as a contingency element estimated to occur within the 20-years following project construction. A volume of 175,000 cy is included in the Park Configuration Alternative at a unit cost of $14.5/cy (estimate from Moffatt & Nichol Engineers, 2007). This volume of sand would widen the entire Park beach about 40 to 50 feet (following redistribution to the entire shoreface). It is anticipated that this level of beach nourishment would be desired following a severe winter such as that associated with a strong El Nino. This may or may not occur within the 20 year planning horizon. This item could also be considered a necessary addition to the other alternatives as well, which are also susceptible to storm impacts and erosion waves.

With removal of the western revetment, extension of the eastern revetment, relocation of the restrooms, new parking lots and lawn, relocation of portions of the sewer line, water line, electric and telephone lines, and the reclaimed water line, replacement of the fill, the initial project cost is estimated to be $4.7M, and with the ongoing beach nourishment as needed on a contingency basis the 20-year project cost is estimated to be $8.4M.

6.2 SUMMARY OF ALTERNATIVES AND COSTS

The alternatives and their estimated costs described above are summarized in the Table 1 below. A detailed cost summary and comparison of the alternatives is presented in Table 2.

Table 1. Summary of Alternatives (2007 dollars)

	Existing Conditions	**Managed Retreat**	**Permeable Pier/ Pile Groin**	**Park Reconfiguration**
Lawn area	4.0	2.87	4.0	4.2 acres
Buffer area (sand or lawn)	-	1.3	-	1.3 acres
Beach area	3.0	4.0	8.6	4.5 acres
Total area for recreation	7.0	8.5	12.6	10.0 acres
Alongshore length of lawn/beach	1,035	1,900	1,300	1,900 ft.
Parking spaces	594	594	594	594
Sand Pre-fill	-	100,000 yds^3	550,000 yds^3	30,000 yds^3
Initial cost	-	$7.5M	$8.7M	$4.7M
20 year cost	-	$11.1 M	$9.6M*	$8.4M

* This cost does not include future nourishment which could increase the cost an estimated $10.5M (see text p. 17)

Table 2. Detailed Summary and Comparison of Alternatives.

Construction Element	Managed Retreat Alternative	Beach Stabilization (Groin) Alternative	Park Reconfiguration Alternative
Estimate Prepared by:	Moffat & Nichol	Moffat & Nichol	PWA
Initial Construction Phase	**Estimated Cost[1]**	**Estimated Cost[1]**	**Estimated Cost[1]**
Mobilization & Demobilization	$200,000	$100,000	$100,000
Temporary Protective Fence	$12,600	$18,600	$9,000
Detour Traffic	$15,000	$15,000	$15,000
Utility Relocations	$275,500	$0	$728,000
Demolition	$687,500	$0	$288,000
New Restrooms	$229,250	$0	$444,000
West. & Mid. Revetments Removal	$220,000	$96,000	$209,000
New East Revetment	$89,750	$0	$90,000
East Revetment Repair	$483,800	$0	$0
West-End Backstop Revetment	$211,121	$216,108	$0
New Parking Lots	$325,500	$0	$612,000
New Lawn	$985,000	$0	$136,000
Removal of Fill Material	$0	$0	$222,000
Beach Nourishment	$1,547,128	$0	$0
Groin, Deck Construction	$0	$759,000	$0
Beach Pre-Fill	$0	$4,924,500	$435,000
Subtotal	$5,282,149	$6,129,208	$3,288,000
Contingency (25%)	$1,320,537	$1,532,302	$822,000
Eng, Design, Super, Admin (15%)	$792,322	$919,381	$493,200
Permitting (2.5%)	$132,054	$153,230	$82,200
TOTAL - Initial Phase	**$7,527,062**	**$8,734,121**	**$4,685,400**
Secondary Construction Phase[2]			
Mobilization & Demobilization	$100,000	$0	$100,000
Temporary Protective Fence	$12,600	$0	$9,000
Detour Traffic	$15,000	$0	$15,000
Beach Nourishment	$1,660,979	$0[3]	$2,500,000
New Lawn	$704,000	$0	$0
West-End Backstop Revetment	$0	$0	$0
Groin, Deck Construction	$0	$588,000	$0
Subtotal	$2,492,579	$588,000	$2,624,000
Contingency (25%)	$623,145	$147,000	$656,000
Eng, Design, Super, Admin (15%)	$373,887	$88,200	$393,600
Permitting (2.5%)	$62,314	$14,700	$65,600

TOTAL - Secondary Phase	**$3,551,925**	**$837,900**	**$3,739,200**
TOTAL	**$11,078,987**	**$9,572,021**	**$8,424,600**
Operating and Monitoring Costs			
Annual	$130,000	$130,000	$130,000
20-year Total	$3,500,000	$3,500,000	$3,500,000

Notes:
1. All costs are presented in 2007 dollars.
2. The secondary construction is anticipated to occur in 2013, but costs are presented in 2007 dollars under the assumption that net escalation of construction costs relative to monetary inflation is small and accounted for in the contingency.
3. This cost does not include future nourishment which could increase the cost an estimated $10.5M (text p. 17)

The operating and monitoring costs are based on estimates for ongoing costs prepared by Santa Barbara County using annual costs with and escalation of 3% annually over the 20-year project period. PWA changed the annual costs for the Groin Alternative from $120k to $130k. It is also likely that the managed retreat alternative and the park reconfiguration alternatives would have reduced annual maintenance costs due to the replacement of aging facilities.

The Park Reconfiguration alternative is the lowest cost, while maintaining / replacing aging facilities (utilities, restrooms, shore protection for restaurant), in addition to enhancing and maintaining the lawn and beach areas and interface. The Park Reconfiguration Alternative does not include the potentially large, adverse effects to the downcoast beaches and tidal inlet associated with the Permeable Groin Alternative.

In contrast, the Permeable Pile Groin project costs approximately 45% more than the Park Reconfiguration Alternative, without providing new parking areas or new restrooms. The pile groin is unlikely to prevent the beach fluctuations associated with sand supply changes and episodic storm events. Given the alteration to the storage capacity of Goleta Beach, and the potential for larger volume losses following erosion events, there is a much higher risk that the permeable pile groin will have downcoast impacts. Initial pre-fill of 550,000 yds^3 may initially mitigate downcoast impacts. However, the increased storage capacity would result in greater sand impoundment following erosion events and increase the time for Goleta to fill up before cascading sand down drift. Downcoast impacts similar to those observed following the 1997-98 El Niño as the causative erosion wave passed through Goleta, could be expected to worsen as a result of the pile groin alternative. It is likely that any contingency nourishment required with the Pile Groin would include the eroded fillet volume (550,000 yds^3) and the volume necessary to infill another erosion wave (~175,000 yds^3). The cost of such a contingency is not included in cost estimating for the groin alternative and would may add an additional $10.5M in nourishment costs to the 20 year total.

It is also important to note that PWA reviewed a hard groin alternative with a similar placement as the proposed pile groin (PWA 2005), and found that the salient created by the groin did not extend updrift (west) enough to protect the west end of the park. Given the proposed groin's permeability of 33%, the groin would be less successful than a solid structure in retaining sand. The greater the permeability designed to mitigate downcoast impacts, the less effective the sand trapping and the smaller the salient. Given the variable coastal process and sediment supply conditions the tuning of the groin would likely require ongoing maintenance increasing operations and maintenance as well as recreational opportunity costs.

PWA's initial assessment of the Permeable Groin alternative is that it is too risky to recommend. In general, the Permeable Groin Alternative is dubious in terms of effects and effectiveness, although more technical work is needed to evaluate the supporting modeling results and assumptions.

As a result of the Park Reconfiguration Alternative's lower cost, the alternative's effectiveness, avoidance of downcoast impacts, and the ability to retain and improve park facilities as well as the uncertainties associated with the proposed groins, the Park Reconfiguration alternative is the preferred alternative.

7. LIST OF FIGURES

Oblique Artistic rendering
Alternative with CAD overlay on Air Photo
Existing utilities – CAD/GIS
Coastal Processes Zone - GIS
Evolution of a Park Transect figure

8. REFERENCES

Adams, P., Inman, D.L. and Graham, N.E., (2008), Southern California deep-water wave climate: characterization and application to coastal processes. *Journal of Coastal Research.* Vol 24(4):1022-1035.

Engineering News Record. 2008. Cost Index and Building Index for Los Angeles County.

Hapke, C.J, and Reid, D., Richmond, B.M., Ruggiero, P., List, J. (2006) National Assessment of Shoreline Change Part 3. Historical Shoreline Change and Coastal Land Loss Along Sandy Shorelines of the California Coast. USGS Open File Report 2006-1219.

Hsu, J.R.C., R. Silvester and Y.M. Xia (1987). New characteristic equilibrium-shaped bays. Proc. 8th Aust. Conf. Coastal and Ocean Eng.

Keller, E.A. and L.D. Gurrola. 2000. Earthquake Hazard of the Santa Barbara Fold Belt, California: Final Report. July 2000. NEHRP Grant #99HQR0081 and SCEC Award #572726.

NASA 2008. Press Release: Larger Pacific Climate Event Helps Current La Niña Linger April 1, 2008. Online at http://sealevel.jpl.nasa.gov/elnino/20080401.html

Moffat and Nichol, 2002. Goleta Beach County Park Long-Term Beach Restoration and Shoreline Erosion Management Final Plan. Prepared for Santa Barbara County Parks. March 15, 2002.

Moffat and Nichol, 2008? Cost Estimating tables from Moffat and Nichol Engineers procured by Environmental Defense Center.

Noble Consultants (1989). Coastal Sand Management Plan: Santa Barbara/Ventura County Coastline. Prepared for BEACON.

Patsch, K. and G.B. Griggs, 2007. Development of sand budgets for California's major littoral cells. Report to California Department of Boating and Waterways. Coastal Sediment Management Work Group.105 pgs. *http://dbw.ca.gov/CSMW/PDF/Sand_Budgets_Major_Littoral_Cells.pdf*

PWA, 2005. Master Plan Goleta Beach County Park: Shoreline Management Alternatives. Prepared for County of Santa Barbara Parks Department. June 14, 2005.

Revell, D.L. and G.B. Griggs (2005). Long Term and Storm Event Changes to the Beaches of Isla Vista, California. Draft Final Report to UCSB Shoreline Preservation Fund.

Revell, D.L. and G.B.Griggs (2006). Beach Width and Climate Oscillations along Isla Vista, Santa Barbara California. Shore and Beach vol 74(3): 8-16.

Revell, D.L. and G.B. Griggs. (2007). Regional Shoreline and Beach Changes in the Santa Barbara Sandshed. In *Coastal Sediments 2007*.ASCE New Orleans, LA May 2007. pg 1740-1753.

Revell, D. L., Dugan, J.E., Hubbard, D.M., in press. Physical and Ecological Responses of Sandy Beaches to the 1997-98 El Niño. Accepted to Journal of Coastal Research 7/24/2007.

U.S.Army Corps of Engineers (1986). Southern California Coastal Processes Data Summary. Southern California Storm and Tidal Waves Study, CCSTWS 86-1.

Walton, T.L., and W.D. Adams, 1976. Capacity of inlet outer bars to store sand. Chapter 112, Coastal Engineering 1976. ASCE. pp. 1919-1937

Willis, C.W. and G.B. Griggs (2003). Reductions in fluvial sediment discharge by coastal dams in California and implications for beach sustainability. Journal of Geology 111:167-182.

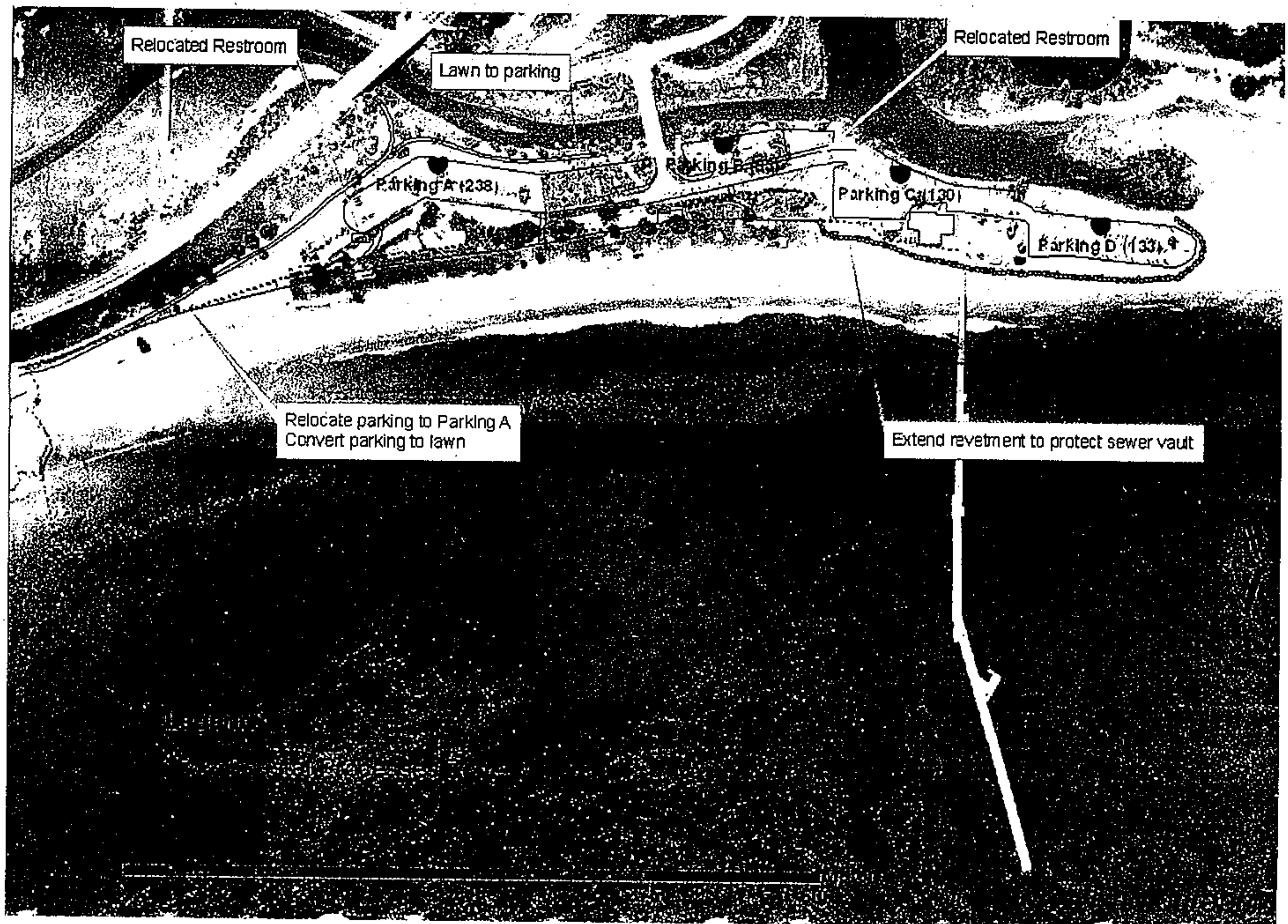
9. LIST OF PREPARERS

This report was prepared by the following PWA staff:

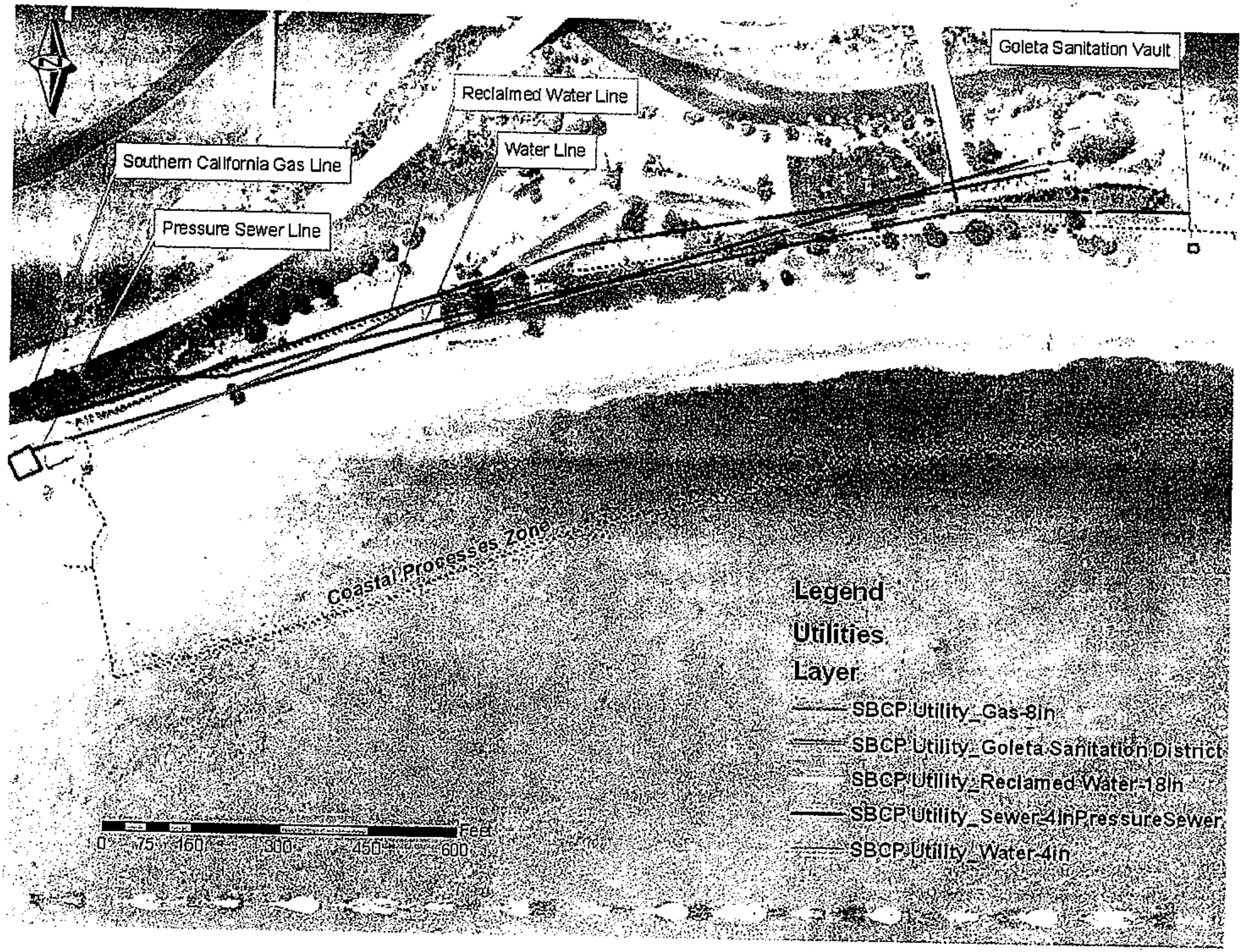
David Revell, Ph.D. – project manager
Bob Battalio, P.E. – project director (CA Civil 41765)
Philip Luecking, P.E.
Jeremy Lowe

With technical review by:

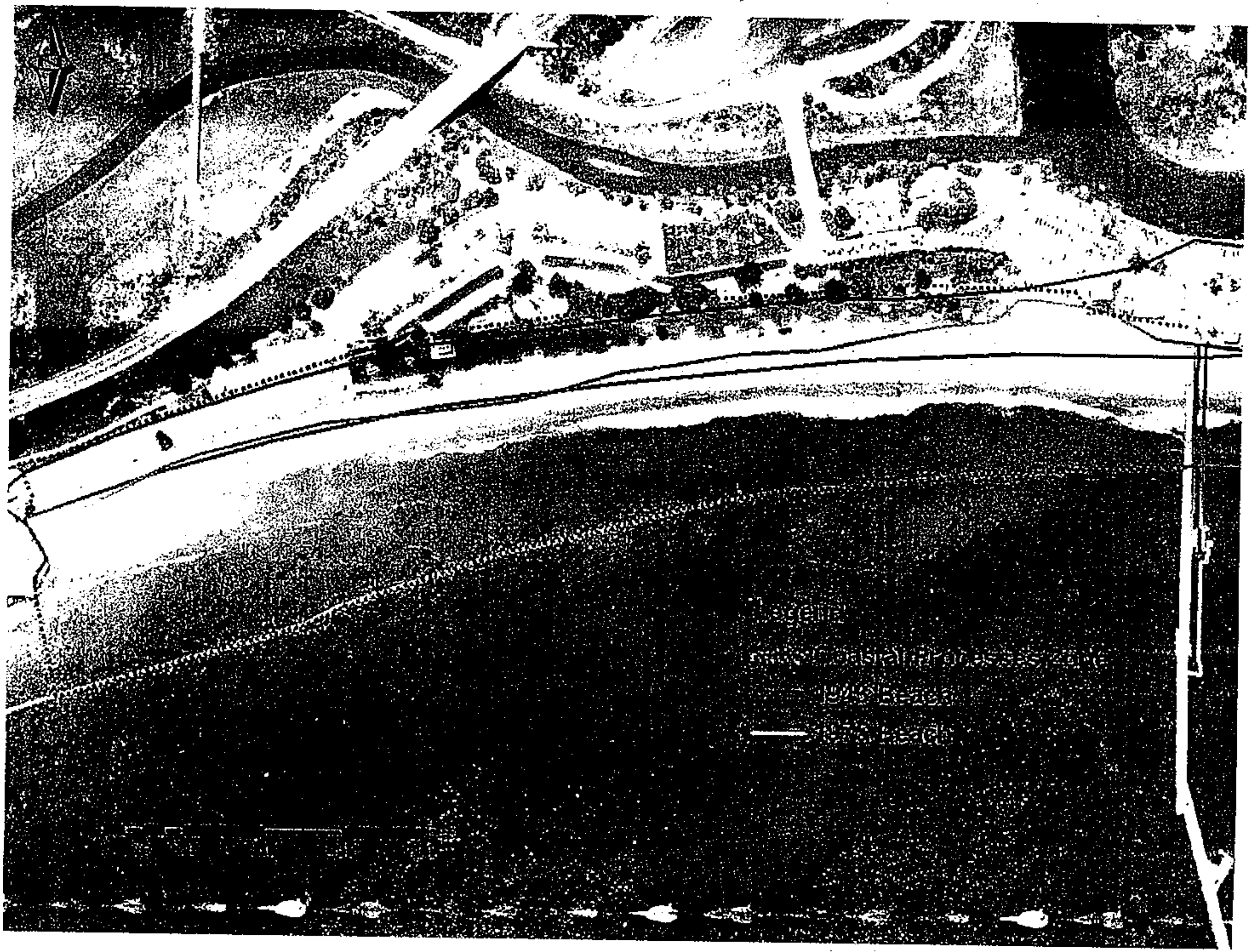
Michael Walther, P.E.



Relocated Restroom
Lawn to parking
Relocated Restroom
Parking A (238)
Parking C (130)
Parking D (133)
Relocate parking to Parking A
Convert parking to lawn
Extend revetment to protect sewer vault



Goleta Sanitation Vault
Reclaimed Water Line
Water Line
Southern California Gas Line
Pressure Sewer Line
Coastal Processes Zone
Legend
Utilities
Layer
SBCP Utility_Gas-8in
SBCP Utility_Goleta Sanitation District
SBCP Utility_Reclamed Water-18in
SBCP Utility_Sewer-4inPressureSewer
SBCP Utility_Water-4in
0 75 150 300 450 600
Feet


Legend
Coastal Processes Zone
Beach
Beach

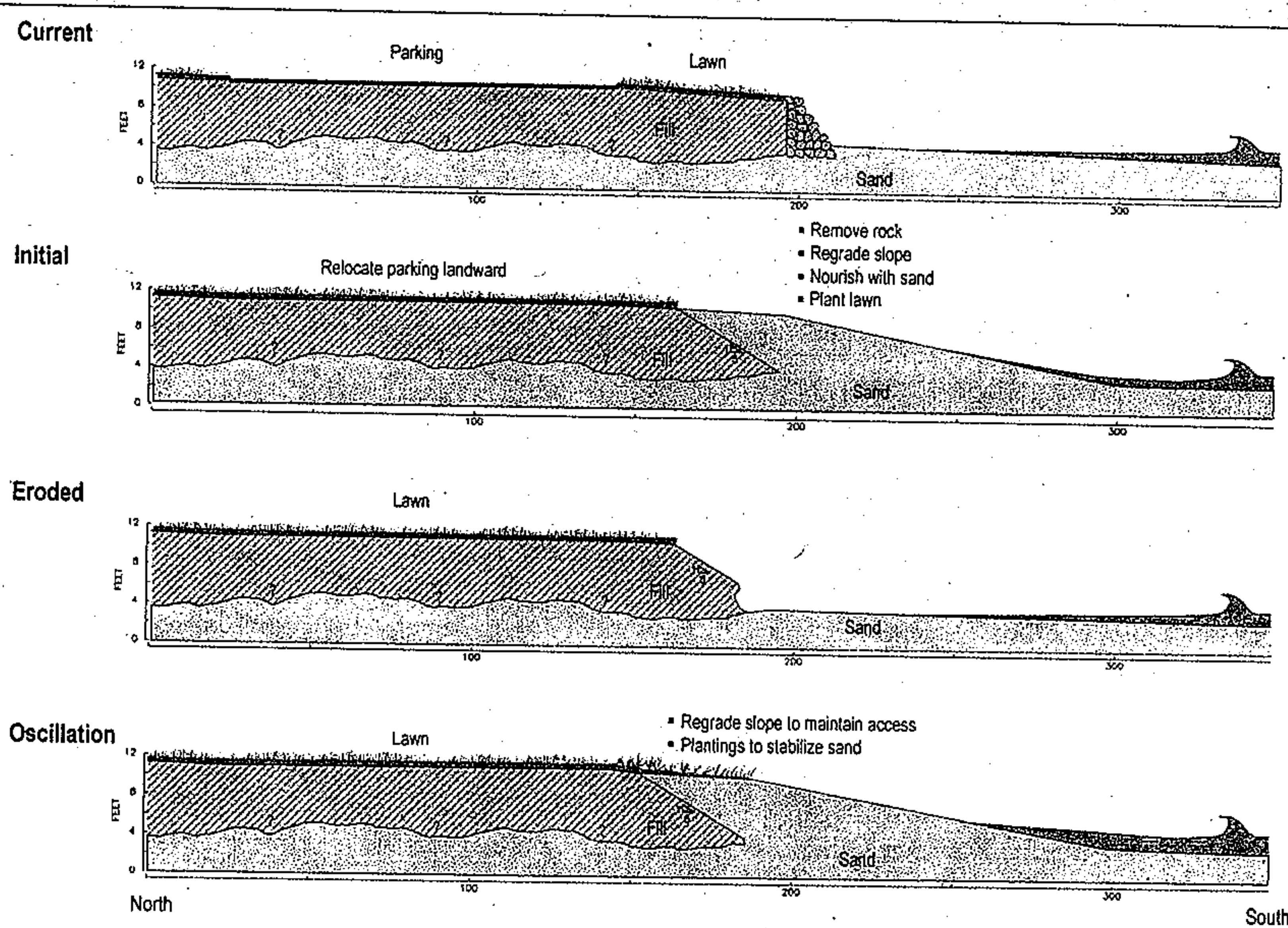


figure 1

Goletta Beach

Evolution of Park Reconfiguration Alternatives

#1940

PWA

Attachment #2

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD.
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
T 415.262.2300 F 415.262.2303
www.pwa-ltd.com

MEMORANDUM

Date: April 15, 2009
To: Brian Trautwein
Organization: Environmental Defense Center
From: Bob Battalio, PE, David Revell, PhD, Jeremy Lowe
PWA Project #: 1960.00
PWA Project Name: Goleta Modeling Review
Subject: Final Memo on Goleta Beach Modeling Review
Copy(ies) To:

GOLETA BEACH MODELING REVIEW

1. PURPOSE

The County of Santa Barbara is pursuing a permeable pile groin constructed on the beach coincident with the pier at Goleta Beach County Park. In January 2008, the County applied to the California Coastal Commission (CCC) for coastal permits to build the groin project (CDP No. 4-08-006). The CCC reviewed the County's permit application and determined the permit application lacked information about a variety of issues including other alternatives, environmental impacts and modeling. The County has conducted engineering modeling of the Goleta Beach Pile Groin Project and other alternatives to ascertain their relative effectiveness at protecting the park and their likely environmental impacts such as erosion of down-coast beaches. This work is described in the County's 'Response to Incompleteness Determination' dated July 23, 2008.

Philip Williams and Associates (PWA) has been retained to review pertinent County documents and provide a technical evaluation of the proposed pile groin alternative and engineering modeling. This memo forms the deliverable for that evaluation. PWA has previously reviewed alternative approaches for the County (PWA, 2005), and further developed the Park Reconfiguration Alternative (PWA, 2008) for The Environmental Defense Center and Surfrider Foundation. The evaluation of the proposed permeable pile groin is also informed by PWA's prior work and staff's involvement in research in the area.

The purpose of this memo is to provide a review of the modeling and a critique of the modeling assumptions and implications of those assumptions. It focuses on the likely effects and effectiveness of the proposed pile groin.

The primary document provided for the review was the County of Santa Barbara's 'Response to Incompleteness Determination' dated July 23, 2008 which included:

Everts Coastal, 2006, *Sand Retention Concept for Goleta Beach, Santa Barbara County, California*, report prepared for The Chambers Group, August 2006. Referred to as the EC report.

Moffatt & Nichol Engineers, 2007, *Final Draft Report on Shoreline Morphology Study, Appendix A- Sand Retention Concept*, draft report prepared for Chambers Group, January 2007. Referred to as the MNE report.

PWA was tasked with contacting the County and Moffatt & Nichol Engineers to obtain all relevant documents and information relating to the modeling of the Goleta Beach project. Other supporting documents reviewed are referenced at the end of this memo.

2. BACKGROUND

There has been considerable research on Goleta Beach since 2005 which forms the basis of our understanding of how the beach has evolved over the last few decades and the major factors controlling its future evolution (PWA 2005, 2008, Barnard *et al.* 2009). This body of work, including work published after the EC and MNE reports, is pertinent to our evaluation. A summary of the pertinent scientific observations, largely missing from the EC and MNE reports, is given below:

- Over the long term (1870s to recent) average annual long term shoreline change rates for Goleta Beach are less than -7 inches per year (Hapke *et al* 2006, Revell and Griggs 2007). These long term rates are approximate owing to the relatively large variability in shoreline positions, manifested in erosion and accretion periods during beach widths have oscillated (Revell and Griggs 2006).

- PWA (2005) identified the hook-shaped (crenulate) bay planform at Goleta, and the pulsating nature of sediment supply and corresponding beach widths at Goleta. Conceptually, the Goleta Beach shoreline migrates within an envelope of shoreline positions resulting from the balance of sediment supply and transport rates.

- PWA (2008) identified that the 1943 shoreline was the most landward extent at Goleta Beach observed in the historic air photo record.

- The beaches along Goleta have not exhibited a high long term erosion trend (PWA, 2005), but rather beach widths oscillate in phase with the Pacific Decadal Oscillation (PDO) (Revell and Griggs, 2006).

- Beaches temporarily narrowed by more than 50%, lost more than 60% of sand volumes, and also rotated in response to the 1997-98 El Niño storms (Revell, Dugan, and Hubbard in press, submitted to County during Public Comments on Draft EIR). Beach rotation is a natural response of beaches adjacent to headlands, such as those along the Santa Barbara County Coast, during large storm events and often associated with El Niños. This response reduces longshore sand transport and maintains a narrowed sand beach.

- Sediment transport modeling using DElft3D show similar patterns in longshore transport velocities as observed in beach widths and rotations (Barnard *et al*, 2009; Revell, Dugan and Hubbard, in press).

- El Niño storms come from a more westerly direction resulting in a reduced sheltering of Goleta Beach from waves (Adams, Inman, and Graham 2008). During the opposite La Niña phase, storms tend to be shifted northward increasing the wave sheltering and reducing wave energy resulting in wider beaches.

- The causative mechanism for the recent erosion at Goleta Beach has been identified as the propagation of an "erosion wave" (Revell, Dugan, and Hubbard, in press, submitted to County during Public Comment on Draft EIR). After the El Niño, updrift Ellwood Beach remained in a rotated (eroded) position for at least two years after the event. During this period, sand was impounded at Ellwood Beach and the beach widened. The trapping of sand at Elwood Beach reduced longshore transport to downcoast beaches, resulting in erosion at Goleta Beach. This process has been verified by tracking the erosion wave in detailed mapping of shoreline positions over time using aerial photographs. Historic cross-shore profiles also show a pulse of sand arriving at Goleta Beach in 2005 following which the beach at Goleta had largely recovered its ability to buffer erosion (Coastal Frontiers 2006; Barnard *et al*, 2009). Currently, the erosion wave has continued to propagate downdrift affecting Arroyo Burro, Shoreline Park and is currently located at Ledbetter Beach on its way to the Santa Barbara harbor.

In addition there are other considerations, including those related to the historic stakeholder process, which are pertinent to the evaluation:

- PWA (2005) described the concept of placing infrastructure landward of the "Coastal Erosion Hazard Zone," defined as the landward edge of the envelope of historic shoreline positions, as a more sustainable and lower cost approach. The Beach Stabilization Alternative, with several "sand retention structures" was found to require substantial ongoing nourishment and was expected to increase downcoast erosion during low-sediment-supply periods. PWA (2005, 2008) also showed that the Park Reconfiguration Alternative was less expensive, and had a lesser adverse effect on downcoast beaches than the shoreline stabilization project, and allowed maintenance of an adequate recreational beach and lawn.

- PWA (2008) also questioned the County's findings (Chambers Group, 2007) that (a) a massive beach fill and groin project would be cost-competitive with managed retreat, and (b) that a groin would not cause downcoast erosion.

- Prior studies have shown that pile supported piers affect nearshore morphology. For example, a pier in North Carolina was found to affect the nearshore within a distance of 1000 feet on each side of the pier, and out to the end of the pier which is about 1800' from shore (Miller, Birkemeier and DeWall, 1983). During uni-directional sand transport, accretion on the updrift side and erosion on the downdrift side has been found. Also, rip-current formation tends to occur near the pilings, and extend beyond the surf zone. The effect of the pier on nearshore depths and shoreline morphology was found to change markedly with changing wave conditions. These processes of localized depth changes and rip current formation were not modeled for Goleta, and the downdrift erosion was not identified. The modeling did not characterize the amount of fluctuation in the shore due to varying wave conditions.

- In addition to the above reports specific to Goleta Beach and vicinity, there are numerous other reports that address groins, piers and permeable groins. A more detailed review of the literature may provide information useful to the evaluation of the proposed structure at Goleta Beach. For example: "Permeable groin structures permit some sand to pass through the groin, but experience has shown that such structures are generally ineffective and are difficult to design, operate and maintain. (Page 4, USACE, 1981)".

3. COASTAL GEOMORPOHOLOGY

Coastal geomorphology is an important part of any coastal engineering endeavor, and is addressed by the EC report. Overall, we find the EC report to be a very useful analysis and contribution to the body of work addressing littoral processes at Goleta Beach. However, we disagree with the analysis and findings in several key areas, as follows.

The report does not adequately address fluctuations in sediment supply and beach width identified in PWA (2005) and Revell and Griggs (2006). The report also does not address the effect of the rock outcrop at the west end of Goleta Beach, even though it affects the shoreline position and can be analyzed as a short groin or small headland, and is an important feature in assessment of the performance of the managed retreat alternative. The EC report also does not address the effect of a reduced ebb-tide delta resulting from the filling of Goleta Slough, as identified in PWA (2005) and Revell and Griggs (2006), as a potentially important factor in shore erosion at Goleta Beach. These oversights reduce the utility of the EC report.

The EC report is an important factor in the MNE approach and is used to substantiate the modeling results. This is evident by review of Figure 3 in the MNE report which is from EC and not a result of modeling. The predicted shoreline is approximate and in our opinion over-predicts the widening of the beach significantly. This can be seen by reviewing Figure 8 of the EC report, where the proposed Beach Stabilization Alternative is off the left side of the graph, based on extrapolation, and the existing Goleta Bay planform plots well above the "best fit" line. The result is that the new shoreline could be oriented more to the west (larger "alpha" on the vertical axis of Figure 8) and the Park shoreline would not widen appreciably beyond the existing shoreline. Moreover, the EC report does not address a major difficulty in applying the crenulate bay data, which is identification of the headlands defining the planform. We therefore do not agree with the estimate shoreline positions or uncertainty provided by the EC report.

We note that the EC report (Figure 9) predicts that the beach at the west end of Goleta Beach would widen at least twice as much at the groin. This finding conflicts with our judgment and is uncertain based on the empirical data, and hence is not supported by this review.

The EC report does not address the mechanism of scour around piles or scour aggregating into a channel leading offshore as a mechanism for rip-current formation, and impact to nearshore bars, wave patterns and offshore transport, including down-coast erosion (Miller *et al*, 1983).

The conditions at the Goleta Pier and other piers in the vicinity were not surveyed to assess their affects.

The assertion that it is relatively easy to add and remove piles to "tune" the permeability of the groin is not substantiated by the EC report. Also the report does not provide a way of assessing whether the adaptive management actions are needed or effective other than to generally add more piles if more sand trapping is desired, etc. The quantitative connection between geometric permeability and sand transmission is not sufficient to assess feasibility or to form a basis for shoreline evolution modeling.

We note that the EC report also states great uncertainty associated with permeable groins, and hence feasibility seems to hinge on the weak conceptual model and associated adaptive management strategy of adding or removing piles. We therefore find that the report asserts feasibility beyond a level substantiated by the findings.

We do agree that the permeable groin would make an interesting experiment that may provide useful information for coastal zone engineering and management in California.

4. MODEL BOUNDARIES AND INPUT PARAMETERS

The GENESIS model was used to simulate changes in shoreline morphology (Moffatt & Nichol, 2007). This is a one-line numerical model that calculates longshore sediment transport and shoreline change as a result of sediment inputs and outflows and differences in nearshore wave breaking over space and time. The modeling areas and input parameters used for the model are described in Section 5.2 of Moffatt & Nichol (2007).

The set up of the model in terms of input parameters should mimic the prototype system as closely as possible, in particular

- temporal variations in the sediment input should be represented;
- temporal and spatial changes in wave conditions should be represented.

From the observations that are described in Section 2 of this memo, sediment input varies over time and is controlled both by conditions at Ellwood Beach and by the phase of the PDO. The model, as set up, has a number of assumptions that reduce its ability to represent the sediment transport system at Goleta Beach:

1. The western boundary of the model is Deveraux Point (Coal Oil Point) (Moffatt & Nichol 2007, Section 5.2.1). This is down drift of Ellwood Beach. The impoundment of sand and rotation of the beach at Ellwood Beach during an El Niño, which initiates an erosion wave that migrates downdrift starving Goleta Beach (Revell, Dugan, and Hubbard, in press), cannot be reproduced in the model. Similarly the episodic release of sand from Ellwood Beach to Goleta Beach will not be

modeled. A time-varying boundary condition could be used to better approximate the actual sediment supply over time, and hence the coastal response in the Goleta Beach area.

2. The "erosion wave" and pulses of sediment could have been represented in the model by varying the sediment input at Deveraux Point over time. However, the net longshore transport in the model is "specified to be the order of 300,000 cy per year to the east" (Moffatt & Nichol 2007, Section 5.2.6). So rather than pulses of sediment moving through the system, a steady supply is provided to Goleta Beach in the model. The known variability in the sediment supply is therefore not represented in the model.

3. The rate at which sediment is moved through the model is dependent upon the wave conditions that the model uses. The wave conditions used to drive the model are from June 2002 to June 2006. This four-year set of waves is then repeated to represent conditions over longer periods (Moffatt & Nichol 2007, p4-15). The variability in wave conditions related to changes in the PDO index are not represented (Adams *et al*, 2008); this time period did not capture a moderate or strong El Niño event. Rather the wave conditions used represent short-term average wave conditions without the El Niño events. As a consequence, the cylic movement of the "erosion wave" through the model is not modeled.

4. The modeled sand volumes and transport rates result in a continuous, net deficit to Goleta Beach. However, this presumed sediment budget is incorrect based on comparison of published sediment records that show a fluctuating net sand supply and volume, with the long term net (accretion or erosion) being small relative to the fluctuation. In other words, the modeled conditions are conceptually opposite of the actual conditions: a steady, long-term trend of erosion versus episodic pulses.

5. The model calibration and verification are weak. Some of the model runs indicate extensive erosion at Campus Beach, while others do not. The rock headland adjacent to the western parking lot is shown to erode rapidly and therefore appears to not be modeled correctly.

6. The MNE reports estimates that about 500,000 cubic yards of sand will be placed to widen the beach by up to 200 feet. The modeling starts with the sand distributed throughout the profile, out to closure depth. However, most beach nourishment results in a steeper nearshore profile with most sand placement nearshore. The subsequent cross-shore adjustment by waves distribute the sand over time. This cross-shore adjustment, adjustment timeframe and amount of sand placement to achieve the initial, theoretical shoreline are not addressed clearly, especially

considering the strong unidirectional transport, and appear to provide an optimistic assessment by assuming all 500,000 cubic yards are perfectly distributed at the start of the model tests.

The net result of the choice of model boundaries input parameters is to average the sediment input and wave conditions and not properly represent the pulses of sediment and "erosion wave" documented by Revell, Dugan, and Hubbard (in press). The important process of beach oscillations shown in episodic erosion and accretion events at Goleta Beach, due to the down drift movement of the "erosion wave", is therefore not represented.

The consequence of this is that alternatives, such as managed retreat and the Park Reconfiguration Alternative described by PWA in 2005 and 2008, that rely on the variability of the natural processes and a dynamic shoreline (i.e. regular pulses of sediment) are not properly represented. Alternatives that rely on a more fixed shoreline due to the trapping of sand by structures will perform better in the model given the inappropriate averaging of sediment supply and wave conditions. This is shown by the modeling of the existing condition which shows continual erosion when the beach is known to build out periodically. The model may therefore be unreliable in predicting shoreline changes under future conditions.

To properly model the "erosion wave" would require an unsteady boundary condition at the western boundary, and a coincident, unsteady wave input data. Neither of these appears to have been specified. The unsteady modeling should be verified by comparison with shoreline position and sediment budget data for the range of conditions pertinent to Goleta Beach. This has not been done in this study, although USGS modeling shows a variety of sediment transport changes for the same study area (Barnard *et al* 2009). Therefore, the ability of the GENISIS model to predict shoreline response at Goleta Beach is unknown. More than likely, the model is not accurate.

5. MODELING OF THE PILE GROIN

The modeling of the pile groin relies on the correct representation of the given structure in the model. The performance of a pile groin is very difficult to anticipate and this fact is acknowledged throughout the literature (USACE, 1981). The pile groin that is represented in the GENESIS model is sketched in Everts (2006, p25-26) who provides a preliminary guess on the size of structure required to retain the desired 200ft salient (Everts 2006, p.27). The permeability of the pile groin in Everts (2006) is defined as a function of the physical dimensions of the structure:

$$\frac{\text{open area}}{\text{total wetted cross-sectional area}} \text{ (Everts 2006, p24)}$$

which will be inversely proportional to flow resistance through the structure and is specified at 35%.

In the GENESIS model, as reported in Moffatt & Nichol (2007), the permeability of the groin is specified differently as:

$$\frac{\text{sand passing through the structure to the downcoast side}}{\text{total amount of sand}} \quad \text{(Moffatt \& Nichol 2007)}$$

and again is specified as 35%. These two definitions of permeability lead to confusion as to the performance of the structure being modeled. Sand transport is not shown to scale linearly with percent opening in either the EC or MNE reports, and the effect on currents is not explicit in these definitions. The GENESIS model is not a test of the dimensions or layout of the structure, but rather it is its anticipated performance assuming that it performs to specification. The modeling is therefore a test of "what happens if you reduce the transport rate by 65% at a particular location along the shoreline" rather than "will this structure perform as specified".

There are two missing steps in the modeling. The first, acknowledged in the reports (Everts 2006, p27), is determining what structure will give 35% permeability in terms of sediment trapping. The Everts (2006) report recommends detailed analysis on the design of the structure but there is no evidence that this was undertaken for the Moffatt & Nichol (2007) report.

Physical modeling has been undertaken on other pile groins, which was recommended in the EC report, but never completed. This has generally been with fixed bed models (e.g. Trampenau *et al*, 2004) which model the effect of the structure on the longshore current velocity and from that infers the impact on sediment transport. Fixed bed models will therefore not provide answers on how much the sediment transport rate is reduced nor on how the beach plan shape will evolve. However, modeling pile groins in a movable bed model is much more problematic.

The scaling of material in mobile bed models is generally related to the velocity at which the material settles in water. This is not usually the same scale as that used for the dimensions of the structure. As a consequence mobile material will tend to be relatively larger in the model than in reality. Due to non-linearities associated with reduced scale hydraulic models, wave-induced sediment transport through structures cannot be accurately scaled. This is not so much of a problem with modeling open beaches or continuous structures such as impermeable groins or sea walls. It is a problem where the physical interaction of the structure and the mobile material needs to be reproduced (i.e. how much sediment will move through the pile structure versus how much will get trapped).

The use of field evidence seems to be the most pragmatic course, coupled with an adaptive management process that will allow the pile groin to be "fine-tuned" following construction. However that adaptive management process may be difficult to implement at Goleta Beach given its particular sediment transport regime.

The second missing step is to determine the down drift impact of not achieving the specified permeability, resulting in actual permeabilites either above or below 35%. Qualitatively:

- if the groin is too impermeable, then sand will be deflected offshore by the structure and not return directly onshore, the result will be downdrift erosion in the lee of the structure;
- if the groin is too permeable, then sand will not be trapped and the updrift fillet will be smaller than anticipated.

6. ADAPTIVE MANAGEMENT OF THE PILE GROIN

Everts (2006, p27) suggests that the "pile groins, especially wide ones, are flexible in the sense they can be tweaked after construction". It is suggested that a pile alignment and pattern be developed that could later be altered by, most probably, removal of some piles. This requires some quantifiable parameter which can be used to judge the performance of the groin. Everts (2006, p.28) appears to suggest using dynamic equilibrium beach width. This would account for the natural variability in beach width in the long–term. Piles would be added or removed until an acceptable dynamic equilibrium beach width had been achieved.

At Goleta Beach, however, this natural beach variability is associated with coherent pulses of sediment or "erosion" and "accretion" waves and the PDO index affecting wave climate (Revell, Dugan, and Hubbard in press, Revell and Griggs 2007). The variability in beach width therefore occurs over periods of decades. Fine-tuning the pile groin will therefore be made very difficult as the wave energy and sand supply climates change over time. It may be that fine-tuning becomes an ongoing process of adapting to changing conditions to minimize downcoast sand supply impacts. Essentially, "chasing the tail" of fluctuating shorelines with structural modifications of unknown effect.

7. SUMMARY

1. The GENESIS model as described in Moffatt & Nichol (2007) will not reproduce the long term sediment transport regime as observed at Goleta Beach (Revell, Dugan, and Hubbard in press). The choice of model boundaries, wave conditions and sediment input does not allow the decadal variability in sand transport to be represented.

2. A pile groin has been described in Everts (2006) based upon observation of similar structures in the field. It is not clear that the pile groin described has been properly represented in the GENESIS model. It is further unclear how the detail design of the pile groin will be undertaken. At present only its performance has been specified, not its structure.

3. The modeling is not adequate to predict the performance of the proposed groin. The effects and effectiveness of the proposed groin are unknown.

4. The proposed adaptive management strategy of removing or adding piles has no quantified basis and hence is difficult to support other than in theory. We do not think the adaptive management concept mitigates the risk of poor performance and adverse environmental effects.

5. The massive beach fill of 500,000 cubic yards is the element of the proposed project that affects the shoreline evolution modeling.

8. IMPLICATIONS

1. The feasibility of attaining the desired beach response with the permeable groin is unproven and dubious.

2. The future shoreline evolution predictions are likely erroneous, and misleading.

3. The Beach Stabilization Project is not likely to perform as presented in the MNE and EC reports. The Beach Stabilization Project may induce erosion downcoast; will likely require massive additional sand placement to protect "the lawn" and other park amenities, and will require extensive resources to adaptively manage the park with structural modifications of unknown effect.

4. The County's assertion that the project should be permitted on the basis of this technical modeling is not, in our professional opinion, valid: the Permeable Groin is experimental, and the Beach Stabilization Project description is erroneous in terms of effects and effectiveness.

9. REFERENCES

Adams, P.N., Inman, D.L and Graham, N.E. 2008. Southern California Deep-water Wave Climate: Characterization and Application to Coastal Processes. *Journal of Coastal Research*, Vol.24, No.4, p1022-1035.

Barnard, P.L., Revell, D.L., Hoover, D., and Warrick, J. 2009. *Coastal Processes Study of Santa Barbara and Ventura County, California*. Report to BEACON and Army Corps of Engineers. USGS Open File Report 2009- 1029.

Chambers Group, 2007. *Environmental Impact Report for Goleta Beach County Park Long-Term Protection Plan*. Prepared for Santa Barbara County Parks. March 2007.

Everts Coastal, 2006. *Sand Retention Concept for Goleta Beach, Santa Barbara County, California*, report prepared for The Chambers Group, August 2006.

Hapke, C.J, Reid, D., Richmond, B.M., Ruggiero, P., List, J., 2006. *National Assessment of Shoreline Change Part 3. Historical Shoreline Change and Coastal Land Loss Along Sandy Shorelines of the California Coast*. USGS Open File Report 2006-1219.

Miller, H.C., Birkemeier W.A.and DeWall A.E., 1983. *Effects of CERC Research Pier on Nearshore Processes*, Proceedings of Coastal Structures '83, ASCE, pp 769-784.

Moffatt & Nichol, 2007, *Final Draft Report on Shoreline Morphology Study, Appendix A- Sand Retention Concept*, draft report prepared for Chambers Group, January 2007.

PWA, 2005, Master Plan, Goleta Beach County Park, Shoreline Management Alternatives, prepared for Santa Barbara County Parks, PWA Project 1743.01. June, 2005.

PWA, 2008, *Goleta Beach County Park: Park Reconfiguration Managed Realignment Alternatives*, prepared for Surfrider Foundation – Santa Barbara Chapter and Environmental Defense Center, PWA Project 1940. October 2008.

Revell, D.L. and Griggs, G.B., 2006. Beach Width and Climate Oscillations along Isla Vista, Santa Barbara California. *Shore and Beach* vol 74(3): 8-16.

Revell, D.L. and Griggs, G.B., 2007. Regional Shoreline and Beach Changes in the Santa Barbara Sandshed. In *Coastal Sediments 2007.*ASCE New Orleans, LA May 2007. pg 1740-1753.

Revell, D. L., Dugan, J.E., Hubbard, D.M., in press. Physical and Ecological Responses of Sandy Beaches to the 1997-98 El Niño. *Journal of Coastal Research.*

Trampenau, T., Oumeraci, H., Dette, H.H. 2004. Hydraulic Functioning of Permeable Pile Groins. *Journal of Coastal Research*, Special Issue 33, 160-187.

USACE, 1981. *Groins – Their Applications and Limitations*, Coastal Engineering Technical Note, CETN-III-10, 3/81, by U.S. Army Corps of Engineers, Coastal Engineering Research Center.

10. LIST OF PREPARERS

Bob Battalio, P.E.
David Revell, Ph.D.
Jeremy Lowe

TECHNICAL REVIEWERS

Michael Walther, P.E.

Attachment #3

Memo

May 11, 2009

To: Brian Trautwein, Analyst - Environmental Defense Center
Via: Michael Walther - Coastal Tech
From: Dilip K. Barua, Ph.D. - Coastal Tech

Re: Comments on the Goleta Modeling Review

This Memo is:

- in response to a request to the *Surfrider Foundation* Environmental Issues Team (EIT) for "peer review of the Philip Williams and Associates critique of Santa Barbara County Parks Department's modeling of the Goleta Beach groin project";
- rendered on behalf of the Santa Barbara Chapter of the *Surfrider Foundation* and solely reflects the cited professional coastal engineering opinions based on review of documents as provided by EDC and as referenced below;
- to provide comments relative to the efficacy of the GENESIS modeling as reflected in the memo titled "Goleta Modeling Review" (dated 03/15/2009) prepared by Philip Williams Associates (PWA); and the report titled "Draft Report: Shoreline Morphology Study – Goleta Beach County Park Long-term Plan" (dated 01/05/2007) prepared by Moffatt & Nichol (M&N).

In general, relative to the fundamental issues at hand, the GENESIS modeling results appear to be inadequate for this particular application due in part to anomalous El Niño storm effects. Additionally, reviews indicate that an alternate modeling strategy involving "sensitivity analysis" would likely have yielded a more broad range of feasible results within the limitations of GENESIS. In any event, it is likely that, even based upon the M&N analysis, the permeable pile-groin is likely to adversely affect the downdrift beaches.

Please note the following:

General: GENESIS is applied by M&N as the modeling tool to study beach processes and erosion, and for assessment/optimization of remedial alternatives. Available literature shows that Goleta Beach has suffered from episodes of high erosion during El Niño events.

The PWA review as well as the M&N report have rightly pointed out that the beach morphology is affected both by regular westerly swells and by anomalous El Niño conditions. The effects of El Niño, caused apparently by water level change, and enhanced wind and wave activities are responsible for beach erosion along the eastern Pacific shorelines (see, for example, Rivas, 1993; Arciniega et al, 2003).

The applied USACE software GENESIS is a line model suitable for investigating long-term and large-scale shoreline trends. It is based on the assumptions that cross-shore profiles remain constant during the simulation period; the translation (retreat or advance) of shoreline in time, therefore, results solely from changes in longshore transport rates (see, Hanson and

Kraus, 1989). GENESIS is not the right tool to simulate shoreline changes caused by anomalous wave activity such as during El Niño events. While M&N recognizes the importance of El Niño or Pacific Decadal Oscillation (PDO) Index (see M&N report, section 3; note the typographical mistake in Chapter numbering), it appears that software limitations or other constraints have prevented them from including it. Line models use boundary forcing of time-series wave data in frequency bands. In other words, real time series is partitioned or folded into height, period and directional bins with different frequencies of occurrence. This is suitable for ensuring run-time efficiency, and is adequate for simplified line-model formulation.

The calibration of GENESIS (Figures 23 and 24, M & N report) appears weak; calibration perhaps could have been tweaked and improved somewhat using a finer grid (model alongshore grid spacing is 100 m, page 4-10). But experience shows that line-model calibration can only be tuned to a certain limit. The M&N statement (page 4-14); "*The calibrated parameters can predict the trends of shoreline change and transport fairly well with the measured data in the verification period.*" is probably an optimistic overstatement.

PWA Memo: The following comments relate to the PWA Memo dated March 15, 2009:

Section 3: Model Boundaries and Input Parameters

1. For such a morphologically active region, the selection of Deveraux Point as a model boundary is not an ideal choice. However, the boundary is far from the area of interest. The modeler could have made some sensitivity runs to resolve the issue following a "gated or pinned-beach" boundary approach.

2. Specification of 'erosion wave' or 'pulses of sediment transport' is not straightforward because, as discussed, boundary conditions are specified in frequency bands. Again judgments and sensitivity runs could likely resolve this issue.

3. The specification of wave conditions is made in frequency bands – therefore, it is the limitation of the software that seems to have prevented the modeling effort in including time-series. GENESIS is neither ideal, nor suitable for specifying real time-series. The software is developed to analyze a portion of the physical processes (in this case only the littoral transport and the resulting shoreline change) under simplified assumptions. The M&N report should have provided the used wave and water level data either in the form of a table and/or as a graph; none of this is presented.

Section 4: Modeling the Pile Groin

There are numbers of issues in the design and assessment of structures – resolution, diffraction and permeability (ability to let sand flow through the structure). Apart from software constraints, success depends on the modelers' skill and creativity. There is a large difference between the permeability in terms of relative water area and that in terms of relative sand passing. Whether a permeability number of 35% is applicable for the pile configuration is debatable – the number should have come from laboratory tests or from physical modeling. In such absence, sensitivity runs could have provided a more broad range of feasible responses. On permeability, the M&N report shows that the Goleta Pier permeability coefficient is 0.8, (Page 4-5, Table 6), while the sand retention structure (no configuration is presented or designed!) is modeled with a permeability coefficient of 0.35. The M & N statement in page 4-23, "*......this structure appears to meet the objective of widening the beach and stabilizing the shoreline position of the long-term, while not inducing downcoast erosion.*" is neither substantiable by model results using only one permeability coefficient, nor intuitively justifiable. If the structure lets only 35% of sand to pass through, simple sediment budget analysis suggests that, the beach immediately downcoast of the structure would face sediment deficit and probable erosion.

If you have any further questions, or if we can assist you further, please contact us.

References:

Arciniega, R.L., Chee-Barragan, A., Gil-Silva, E., Mendoza-Ponce, T. and Martinez-Diaz de Leon, A., 2003. Effect of El Nino on the subaerial beach Playas de Rosarito, B.C., Mexico. Geofisica International, 42(3), 419-428.

Hanson, H. and Kraus, N.C., 1989. GENESIS: Generalized Model for Simulating Shoreline Change. Report 1, Technical Reference. USACE.

Moffatt & Nichol (M & N), 2007. Draft Report: Shoreline Morphology Study – Goleta Beach County Park Long-term Plan. Moffatt & Nichol, January 5, 2007.

Philip Williams & Associates (PWA), Ltd., 2009. Goleta Modeling Review. Philip Williams & Associates, March 15, 2009.

Rivas, N.T., 1993. Erosion and Accretion Processes during El Nino Phenomenon of 1982-1983 and Its Relation to Previous Events. Bull. Inst. fr. etudes andincs, 22(1), 99-110.

Attachment #4

Goleta Beach County Park Master Plan
County and Coastal Act Policy Discussion and Consistency Analysis

Prepared by Environmental Defense Center for Surfrider Foundation
7-1-09

<u>Coastal Act</u>

WETLANDS

<u>Section 30233:</u>
"The diking, filling, or dredging of open coastal waters, wetlands, estuaries, and lakes shall be permitted in accordance with other applicable provisions of this division, where there is no feasible less environmentally damaging alternative, and where feasible mitigation measures have been provided to minimize adverse environmental effects, and shall be limited to the following:"

(1) new or expanded port or energy or coastal dependent industrial facilities;
(2) maintaining navigational channels, berthing areas, mooring areas;
(3) entrance channels for new or expanded boating facilities;
(4) placement of piers that provide public access and recreation;
(5) incidental public services (e.g., burying cables and pipes);
(6) mineral extraction, including sand for restoring beaches, except in environmentally sensitive areas;
(7) restoration purposes;
(8) nature study, aquaculture.

<u>Analysis:</u>
Like Local Coastal Plan (LCP) Policies 9-6 and 9-9, Coastal Act Section 30233 does not permit structures such as groins – where the primary purpose is erosion control – in open coastal waters and wetlands such as the beach below the Mean High Tide Line. The Groin Project is not "placement of piers that provide public access and recreation" because the pier already exists and already provides public access and recreation. The purpose of the groin is not to provide access and recreation on a pier but to make Goleta Beach wider by trapping sand. Hence the groin clearly violates Coastal Act Section 30233.

The staff report alleges that even if the groin would conflict with Section 30233, that is acceptable because the groin is consistent with Section 30235, which is more specific to shoreline structures than Section 30233. However, Section 30233 is specific to protecting coastal waters from dredge and fill activities. The groin project must comply with both Section 30233 *and* Section 30235.[1] The project violates Section 30233 as noted above,

[1] A statute should be construed in the context of the entire statutory system of which it is a part in order to achieve harmony among the parts. *Nickelsberg v. Workers' Comp. Appeals Board* (1991) 54 Cal.3d 288, 298 [285 Cal.Rptr. 86].

and thereby must be rejected. In addition, as noted above, the project also violates Section 30235 because the groin is not required to serve coastal-dependent uses or to protect existing structure or public beaches.

To the extent policies may overlap (for example, Sections 30233 and 30235) the Coastal Commission must resolve said conflict in the manner which is overall most protective of coastal resources. (Coastal Act Section 30007.5) To achieve the greatest protection on balance for coastal resources, the Groin Project must be denied in favor of the Park Reconfiguration Alternative.

SHORELINE STRUCUTRES

Section 30235:
"Revetments, breakwaters, groins, harbor channels, cliff retaining walls, and other construction that alters natural shoreline processes shall be permitted when required to serve coastal dependent uses or to protect existing structures or public beaches in danger from erosion and when designed to eliminate or mitigate adverse impacts on local shoreline sand supply...."

Analysis:
This section of the Act allows groins when required, but only when they are designed to avoid or mitigate sand supply impacts, and only when consistent with the other applicable policies and laws. The Groin Project will cause down-coast impacts (PWA 2008, PWA 2009, Keller 2006, and Coastal Tech 2009) which can be only partially mitigated and only mitigated after-the-fact, i.e. after the threshold is exceeded. Bluff erosion cannot be mitigated once it is initiated.

The accumulation of wrack on the groin will reduce its permeability and increase the impact of down-coast beach sand supply. There is no plan to remove the wrack in the County's Coastal Development Permit (CDP) application, because this impact was not anticipated until it was raised by Dr. Dugan on May 20, 2009. Even if the wrack is periodically removed, it will reduce sand supply beyond the design permeability, adding to down-coast impacts.

Moreover, groins and other structures are only allowed on beaches "when required to serve coastal dependent uses or to protect existing structures or public beaches in danger from erosion." (Emphasis added.) Because the Park Reconfiguration Alternative is feasible and fully protects Goleta Beach Park and the beach itself, the Groin Project is not "required" to serve coastal dependent uses or to protect existing structures or beaches and must be viewed as inconsistent with Coastal Act Section 30235.

ENVIRONMENTALLY SENSITIVE HABITAT AREAS (ESHA)

Section 30240:

(a) "Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.

(b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas."

Analysis:

The Groin Project violates Section 30240 of the Coastal Act because the groin is a use and development in ESHA that is not dependent on the ESHA; the groin is not designed to protect, enhance or increase human enjoyment of the ESHA. Section 30240 requires protection of beach ESHA from development and uses that cause significant impacts to ESHA. Intertidal areas and beaches supporting grunion are ESHA. (Dr. Karen Martin, Pepperdine University, comments on draft EIR for Goleta Beach Project, May 14, 2007.) Attached EIR comments by biologist Mark Holmgren also describe why Goleta Beach is ESHA. The Groin Project would cause down-coast narrowing of beach ESHA, significantly reducing the habitat values of the ESHA. Uses that harm ESHA and are not dependent on the resources of the ESHA are not allowed in ESHA. Therefore, the groin violates section 30240 of the Act.

The proposed sea floor sand dredging and beach sand berm construction violate Section 30240 of the Act. Additionally, the groin's reduction in down-coast beach width leads to erosion of other ESHA, including bluff scrub. Increased bluff erosion caused by the groin's depletion of down-coast sand would constitute a violation of the Coastal Act.

Additionally, the pile groin will trap beach wrack, interfering with wrack reaching down-coast beaches. Trapping of the wrack on the groin and depletion of wrack on down-coast beaches further degrades the onsite and down-coast beach ESHA in violation of Section 30240. Pile groin maintenance such as removing accumulated wrack from the beach ESHA is not a use that is dependent on the resources of the ESHA and is a further violation of Section 30240(a).

ACCESS AND RECREATION

Section 30210:

"In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for the people consistent with public safety needs and the need to protect public rights, rights of property owners, and natural resource areas from overuse."

Analysis:

Access and recreational opportunities must be consistent with the need to protect natural resources from overuse. When conflicts arise, access and recreation are ultimately subordinate to habitat protection under the Coastal Act and LCP.

Installing a groin to protect recreation while incidentally adversely affecting ESHA is inconsistent with Coastal Act Section 30210.

The County LCP notes "These fees may present a barrier to use of public beaches by persons of low and moderate income." (LCP Page 81) Initiating parking fees to fund a project purportedly intended to maintain access and recreation is not providing maximum access and will limit some people from accessing Goleta Beach.

Section 30211

"Development shall not interfere with the public's right of access to the sea where acquired through use or legislative authorization, including but not limited to, the use of dry sand and rocky coastal beaches to the first line of terrestrial vegetation."

Analysis:

The groin structure will result in significant recreational impacts and would interfere with the public's right to access and use the beach. Specifically, the pier and adjacent beach area would be closed by the groin project from June through April for construction, would be closed intermittently for groin pile tuning, and would also be closed by beach nourishment further limiting access to the beach during project construction and operation. Even the County's EIR found pier and adjacent beach closures caused by the groin construction, tuning and nourishment to be Class I significant impacts to recreation which cannot be mitigated. The groin project's interference with public beach access violates Coastal Act section 30211.

Charging parking fees to pay for the groin as outlined in attached County documents would also limit the public's right to access the beach as noted on page 81 of the County's LCP: "These fees may present barriers to use of public beaches by persons of low and moderate incomes." Plans by the County to charge parking fees interferes with the public's right to access the beach pursuant to section 30211.

Like the groin project, the Park Reconfiguration Alternative would cause temporary closures during removal of revetments. However, The Park Reconfiguration Alternative avoids pier and beach closures caused by the groin construction and tuning, and lessens the nourishment related beach closures by approximately 95% according to Philip Williams and Associates.

Section 30214:

"The public access policies of this article shall be implemented in a manner that takes into account the need to regulate the time, place, and manner of public access depending on the facts and circumstances of each case including, but not limited to, the following: (3) The appropriateness of limiting public access to the right to pass and repass depending on such factors as the fragility of the natural resources in the area …."

Analysis:

This Coastal Act provision reinforces the requirement that access and recreation, while important, are ultimately a lower priority than protecting natural resources. The Groin

Project prioritizes access and recreation over fragile natural resources (e.g., Grunion spawning areas, beach ESHA) and conflicts with Coastal Act Section 30214.

MARINE ENVIRONMENT

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, recreational, scientific, and educational purposes."

Analysis:
The proposed Groin Project can reduce the biological productivity of the beach wetland environment. (See attached evidence from Mark Holmgren, Biologist.) According to the County's own analysis, dredge and fill causes water quality and biological impacts on the sea floor and beach, and groin construction and operation reduces the biological productivity of the beach habitat. (See Proposed Final EIR, Impacts BS-Mar-1, -3, -5, -6, -7, -8, -9, -10; pp 4.1-17 to 4.1-27.) The groin will narrow beaches down-coast, affecting grunion runs and other species that require wide sandy beaches. (See attached comments by Dr. Jennifer Dugan regarding Goleta Beach draft EIR.) In this way, the Groin Project is inconsistent with Coastal Act Section 30230.

Section 30231:
"The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored, through, among other means, ..."

Analysis:
The Groin Project is inconsistent with Section 30231 because it will narrow down-coast intertidal beach wetlands, thereby reducing the biological productivity of those wetlands. (See attached comments on Draft EIR by Dr. Jennifer Dugan; see also Philip Williams and Associates 2008, 2009.) Extensive sea floor dredging required for the groin (but not required for the Park Reconfiguration Alternative) reduces the quality of coastal water by agitating sediment and causing turbidity plumes. (Chambers Group 2001; Altstatt 2007.)

Beach grooming also significantly interferes with biological productivity, according to current scientific evidence. To the extent the groin widens Goleta Beach, the beach would be groomed over a larger area. Conditions should limit beach grooming to mitigate impacts to the sandy beach.

VISUAL RESOURCES

Section 30251:

"The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance. Permitted development shall be sited and designed to protect views to and along the ocean and scenic coastal areas, to minimize the alteration of natural land forms, to be visually compatible with the character of surrounding areas, and, where feasible, to restore and enhance visual quality in visually degraded areas...."

Analysis:
The County's Visual Simulations (attached) of the proposed Groin Project depict significant degradation of the scenic views to and along Goleta Beach and of Goleta Point. The County's consultant calls these simulations "not too pretty to be sure." (February 1, 2008 e-mail from Chris Webb, Moffett and Nichols to Dave Ward, Santa Barbara County.) The pile groin almost entirely blocks views looking through the existing relatively open pier structure, intrudes into public skyline views and violates Coastal Act Section 30251.

GEOLOGICAL PROCESSES

Section 30253:
"New development shall: (2) neither create nor contribute significantly to erosion...."

Analysis:
Evidence in the record (PWA 2008, PWA 2009, Coastal Tech 2006, and Coastal Tech 2009) demonstrates that the groin will cause down-coast beach erosion and may potentially cause irreversible bluff erosion and consequent violations of the Coastal Act.

Local Coastal Plan (LCP)

GUIDING POLICIES

LCP Policy 1-2:
"Where policies of the land use plan overlap, the policy which is the most protective of coastal resources shall take precedence."

Analysis:
Coastal Act and LCP policies for access and recreation are very important, yet are subordinate to the protection of natural resources. LCP Policy 1-2 requires that ESHA policies override access and recreation policies if policies for access/recreation and habitat protection overlap. For instance, LCP policies and Coastal Act Section 30240 strictly require protection of ESHA such as beaches, dunes, bluffs and wetlands. The Groin Project prioritizes access and recreation above ESHA. Therefore, the Groin Project's adverse ESHA effects are violations of Policy 1-2. The Park Reconfiguration Alternative, on the other hand, protects ESHA, maintains access and recreation, and complies with Policy 1-2.

SHORELINE PROTECTION

Policy 3-2:
"Revetments, groins, cliff retaining walls, pipelines and outfalls, and other such construction that may alter natural shoreline processes shall be permitted when designed to eliminate or mitigate adverse impacts on shoreline sand supply and so as to not block lateral beach access."

Analysis:
Policy 3-2 requires mitigation of impacts to shoreline sand supply. However, if down-coast impacts do not exceed a threshold, mitigation would not be triggered. If an impact that does exceed the threshold is detected, the impact has already occurred. It will take some time for: (1) piles to be removed, (2) beaches to be nourished, and (3) sand to reach and replenish down-coast beaches. Mitigation is therefore insufficient, and the Groin Project would violate Policy 3-2.

Action GEO-GV-1.2 of the County's General Plan supports a non-structural solution which includes placing development outside of erosion hazard areas.

Accumulation of wrack on the pile groin structure will reduce permeability and limit sand supply necessary to replenish down-coast beaches. While groin pile tuning is proposed to adapt the structure to changing sand supply conditions – in order to try to mitigate down-coast impacts after-the-fact – no mitigation measure or special condition is proposed that would adapt the groin's permeability to frequent wrack accumulation. This would cause a violation of LCP Policy 3-2.

Moreover, a project must comply with all LCP Policies, or the County may not approve it. Policies 9-32 and 9-9 below state respectively that shoreline structures should not be in the intertidal zone and are not permitted within 100 feet of a wetland (including the beach). Policy 3-1 above requires the County to find that no less damaging alternative is feasible before any type of structure can be approved. Policy 1-2 states that the policy most protective of coastal resources controls when there is a conflicts amongst LCP policies. Policies 9-32, 9-9 and 3-1 are more protective of coastal resources than Policy 3-2. The groin fails to comply with these policies. Therefore the project is inconsistent with the LCP.

VISUAL RESOURCES

Policy 4-3:
"In areas designated as rural on the land use plan maps, the height, scale, and design of structures shall be compatible with the character of the surrounding natural environment, except where technical requirements dictate otherwise. Structures shall be subordinate in appearance to natural landforms; shall be designed to follow the natural contours of the landscape; and shall be sited
so as not to intrude into the skyline as seen from public viewing places."

Analysis:

The pile groin structure would intrude above the skyline as viewed from public viewing locations including the beach and depicted in visual simulations attached to EDC's letter.

RECREATION / CARRYING CAPACITY

Policy 7-4:

"The County, or appropriate public agency, shall determine the environmental carrying capacity for all existing and proposed recreational areas sited on or adjacent to dunes, wetlands, streams, tide pools, or any other are designated as "Habitat Areas" by the land use plan. A management program to control the kinds, intensities, and locations of recreational activities so that habitat resources are preserved shall be developed, implemented, and enforced. The level of facility development (i.e., parking spaces, camper sites, etc.) shall be correlated with the environmental carrying capacity."

Analysis:

Policy 7-4 requires the Goleta Beach Carrying Capacity Study (GBCCS) to be completed "as staff and funding become available." (LCP Policy 1-5.) The County has had the staff and funding necessary to complete the GBCCS since it was drafted in the 1990s.

This study is supposed to include a management program to control the kinds, intensities and locations of recreation. Since development should be correlated with carrying capacity, the GBCCS should be done prior to consideration of additional developments at Goleta Beach.

To comply with Policy 7-4, the Goleta Beach project must include and be consistent with an updated GBCCS.

HABITAT POLICIES

Policy 9-1:

"Prior to the issuance of a development permit, all projects on parcels shown on the land use plan and/or resource maps with a Habitat Area overlay designation or within 250 feet of such designation or projects affecting an environmentally sensitive habitat area [ESHA] shall be found to be in conformity with the applicable habitat protection policies of the land use plan. All development plans, grading plans, etc., shall show the precise location of the habitat(s) potentially affected by the proposed project. Projects which could adversely impact an environmentally sensitive habitat may be subject to a site inspection by a qualified biologist to be selected jointly by the County and the applicant."

Analysis:

The LCP policies are mandatory and habitat maps must be included in the project's application materials. Goleta Beach is a major grunion spawning habitat and includes the Goleta Slough mouth. (Dr. Karen Martin 2007.) In addition, a significant seabird nesting and roosting site exists just across the Slough mouth from the project site. (See attached 2008 email from Mark Holmgren, UCSB biologist.)

ESHAs are defined in Coastal Act Section 30107.5 as "any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments."

Goleta Beach's sandy beach plays a special role in the ecosystem by providing zones for species to migrate with the tides to avoid predation and detrimental conditions. Goleta Beach's sandy beach is an ESHA.

Additionally, beaches are a type of wetland habitat. Given this information, the sandy beach, intertidal and rocky point areas at Goleta Beach County Park and affected beaches down-coast are ESHA.

WETLANDS

Policy 9-6:
"All diking, filling and dredging activities shall conform to the provisions of Sections 30233 and 30607.1 of the Coastal Act. Dredging, when consistent with these provisions and where necessary for the maintenance of the tidal flow and continued viability of the wetland habitat or for flood control purposes, shall be subject to the following conditions:

a. Dredging shall be prohibited in breeding and nursery areas and during periods of fish spawning and migration.
b. Dredging shall be limited to the smallest area feasible.
c. Designs for dredging and excavation [projects shall include protective measures" ... e.g., silt curtains, etc."

Analysis:
The groin involves fill of wetlands and waters of the State (i.e. construction of piles). Section 30233 of the Coastal Act only allows fill in wetlands for 8 specific uses, none of which are groins. Furthermore, the specified uses are only allowed if there is no alternative to filling the wetlands and if impacts are mitigated to the extent feasible. The groin project includes no mitigation for the placement of fill in wetlands. There is a feasible alternative which fulfills all project objectives and avoids placing piles as fill in wetlands. Therefore, placement of the piles as fill in coastal wetlands violates Coastal Act Section 30233 and LCP Policy 9-1.

Policy 9-9:
"A buffer strip, a minimum of 100 feet in width, shall be maintained in a natural condition along the periphery of all wetlands. No permanent structures shall be permitted within the wetland or buffer area except structures of a minor nature, i.e., fences, or structures necessary to support the uses in Policy 9-10.

The upland limit of a wetland shall be defined as: 1) the boundary between land with predominantly hydrophytic cover and land with mesophytic or xerophytic cover; 2) the boundary between soil that is predominantly hydric and soil that is predominantly non-hydric; or 3) in the case of wetlands without vegetation or soils, the boundary between the land that is flooded or saturated at some time during years of normal precipitation and land that is not.

Where feasible, the outer boundary of the wetland buffer zone should be established at prominent and essentially permanent topographic or manmade features (such as bluffs, roads, etc.). In no case, however, shall the boundary be closer than 100 feet from the upland extent of the wetland area, nor provide for a lesser degree of environmental protection than that otherwise required by the plan. The boundary definition shall not be construed to prohibit public trails within 100 feet of a wetland."

Analysis:
The Groin Project would be constructed within coastal wetlands and State waters and would violate Policy 9-9, which prohibits any new development including groins in or within 100 feet of wetlands (e.g., the beach and slough). Intertidal areas meet the Coastal Act and LCP definitions of wetlands. Groin construction in wetlands is prohibited by Policy 9-9.

Policy 9-14:
"New development adjacent to or in close proximity to wetlands shall be compatible with the continued existence of the habitat area and shall not result in a reduction of the biological productivity or water quality of the wetland due to runoff (carrying additional sediment or contaminants), noise, thermal pollution or other disturbances."

Analysis:
According to the engineers and geologists who have commented on the Groin Project, the groin will result in a narrowing of sandy beaches down-coast. This will narrow the habitat zones, potentially eliminating the dry sandy beach zone according to Dr. Jenny Dugan. This would also decrease the productivity and diversity of the beach wetland habitat, according to Dr. Dugan. These impacts render the groin inconsistent with Policy 9-14.

Policy 9-16b:
"The County shall request the Department of Fish and Game to identify the extent of degradation which has occurred in the Carpinteria Estero and Goleta Slough pursuant to Section 30411 of the Coastal Act. As part of the study, the Department, working jointly with the Santa Barbara County Flood Control District and the Soil Conservation Service, will also identify the most feasible means of restoration of the areas of wetlands to be restored."

Analysis:
The record illustrates that the County has not coordinated with the Department of Fish and Game regarding Goleta Slough protection or restoration in the context of the Groin Project.

ROCKY POINTS AND INTERTIDAL AREAS

Policy 9-31:

"Only light recreational use shall be permitted on public beaches which include or are adjacent to rocky points or intertidal areas."

Analysis:

The proposed groin is adjacent to an intertidal area but is not a light recreational use. Therefore, construction, operation, and maintenance of the groin and grading for sand berms are inconsistent with Policy 9-31.

Policy 9-32:

"Shoreline structures, including piers, groins, breakwaters, drainages, and seawalls, and pipelines, should be sited or routed to avoid significant rocky points and intertidal areas."

Analysis:

The groin is planned in an intertidal area. Therefore the groin violates Policy 9-32. Feasible project alternatives avoid shoreline structures in intertidal areas in compliance with Policy 9-32, demonstrating the County can avoid the intertidal area, comply with Policy 9-32, and still fulfill its objectives.

Coastal Zoning Ordinance

Sec. 35-61: Beach Development

To avoid the need for future protective devices that could impact sand movement and supply, no permanent above ground structures shall be permitted on the dry sandy beach except facilities necessary for public health and safety, such as life guard towers, or where such restriction would cause the adverse condemnation of the lot by the County.

Analysis:

The proposed groin would be a structure on the dry sandy beach. The groin would not be necessary to protect public health or safety, such as a life guard tower, and is not necessary to avoid inverse condemnation of the lot by the County. Therefore the proposed groin is inconsistent with the zoning ordinance and cannot be approved.

Goleta Community Plan

GEOLOGY, TOPOGRAPHY, AND SOILS

Policy GEO-GV-3:

"Where feasible and where consistent with Local Coastal Plan Policies, relocation of structures threatened by bluff retreat shall be required for development on existing legal parcels, rather than installation of coastal protection structures." (Emphasis added.)

Analysis:

This policy requires that, where feasible, relocating threatened structures shall be pursued instead of coastal armoring. Relocation of existing utilities is feasible at Goleta Beach according to PWA 2005 and PWA 2008. The fact that this area is County-owned (public) property makes it even more feasible (i.e., the County has or can obtain the resources and authorizations necessary to relocate structures). Even including the costs of relocating utilities, the Park Reconfiguration Alternative is less expensive than the proposed Groin Project. (PWA 2008) The groin proposes to protect threatened structures which can otherwise be relocated, and it therefore violates Policy GEO-GV-3.

Policy GEO-GV-2:
"To the maximum extent feasible, sediments removed from debris basins, which are of appropriate size and composition to enhance sand supply, shall be conveyed to appropriate locations by Flood Control."

Analysis:
Use of sediment from debris basins can help nourish the beach and is consistent with this policy. Utilizing upland materials for beach nourishment should be preferred to sea floor dredging (due to sea floor and water quality impacts) and this prioritization should be captured in conditions of approval.

SEWER AND STORM DAMAGE

Policy SD-GV-1.2:
"The County shall work with the sewer districts to acquire grants and other funding to relocate untreated effluent lines out of Environmentally Sensitive Habitat [ESHA] and riparian areas."

Analysis:
The sewer line under Goleta Beach is a County line which runs through the Park and adjacent to the existing shoreline and ESHA. Policy SD-GV-1.2 supports the County proactively working towards the relocation of all sewer lines and, more generally, all utility lines from the beach and intertidal ESHA. The County claims that it is too hard to work with the utility companies to relocate the sewer line from sensitive areas. However, Policy SD-GV-1.2 requires the County to do just that. The groin Project fails to consider relocating sewer lines away from the beach and appears inconsistent with this general plan policy. The Park Reconfiguration Alternative which seeks to relocate utility lines and restore beach ESHA and wetlands is feasible and is consistent with this policy.

BIOLOGICAL RESOURCES

Policy BIO-GV-1:
"The County shall designate and provide protection to important or sensitive environmental resources and habitats in the Goleta Planning Area."

Analysis:
Action BIO-GV-1.1 identifies attributes that make an area an ESHA: (1) "Unique, rare or fragile communities which should be preserved to ensure their survival in the future;" (4) "specialized wildlife habitats" (e.g., grunion, invertebrate and mollusk beach habitat); (5) "outstanding representative natural communities that have ... particularly rich flora and

fauna .... Unusual diversity of species;" (6) "Areas that are important because of their high biological productivity such as wetlands;" and (7) "Areas that are structurally important in protecting natural land forms and species, e.g., riparian corridors that protect stream banks from erosion and provide shade" (e.g., beaches that reduce erosion and provide habitat (e.g., for grunion)).

Action BIO-GV-1.2 specifies that wetlands (for example, beaches below Mean High Tide Line) are ESHA.

Goleta Beach and affected down-coast beaches meet the County and Coastal Act definition of ESHA. Dr. Jenny Dugan describes local beaches as having some of the highest biological diversity and bio-mass of any beaches in the world. Pursuant to Coastal Act Section 30240, the beach ESHA receives protection from all development and uses that would cause a significant impact to the ESHA or that would not be dependent on the resources of the ESHA. The groin development would significantly impact ESHA by reducing the width of down-coast beaches and bluff erosion, and through impacts on the nearby shorebird roost and marine environment. The groin is not dependent on the ESHA and is therefore inconsistent with Action Bio-GV-1.2.

Policy BIO-GV-2:
"Environmentally Sensitive Habitat (ESH) areas and Riparian Corridors within the Goleta Planning Area shall be protected and, where feasible and appropriate, enhanced."

Analysis:
This policy requires protection of the beach ESHA and supports actions to restore the beach ESHA (e.g., revetment removal, managed retreat, dune restoration, utility relocation, controls on beach grooming and berm building). Actions such as leaving the eastern revetment in place, repairing/enhancing the revetment, adding more revetment and proposing to maintain revetments are all inconsistent with Policy BIO-GV-2, but beach restoration elements in the Park Reconfiguration Alternative are consistent with the policy.

DevStd BIO-GV-2-2 requires buffers for development (e.g., the groin) within 100 feet of ESHA. The project includes construction of a groin (and resulting down-coast impacts) within ESHA and within 100 feet of ESHA in conflict with this development standard.

Attachment #5

November 26, 2003

Honorable Commissioners
California Coastal Commission
89 S. California Street
Second Floor
Ventura, CA 93001

Re: Comments Opposing Approval of Goleta Beach Seawall, Agenda Item Th 8-e (12-11-03)

Honorable Commissioners:

I am writing to you as a marine ecologist with over 20 years of experience studying the ecology of California's sandy beaches. My research focuses on the responses of invertebrate animals and their predators, the shorebirds, to the dynamic physical and biological characteristics of sandy beaches. I have conducted research at Goleta Beach for more than 20 years, and write to you regarding the potential ecological impacts of seawalls and coastal armoring in general and as they may relate to Goleta Beach.

California's populous coast is a vital yet understudied resource that is experiencing large scale alteration associated with increasing human development. The importance of incorporating scientific information into decision-making processes about sandy beaches can not be overemphasized. The effects of seawalls and coastal armoring on the ecology of beaches and coastal strand habitats needs to be studied and understood on all coastlines, particularly California's. To my knowledge, even simple comparative surveys have not been conducted to address questions concerning the ecological effects of seawalls and coastal armoring on sandy beach habitats in California.

Although I have not had an opportunity to directly investigate the effects of seawalls on beach ecology, my years of field observations on more than 50 sandy beaches in southern and central California suggest that coastal armoring, including seawalls and revetments, can have significant ecological impacts. Seawalls or revetments, such as the one proposed for Goleta Beach County Park, that interact with the intertidal zone, either by design or as the beach narrows from erosion associated with the armoring, can have significant negative effects by greatly curtailing the width and complexity of the intertidal zone and habitats. This is most apparent at the upper levels of the shore where the zone of drying and dry sand can disappear entirely in front of armoring structures at all tide heights. This reduction in habitat alone can decrease biological diversity and abundance, reduce shorebird feeding habitat and eliminate grunion spawning habitat, all of which are of specific concern at Goleta Beach County Park. For this reason, while investigating other basic ecological questions we have specifically avoided beaches with seawalls or revetements that interact regularly with intertidal processes, such as waves and swash, in much of our research on this habitat.

Coastal armoring, including revetments such as those in place and proposed at Goleta Beach County Park, likely limits the critical process of migration of lower intertidal animals during high tides and higher surf conditions. This limitation could significantly decrease survival and retention of a number of mobile invertebrate species and negatively affect biodiversity, biomass, and abundance over time. This impact on invertebrates can in turn significantly reduce the prey resources available to at least 27 species of shorebirds, including rare and declining species, as well as their feeding habitat.

The loss of the dynamic coastal strand and foredune habitat above the active intertidal zone is another important concern regarding coastal armoring. As in the intertidal zone, coastal armoring can eliminate or greatly alter higher zones, the supralittoral and strand zones, on a beach through the placement of the armoring material, by altering depositional processes and narrowing the beach. Impacts of revetments and seawalls on native plants and associated insect and vertebrate fauna of this zone, some species which are of concern, (e.g. Red Sand Verbena, Dunedelion, Western Snowy Plover, Globose Dune Beetle, and California Legless Lizard) are potentially highly significant. Some of these species of concern have been recently extirpated from Goleta Beach County Park.

The degree of ecological impacts from armoring depends upon the extent of a seawall or revetment, the condition of the surrounding coast, and the amount of the coast that is already armored in the vicinity. The cumulative effects of multiple seawalls and revetments also need to be considered and scientifically assessed in decision-making. Due to the potential for significant impacts from the proposed Goleta Beach rock revetments, I suggest that comprehensive study and analysis of ecological impacts and alternatives is critically needed.

Sincerely,

Jenifer Dugan, Ph.D.
Associate Research Biologist

Attachment #6

Brian Trautwein

From:	j_dugan@lifesci.ucsb.edu
Sent:	Wednesday, May 20, 2009 3:42 PM
To:	Brian Trautwein
Cc:	David Hubbard; David Revell
Subject:	Re: comments to CCC
Importance:	High
Attachments:	Airoldietal05.pdf; VaselliBulleriCecchi08.pdf; BulleriAiroldi05.pdf; WalkerSchlacherThompson08.pdf; Page et al. MEPS 2006.pdf

Hi Brian,

Sorry for my slow replies to your queries. A bit under water here already and then not one but two family crises have arisen since our return.

I think that narrower beaches will provide less intertidal habitat. Thus habitat loss is an issue to be considered for beach animals of all types (invertebrates, fish, birds) with expected impacts to biodiversity, abundance, biomass, and prey availability as well as spawning, foraging and roosting habitat. However whether the beaches downcoast of a groin or other shore-normal structure would lose upper beach zones disproportionately as predicted for beaches in front of a seawall or revetment is a good question.

What I think may be of immediate concern would be the loss of upcoast sources of colonists and propagules to replenish the narrowing beaches in the lee of a shore-normal structure. Beaches that are dependent on upcoast sources to regenerate after normal seasonal changes and beach erosion/accretion cycles will not recover very quickly, if at all, if the upcoast sources of colonists (and sand) are cut off by a groin of any type. The longshore dominated beach ecosystems of the Santa Barbara coast appear to be very dependent on a connection to upcoast sources of colonists and propagules (as well as sand) e.g. beaches where animals can survive the winter and then repopulate the rest of the coastline via littoral transport. Goleta beach has the potential to be one of these key source areas if managed to maintain the invertebrate populations and habitat quality over the winter months and its up and downcoast littoral connections.

In addition, a permeable groin will very likely act to catch large quantities of wrack and other drift material on the upcoast side (west of the pier), not only starving the downcoast beaches of wrack subsidies but creating a potentially undesirable conditions for beachusers, fishermen, and marine life in the form of a dense tangled matrix of drift algae and material that will probably decompose in place. This decomposition will lower oxygen content of the water and sediments, creating anoxic conditions that will be harmful to marine life. Our research suggests that input rates of marine macrophytes to beaches is very high in the Goleta beach and UCSB campus area. We estimated a deposition rate of >500 kg wet weight per meter of shoreline per year based on late summer estimates in 2002. This is likely quite conservative. The actual amount of drift algae that lands on the beaches is likely higher and as the kelp forest in Goleta Bay recovers, can only be expected to increase.

Lastly, Groins and other artificial structures may harbor a higher proportion of exotic marine organisms. including algae and invertebrates, than natural structures. This could include the exotic kelp, Undaria, and other species of concern. This has been studied in the Mediterranean, some reprints are attached. Santa Barbara Harbor and the offshore oil platforms, including platform holly, harbor numerous exotic/invasive marine species already.

I also think that human (wader and swimmer) safety in the more turbulent and potentially hazardous currents and holes created by a permeable groin need to be addressed explicitly in any analysis of this alternative.

Thanks for your efforts to inform and improve this process.

Best wishes,

Jenny

Artificial marine structures facilitate the spread of a non-indigenous green alga, *Codium fragile* ssp. *tomentosoides*, in the north Adriatic Sea

FABIO BULLERI* and LAURA AIROLDI
Centro Interdipartimentale di Ricerca per le Scienze Ambientali in Ravenna, Università di Bologna, Ravenna, I-48100, Italy; and Dipartimento di Biologia Evoluzionistica e Sperimentale, Università di Bologna, Italy
*Correspondence and present address: Fabio Bulleri, Dipartimento di Scienze dell'Uomo e dell'Ambiente, Università di Pisa, Via A. Volta 6, I-56126, Pisa, Italy (fax +39 05049694; e-mail fbulleri@discau.unipi.it).

KEYWORDS
biological invasions * *Codium fragile* ssp. *tomentosoides* * facilitation * hard coastal defence structures * recruitment * urbanization * wave exposure

Summary

* 1.
* Artificial structures have become ubiquitous features of coastal landscapes Although they provide novel habitats for the colonization of marine organisms, their role in facilitating biological invasions has been largely unexplored.
*
* 2.
* We investigated the distribution and dynamics of the introduced green alga, *Codium fragile* ssp. *tomentosoides*, at a variety of spatial scales on breakwaters in the north Adriatic Sea, and analysed experimentally the mechanisms underlying its establishment. We assessed the provision of sheltered habitats by breakwaters, the role of disturbance (e.g. from recreational harvesting and storms) acting at different times of the year, and the interactions between *Codium* and the dominant native space-occupier, the mussel *Mytilus galloprovincialis*.
*
* 3.

* *Codium fragile* ssp. *tomentosoides* has established viable populations on artificial structures along the shores investigated. The density, cover and size (length, branching and weight) of annual erect thalli of *Codium* was enhanced in sheltered conditions, resulting in the monopolization of landward low-shore habitats of breakwaters.
*

* **4.**
* On the landward sides of breakwaters, disturbance enhanced recruitment of *Codium*. The time when bare space was provided within mussels beds was crucial. Removal of mussels in April or January did not affect the recruitment of *Codium*, whereas harvest in August, shortly before *Codium* gamete release, doubled its success. On the seaward sides of breakwaters, the effects of disturbance were more complex because mussels both inhibited recruitment of *Codium* and provided shelter from wave action to adult thalli.
*

* **5.**
* *Synthesis and applications.* Artificial structures can provide suitable habitats for non-indigenous marine species and function as corridors for their expansion. Physical (wave exposure) and biotic (resident assemblages) features of artificial habitats can be important determinants of their susceptibility to biological invasions. Alternative options in the design of artificial structures and effective management of native assemblages could minimize their role in biological invasions. In particular, increased water motion and retention of space by mussels in spring-summer would be effective in reducing the ability of *C. fragile* ssp. *tomentosoides* to persist on the breakwaters investigated in this study.
*

Received 25 March 2005; final copy received 20 July 2005 Editor: Phil Hulme
DIGITAL OBJECT IDENTIFIER (DOI)
10.1111/j.1365-2664.2005.01096.x About DOI

Attachment #7

- Animal support provided by sand flies, beach hoppers, and beach detritus not discussed.
- Importance of beach invertebrate fauna to other animals is not discussed.
- Tidal Processes. Migration of invertebrate animals in accord with tides predicates the survival of their kind and the support they provide to shorebirds, mollusks, and other invertebrates.
- Storms and their effect on the beach.
- Aeolian forces.

Inadequate Definition of the Project Area and County Park Boundaries
No map of the project area is shown in the document. CEQA requires that a detailed map show the precise project location and boundaries of the proposed project. The location of the project must also appear on a regional map. Neither map is presented in this dEIR. The closest the dEIR comes to defining the Project Area is in Fig. 3.3-1, the 'Habitat Map of the Project Area'. This map shows habitats within one definition of the County Park but does not provide a definition of the Project Area. A different definition of the County Park is shown in Figure 1 in the January 2007 Chambers Report (in Vol. II) showing the 'Project Vicinity and Site Map'. Using an unaltered USGS topo map, this figure provides no boundaries the Goleta Beach County Park but and it ambiguously labels the 'Project Site'. Meanwhile, contradicting Fig 3.3-1 is Figure 7 'Study Areas (Goleta Beach County Park and Goleta Littoral Subcell)' in the January 2007 Chambers report. This shows the County Park Boundary well to the east of the slough mouth. The terms 'Project Area' and 'Project Site' are not defined and the 'Project Area', 'Project Site', and the Goleta Beach County Park are not depicted visually.
While some studies prepared for the dEIR extend east of the slough mouth, not all studies cover these areas and the relationship of study areas to the project area is never clear.

These shortcomings are critical flaws in the dEIR. Maps and definitions of the Project Area and County Park are important to understand habitats likely impacted by the project; to know which, and the extent of, impacts occur within the project area; and to understand whether and where appropriate mitigations can occur.

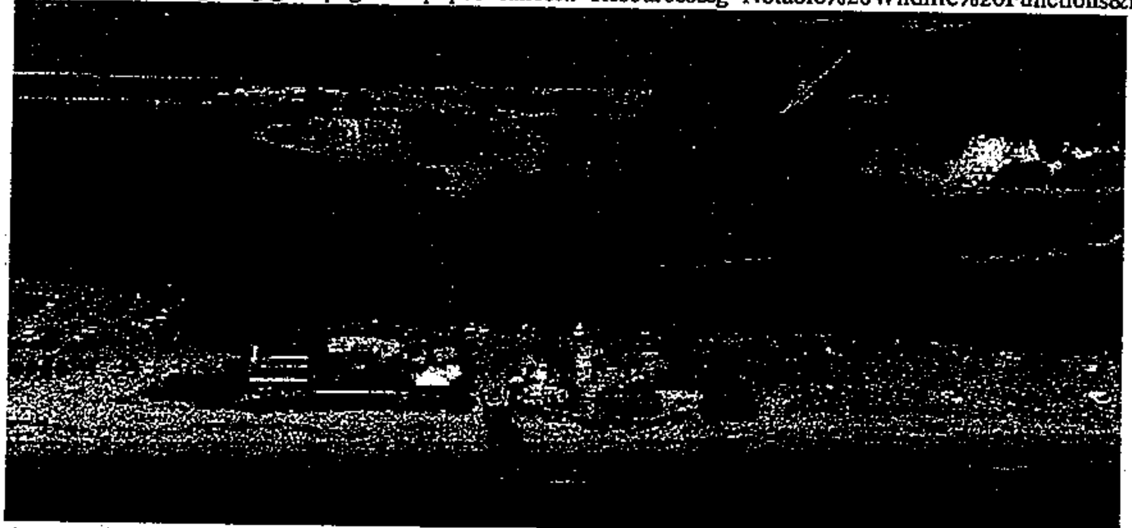
To understand project impacts, devise, and measure the effects of both, I recommend that the revised EIR designate a Goleta Beach Management Area. This might encompass the area from Mescalitan Island to Goleta Bay and from Goleta Point to More Mesa. Defining a management area might facilitate proposals for trade-offs that may allow compromise among the parties concerned.

The management area might include area or areas within which human activities are restricted. Many beaches now have set-aside areas that allow resources to be exempted from direct human contact. We have a strong local example where this has been done and we have sufficient data to recognize that benefits can accrue quickly (within1-3 years) following this action (Lafferty 2001). The principle of setting aside habitat for animal activities is appropriate and feasible east of the Goleta Slough mouth.

Biological Resources Insufficiently Analyzed in dEIR
Animals supported in Offshore and Nearshore habitats must be included in the analysis.

The Beach Stabilization alternative will enhance the use of the park pier by Brown Pelicans and this might be seen as a project benefit. However, more pelicans perching on the permeable groin may also mean more clashes with fisherman and more injured pelicans as a result. This impact is not discussed.

Great Blue Heron. California Sensitive species. The dEIR references former nesting of this species in the park but neglects the active rookery just north of the slough channel 60 meters from the former heron nest site. Resources in the park, on the beach, and in areas clearly affected by either proposed action support this rookery. Because the effects of either alternative will persist beyond the period of construction, this effect on the State Protected resource must be analyzed. The nesting period is more than 6 months, from January to early July. Approximately 18 pairs of herons nest here. Although great blue heron rookeries may no longer be fully protected under the state's umbrella, this is the south coast's largest and most important rookery and qualifies as ESHA. Great blue herons are of local importance as they are the principle predator on gophers. (See photo image of the rookery in proximity to GBC Park at http://www.goletaslough.org/gsmcpagenote.php?s=func&n=Resources&g=Notable%20Wildlife%20Functions&m=1)



Arrow shows Great Blue Heron and Great Egret rookery location at Goleta Beach.

Great Egret. California Sensitive species. The dEIR omits mention of nesting of this species just north of the slough channel. One or two pairs of Great Egrets have used the main heron rookery in the Eucalyptus north of the slough channel for the last 4 years. The nesting period is more than 5 months, from March to late July. The same reasons for analysis of the great blue heron rookery apply to this species at Goleta Beach. This is the only known nesting site for Great Egret in Santa Barbara County.

Cooper's Hawk. California Special Concern species. The Goleta Beach County Park is a territory for nesting pairs of this species. The ground squirrels in the park are a favorite food supply for adults and young. The dEIR omits mention of nesting of this species, which occurs between March and late July.

Merlin. California Special Concern species. Merlins use Goleta Beach County Park regularly from September to late April as a winter foraging site. The dEIR fails to mention this species.

Peregrine Falcon. State endangered, Sensitive, Fully Protected. One or two Peregrines are seen every winter for the last ten years, throughout the winter and forage in the Park. Between August and April, they feed on rock pigeons, mallards, bufflehead, grebes, kingfishers, and several other winter occupants of the park.

Tricolored Blackbird. California Special Concern species. This species winters at Goleta Beach and can be found occasionally between August and April feeding in the parking areas with other blackbirds.

Dredging Impacts. Dredging from the Offshore borrow site located approximately one mile southeast of the Goleta Pier will contribute to the down coast sand deficit for many years as the dredged area may absorb sand that would otherwise reach down coast beaches. Although this area may not receive long shore sand, it may receive sand ejected from the estuary associated with storm events. It is this sand that may be deprived from downcoast beaches. Especially because this may be a prolonged and repeated impact, the effects on both beach and benthic communities should be discussed in the dEIR.

According to the dEIR, the GB area currently shows low concentrations of trace metals. It is possible that positive effects could result from the filling of sand from West Beach if the imported sand holds even lower levels of trace metals, toxins, and bacteria than are present at Goleta Beach. On the other hand, unless assessments are made of the West Beach sand, the impact of the introduction of toxic sands from West Beach cannot be determined. The issue may be important because of the possibility of introducing conditions that work against grunion colonization or invertebrate population support.

A Modified Alternative. An different method of beach nourishment alternative that uses fill in the uplands only (on the very high beach) would avoid smothering existing beach resources, allow natural 'grab' of sand for lower beach replenishment by storm forces (i.e., a natural process), would maintain the high beach recreational function that seems to be what some of the public really values. This sand could be manipulated without disturbing the more dynamic wet beach processes and resources. In other words, sand deposited on the high beach could be pushed towards the beach in anticipation of storms or evened out to facilitate dry beach (upland) recreational space. Additionally, it would provide for dune restoration opportunities. Because dune habitats are among the easiest to implement and require a very short response time, manipulation of created dunes can happen at regular frequency with less concern about costs.

Cumulative Effects on the Estuary from Prolonged Closure. The effects of closure touch many aspects of the ecosystem and closure should be considered likely under certain conditions. It would constitute a Class I impact due to its broad effects on water quality, toxin accumulation within the estuary, creation of mosquito habitat, and loss of support for a range of plants and animals.

Other Mitigations

1. The dEIR should establish a framework within which decisions about overall beach management can be made. A Goleta Beach Management Area might encompass the area from Mescalitan Island to Goleta Bay and from Campus Point to Hope Ranch. Defining a management area will facilitate proposals for trade-offs that may allow compromise among the parties concerned.

2. To understand project impacts and benefits, devise appropriate mitigations, and measure the effects of both, some sort of beach monitoring program should have been studies for this dEIR. Comments submitted to the GB Working Group and letters submitted at the Scoping Phase of the EIR process called for such a program.

   The small-scale monitoring described on p. 5.1-25 of the dEIR was inadequate to determine impacts from unrevetted vs. revetted sections of the beach. The conclusion drawn that there is no effect on invertebrates and birds is invalid because it disregards the broad scale effects where any beach has significant amounts of revetment. The units of experimental comparison should be between beaches, not between sections of a beach.

   I recommend a twice-monthly monitoring program for shorebird presence and abundance relative to human activity, tides, beach depth and width, from Campus Point to Hope Ranch.

3. Create set-aside area. Many beaches have set-aside areas that allow resources to be exempted from direct human contact. We have a strong local example now where this has been done and we have sufficient data to recognize that benefits can accrue quickly (within 1-3 years) from this action (Lafferty 2001). The principle of setting aside habitat for animal activities is appropriate and feasible east of the Goleta Slough mouth.

Conclusion
The prediction of Revell and Griggs (2006) that GB is likely to receive sand presently poised upcoast carries some weight here. This prediction influences my consideration that more conservative options (both economic and engineering) are favored at this time. While we may not wish to rely wholly on the prediction that Goleta Beach may widen naturally from its present configuration in the near future, the prediction urges us to hold off on groin construction that may not be necessary in the next 10 or so years.

The ecosystem support provided by the beach is critical to the most basic debate for or against the project alternatives. To have been deprived of a database and analysis that can address the baseline conditions, impacts, and mitigation opportunities as they pertain to the beach and the animal community it supports is a flaw that requires this dEIR be revised and recirculated before it is acted upon.

Respectfully submitted,

Mark Holmgren

~~ ~~ ~~ ~~

References

Goleta Slough Ecosystem Management Plan. 1997. Appendix L to the Santa Barbara Airport Facilities Plan Environmental Impact Report/Environmental Impact Statement. City of Santa Barbara, CA

Lafferty, K. D. 2001. Birds at a Southern California beach: seasonality, habitat use and disturbance by human activity. *Biodiversity and Conservation* 10:1949-1962.

Lafferty, K. D., D. Goodman, and C. P. Sandoval. 2006. Restoration of breeding by snowy plovers following protection from disturbance. *Biodiversity and Conservation* 15:2217-2230.

Revell and Griggs. 2006. Beach Width and Climate Oscillations in Isla Vista, Santa Barbara, California. *Shore and Beach*

Attachment #8

Santa Barbara County Parks
Attention: Coleen Lund
610 Mission Canyon Road
Santa Barbara, CA 93105
By email to:
lund@co.santa-barbara.ca.us
sfoster@co.santa-barbara.ca.us

May 14, 2007

Dear Ms. Lund:

Thank you for the opportunity to provide comments to the Goleta Beach County Park Long-Term Protection Plan Draft Environmental Impact Report. I am providing these comments based upon my professional experience as a marine biologist. I hold a Master's Degree in Marine Biology from UC Santa Barbara, I have performed more than 1300 dives in local waters and I have been employed since 1999 as the Science Director at Santa Barbara Channelkeeper, a non-profit environmental organization whose mission is to protect and restore the Santa Barbara Channel and its watersheds (www.sbck.org). A major part of Channelkeeper's Marine Program involves the restoration and monitoring of eelgrass (*Zostera sp*) beds. While our restoration work takes place at Anacapa and Santa Cruz Islands, the eelgrass bed in Goleta Bay serves as a nearby reference point for our work. I also speak from my personal experience as a local Goleta resident and user of Goleta Beach since 1985. Goleta Beach is the closest coastal access point from my house and I visit the beach on average 4 days a week to walk on the beach, walk my dog, paddle my surfboard or merely look at the ocean. I feel that given my background I am qualified to speak to the inadequacy of the DEIR to address potential impacts to valuable marine and coastal resources.

DEIR's Inconsistency with County's Policy

(1) Evaluation of Resources: Resource Inventory: the description of the eelgrass beds with Goleta Bay is not detailed enough. There is not mention of the limited physical habitat available for eelgrass in our area and the possibility that Goleta Bay comprises a large proportion of that habitat.
(2) Evaluation of Resources: Condition and Quality: there is not enough discussion about how the eelgrass beds are already impacted by recent slough dredging/beach enhancement activities, and what the cumulative impacts may be. Eelgrass beds perform valuable services in reduction of nutrients and settlement of fine sediment—however, the plants might already be stressed and these services may already be reduced by on-going activities and thus the project may cause increased harm.
(3) Evaluation of Project Impacts: The DEIR mentions potential for short-term impacts but fails to address " longer-term, more subtle impacts such as interruption of…plant or animal propagation". A change in near-shore bathymetry would affect eelgrass habitat, and yet this is not addressed in the DEIR.

(4) Types of Impacts to Biological resources: this project may substantially limit or fragment the distribution of eelgrass within Goleta Bay. A fragmented bed experiences more 'edge-effects' and is thus more susceptible to scour, bay ray foraging, etc. (please explain) As this eelgrass bed may be the largest contiguous bed along our coast, any degradation or fragmentation would be a significant impact. This has not been addressed in the DEIR.

(5) Habitat Replacement/Compensation Guidelines: quoting County policy, *"The mitigation approach of replacing habitat either on-site or off-site, to compensate for habitat loss, is generally not a preferred approach because it always results in some habitat loss (either short-term or long-term) and because prospects for successful habitat replacement are problematic."* As eelgrass has very strict physical requirement for survival (sediment type/water clarity/protection from wave action) there are limited areas where it will survive—and those areas may already support eelgrass.

Importance of Eelgrass beds as habitat

Eelgrass habitats are environmentally important and sensitive due to their role in the marine ecosystem. Many species of important recreational and commercially fished species are found in eelgrass beds as adults and juveniles, including rockfishes, kelpbass, flat fish, surf perch, lobster and rock crabs. Species recorded in the Goleta Bay eelgrass bed include kelp bass, giant sea bass, sand bass, pile perch, rubberlip perch, shiner surfperch, rainbow surfperch, senorita, tube snouts, pipefish, and young of the year rockfish recruits. Many species recruit into shallow waters during the later summer into fall. Any activity that lowers water clarity and/or increases sedimentation within eelgrass habitat (i.e. dredging and beach nourishment) during this period could negatively affect fish and invertebrate recruitment.

DEIR Contains Inadequate Evaluation of Soft-bottom Resources within Goleta Bay

Eelgrass has very specific requirements where it can survive. It can only grow in soft-sediment, very sheltered environments. In Southern California, there are few places along the coast outside of bays and harbors where there is enough protection from waves and swell and the necessary sediment environment. Sediment needs to be fairly stable to provide for rhizome persistence. Most protected habitat south of Santa Barbara County has been destroyed by dredging, filling and development activities (e.g. Anaheim Bay, Newport Bay, San Diego Bay).

Eelgrass along the Santa Barbara coast is a fragmented and potentially diminishing resource; although there are reports of scattered beds along the coast from Gaviota to Santa Barbara, comprehensive mapping has *not* been done and based on my diving experience and expertise with eelgrass habitat, it is quite likely that the bed within sheltered Goleta Bay is the largest bed within Santa Barbara County, and thus a critical resource that needs the fullest protection. The DEIR does not address the significance of the eelgrass habitat found within Goleta Bay.

The DEIR does not adequately describe the importance of this marine plant as a valuable but limited habitat. The DEIS casually mentions Goleta Bay eelgrass as *Zostera asiatica,* "an introduced species". This identification is wrong: a recent genetic study *(in press)* verifies that the eelgrass along our mainland coast as *Zostera pacifica*, a species whose type locality was Goleta/Isla Vista when the species was described over 100 years ago. The DEIS, by implying that this 'introduced' eelgrass is somehow less valuable than other species of *Zostera*, downplays the global importance of this valuable genus of marine plant, and is totally misleading, regardless of quibbles over species identification.

Eelgrass habitats are environmentally sensitive areas. They are limited in range, especially valuable due to their role in the marine ecosystem, and are easily disturbed by human activities. World-wide, they are a vanishing resource and need full protection.

Impact BS-MAR-6 acknowledges that the placement of a dredge pipe could disturb eelgrass and kelp habitat and the plants themselves. Contact will be minimized, and habitat compensation as mitigation is presented as the only solution. Why not seek outright avoidance? There is no mention of potential sites for this restoration (will it take place only after the dredge is removed? What happens if more beach enhancement is needed in following years, requiring another pipeline?) And, interestingly, the agency that would give project permits and oversee any potential mitigation, the National Marine Fisheries Service, was *not* noticed on this DEIR.

Quoting from the Southern California Eelgrass Mitigation Policy, Section 1 Mitigation Need:

"Eelgrass transplants shall be considered only after the normal provisions and policies regarding avoidance and minimization, as addressed in the Section 404 Mitigation Memorandum of Agreement between the Corps of Engineers and Environmental Protection Agency, have been pursued to the fullest extent possible prior to the development of any mitigation program. Mitigation will be required for the loss of existing vegetated areas, loss of potential eelgrass habitat, and/or degradation of existing/potential eelgrass habitat."

There is mention that the bathymetry might change in response to the salient (BS-COAS-5). However, I find it troubling that this potential is not explored in any great detail. The DEIR must show that changing the sand profile of the beach will not negatively affect currently vegetated subtidal areas and potential eelgrass habitat. This has not been addressed.

Water column turbidity is a leading cause of seagrass declines world-wide. The plants require sunlight for photosynthesis. Although eelgrass beds dampen wave and current action, trap suspended particulates, and reduce erosion by stabilizing the sediment, they cannot survive in continuously turbid waters. In San Francisco Bay, an area not known for clear water, eelgrass grows in less than five feet of water. It must be this shallow in order to get enough light. In Goleta Bay, eelgrass is growing in areas 18' to 40' deep- a clear indication that overarchingly, light levels are suitable at these depths. To what extent will the dredging and dumping of sediment on the beach affect water clarity over the extent of the range of eelgrass habitat within Goleta Bay? The DEIR does not address the potential for increased turbidity within the littoral zone, which includes eelgrass habitat. And, at what point do short-term impacts become long-term, significant impacts, especially when considering the life history of this species? The DEIR states that as both kelp and eelgrass experience a 'die-back' each year (pg 4.2-20) they would easily 'recover' from the dredge pipeline. This is misleading and inaccurate, as both species can persist over many years depending on conditions. While it is true that the growth of new eelgrass shoots may slow during the winter, the plants do not disappear; they are not annuals. Individuals in kelp forests can persist for many years as long as disturbances are low. The stability of an eelgrass bed depends upon an extensive, interlacing shallow network of rhizomes remaining in the sediment. If the sediment is disturbed and the rhizomes exposed, sand scour and currents may begin to dislodge the bed. Unlike a kelp forest, which in addition to persistence of older individuals depends heavily on annual recruitment from spores, eelgrass beds primarily spread by vegetation growth. However, flowering and seed production is important to maintain genetic variability. Flowering is highly variable from year to year, seed dispersal is limited and seedling mortality high. The placement of a large dredge pipeline (Impact BS-MAR-6) throughout the eelgrass bed could cause lasting negative effects, in that it could abrade shoots and leaves, disturb eelgrass rhizomes within the sediment and change the small-scale hydrodynamics leading to scour around the rhizomes. This is turn makes them more susceptible to erosion and eventual dislodgement. While the DEIR finds these as Class II impacts, any impacts to environmentally sensitive eelgrass habitat should be considered significant due to the importance, limited range and fragility of this habitat. If the offshore area has already been carefully mapped for eelgrass bed extent and areas of suitable habitat, it is not readily apparent from the maps presented in the DEIR, and the information is not presented within. Habitat restoration is mentioned in passing in the DEIR but details are scanty. However, avoidance may be a feasible way to eliminate impacts and the need for mitigation. Mitigation by transplanting is supposed to be a last resort, not the rational for allowing the disturbance.

I have personally observed the large plume of dirty water during the slough dredging/beach enhancement during the winter of 2005-6 from both shore and by boat. I performed dives to count eelgrass shoot density in 28-30' water depth south of the end of the pier on October 13 2005, May 10 2006 and June 6 2006. In October before the dredging and beach enhancement began, the water clarity was good enough for photo documentation of the beds and surveys (15' to 20'). In May and June the visibility was less than 3 feet, a thick 4-5" layer of gooey sediment covered much of the bottom and the density of shoots was a quarter of that surveyed in October 2005. Was this in spite of, or because of, the beach enhancement using dredge spoils? Increased turbidity and sedimentation (BS-MAR-9) could become much more than a "temporary" effect, especially if the dredge/fill activities extend on for several months throughout the winter, exacerbating the occasional naturally turbid conditions following seasonal and isolated rain events, or if dredging and beach fill were required on an ongoing basis as proposed (e.g. Mitigation Measure BS-COAS-4 indicating 47,000 cubic yards of dredge and beach fill may be required for the Beach Stabilization project annually or periodically).

The project as described has a lot of unknown conditions and it seems plausible that the large amount of sediment proposed for enhancement could move offshore such to bury the eelgrass. Lowered light conditions from particles in the water column will stress the plants. Even a short-term burial could be disastrous. Generally, the autumn is when ripe seeds are released to fall into the sediment and organic matter below the parent plants. An influx of sand during this period could deeply bury the seeds, preventing germination and sprouting. We have documented plants in Goleta Bay still flowering well into the autumn and winter months. The DEIR does not take into account the life history characteristics, reproductive cycle nor the sensitivity of flower pollination and seed germination.

The DEIR falls back upon eelgrass restoration as a potential mitigation if impacts occur, rather than putting more emphasis on avoidance of harm. In order to document and avoid impacts, the eelgrass should be carefully mapped as part of the DEIR rather than deferring analysis of avoidance until after project approval. Please describe the areas into which eelgrass would be planted, where the donor plants will come from and describe how these areas will not be affected by the dredging, dumping of sand and changes to the nearshore sediment budget.

<u>Offshore "borrow" site</u>

Based upon my review of the DEIR, it appears that a detailed survey of fish and invertebrates, including benthic infauna has not been performed in the target Dredge Area. The DEIR assumes that species abundances and composition will recover 'quickly', and there appears to be a tacit assumption that the species found in this habitat are of low human value and so a major disturbance to up to 80 acres of this habitat is no big deal. Just because this area is out of sight does not mean that a disturbance this large is non destructive.

The idea that crabs and any other animals would know to crawl away from a large sucking dredge, and to crawl in the right direction, is ludicrous and not supported by biological sciences or other evidence in the DEIR. Excavating such a large hole will create areas of loose, unstable sediment. In fact, crabs and whelks not sucked up by the dredge may become trapped with the 15' deep pit, unable to climb up the walls.

The offshore sandy habitat between 50 and 70' of water is well-used by local commercial rock crab fishermen. Dredging activity in this area will doubtless prevent access to a much larger footprint. How will the project mitigate the loss of recreational and commercial fishing opportunities? Loss of opportunities could lead to economic losses and shifting of fishing pressures onto nearby habitats, which are not addressed in the DEIR. Any alternative that minimizes offshore dredging would minimize the potentially significant impacts to the seafloor habitat, the rock crab fishery and fishing for other species (e.g. halibut) at the potential dredge area.

This dredge site is near the Goleta Sanitary outfall. Please provide a more detailed description of the outfall plume and the likelihood of dredge spoil contamination. Please provide more information on testing of sediment (i.e. for human pathogens) since the dredge spoils would go onto the beach where there is body-contact recreation. Also, dredging could re-suspend other contaminants.

Routing of Submerged Pipeline

Any submerged pipelines *must* be routed so as to avoid impact to the eelgrass resources. According to the Southern California Eelgrass Mitigation Policy, if the area of impact from a submerged pipeline, cable or other similar utility line across an eelgrass bed is more than 1 meter wide, mitigation measures will apply. The DEIR assumes a 10'-wide area of impact but does not analyze the feasibility of avoiding the eelgrass habitats. Currently, there is a narrow window on either side of the outfall pipeline where eelgrass does not grow—the DEIR does not mention this as a potential site for the dredge pipeline. What measures would be taken to prevent or minimize the dredge pipeline's lateral movement on the sediment once in place?

Mid-park revetment removal

According to the DEIR page 4.2-2, this is scheduled to occur during summer months which may coincide with periods of grunion spawning, and could take 1 month. I have been a volunteer Grunion Greeter for several years, walking the entirety of Goleta Beach during nighttime high tides documenting grunion spawning activity. I have seen grunion at all stretches of beach. Any activity with heavy equipment on the upper beach will impact the buried eggs—studies have shown that survival of eggs drops dramatically when there has been any level of bulldozer or tractor activity overhead. As grunion eggs remain in the sand for many weeks, what is the plan to find an entire month to work during grunion season where there are not eggs present? What happens if a grunion run occurs during the month-long period of removal? What measures would be in place to minimize beach closure during this waiting period? The DEIR leaves these questions unanswered.

Potential for project to shift the mouth of Slough further east

The build-up sand to the immediate west of the Goleta Slough mouth seems likely to shift the mouth of the slough further east and constrain the shape of the estuary. This could have negative effects on fish species that use the shallow, warm Slough as nursery habitat, and also affect those species that might exist in (Tidewater Goby) or enter (Steelhead Trout) the slough. Increased artificial breaching of the Slough Mouth – proposed as a mitigation measure for Beach Stabilization (BS-COAS-2) - may also impact these species and the Slough habitat but is not analyzed.

Other Potential Impacts not mentioned in DEIR

Access to Boat Hoist

Construction that closes the pier (BS-AES-1) eliminates access to the small boast hoist on the pier. This hoist, the only hoist along the coast, is used on weekends by the public and extensively during the week by researchers from UCSB. As a graduate student, I personally used this hoist 2-3 times a week, year-round over a period of several years from 1995 to 1998 in order to access my study sites. Any reduction of access to this resource will greatly curtail research activities. The only alternative will be to launch boats from Santa Barbara Harbor, adding additional costs in fuel, launch fees and travel time back and forth. What is the mitigation for this impact?

The DEIR also fails to analyze potential impacts to the boat launch caused by the build-up of sand around the Goleta Pier. During low tides will the boat launch facility (water depth) be impacted by the groin?

Potential for project to change surfing conditions at Poles

The DIER repeatedly states that the placement of sand at Goleta Beach will not affect the 'main surfing area at Campus Point'. However, the break *inside* of Campus Point, known as "Poles", is just as popular during the winter as Campus Point and is a better, much longer wave. I have frequently ridden waves that wrap into the Bay past the Engineering II building, which is to the east of the Donald Bren building. As a surfer who considers Poles to be my favorite local break, I am very concerned that this important surfing resource is *not* mentioned in the DEIR. How can it *not* be affected if the sand profile of the beach changes as far west as the Bren building? How can we be sure that there will be no change? The February 5, 2004 minutes of the Goleta Beach Master Planning Working Group note that "deposition of sand will change bathymetry, changing surfing conditions". Any adverse change to the surfing conditions at Poles is a highly significant impact. How will this loss be mitigated short of avoiding the groin? It cannot.

Potential for project to change depth of bay and negatively affect anchoring area

There are very few places that a vessel can safely anchor overnight between East Beach in Santa Barbara and Point Conception. Goleta Bay offers the best protection from prevailing westerly conditions and is used for both a day-time and overnight anchorage. Sailors use Goleta Beach as a picnic destination and commercial fishermen rely upon finding a safe harbor here. The best and most comfortable spot to anchor overnight is close in to the rocky area at the west end of Goleta Beach. As the owner of a sailboat I am very aware of the limited places to find safe harbor along our coast. The DEIR fails to mention this important, and very limited resource. How will widening the beach by either a groin or the placement of 500,000 cubic yards of sand throughout this area affect the near-shore depths and anchoring conditions, especially if the sand is expected to fill in to the Bren building? There appears to be a lot of uncertainty in what will actually happen within the near-shore environment once a groin is built and/or a large amount of sand is dumped on the beach (BS-COAS-5). The area east of the pier is already too foul and shallow to anchor. It is only this area tucked in close to the west end of the parking lot that is a safe anchorage. A new anchorage area can not just be created so this impact cannot be mitigated and is thus highly significant, and yet is not mentioned in the DEIR.

Importance of More Mesa/Black Rocks shallow subtidal area as lobster habitat

To get a good idea of how important the rocky shallow subtidal at Black Rocks (1 mile east of Goleta Slough mouth) is for spiny lobster habitat, all one needs to do is to observe the great number of commercial lobster traps set here when the season opens in October. It is well known that lobsters are in shallow water during the summer and fall months, moving offshore later in winter during big swells. In October and November, many fishermen are setting traps in very shallow water. The possibility of increased sediment movement through this area during the time of year when lobsters are congregating could be disastrous to the resource and to the fishery. This is a significant impact the DEIR does not mention and thus the DEIR should be revised to fully address this issue.

<u>Other Non-Marine Comments</u>

Degradation of roadway from construction traffic

During the last round of slough dredging/beach nourishment, a major impact to park visitors was the condition of the roadways both within the park and some distance away from the park. The heavy machinery and trucks spread dirt and mud for some distance which ends up on car and bicycle wheels. The roadway surface developed potholes. This degradation is an eyesore, a nuisance and a danger.

Presentation of Managed Retreat Alternative as 'all or nothing' rather than a menu of options

In reading through the DEIR, it appears as though the writers have tried to present the Managed Retreat concept as onerous as possible. I visit Goleta Beach on average 4-5 days a week for recreation and the thought of almost total park closure for a period of six months or more, for several years (Impact MR-AES-1) is unacceptable. All of the construction is scheduled to occur during the high-use summer months which is nonsensical. The DEIR repeatedly states that more than 1,000,000 people visit the park annually, with more visits taking place during the summer months. Why purposefully create a huge loss of recreational opportunities during peak visitation?
Personal experience has shown me that during the July 4th holiday the Park is full to capacity yet this construction would take place during this time anyways. I am not convinced that the erosion of the shoreline is as predictable as assumed in the DEIR and I also don't see that all of the deconstruction/reconstruction of lawns, parking lots, picnic areas, etc would have to happen all at once, if at all. If the "Managed Retreat Alternative is designed to allow the shoreline to evolve naturally over time" (pg 4.2-33) then why can't the Park evolve over time in response to changing conditions? Relocation of so many structures and placement of a 'backstop' revetment may not become necessary for years, if at all. The process is described as very disruptive to Park function and is probably expensive, so wouldn't it be better to wait until each action is really needed?

A suggested potential mitigator of the loss of parking is the presence of two parking structures at UCSB (MR-TRAF-2)—but without a shuttle service, why would the average public want to park a mile or more away when they could drive to another beach with a shorter walk (Hendry's, Isla Vista)? The University probably would not support offering their parking structures on campus for use off-campus at Goleta Beach, when parking is becoming such a limited resource. Lack of public access at Goleta might result in an increase in use at other coastal access locations. This potential effect is not examined in the DEIR.

Impact MR-TRAF-3 suggests an increased risk to bicycle traffic. As a bike rider and commuter, I will attest to the existing semi-hazardous conditions at the entrance to the Park. Motorists simply are not aware that there is a bike path that shares the Park entrance. Any increased traffic, especially involving large construction vehicles, would definitely increase the risk of accidents involving bicycles. There have been several highly-publicized deaths of cyclists due to large vehicles (SUVs, construction trucks) in the past couple of years on County roads. In both cases it was the fault of the driver, not the cyclist. Wouldn't it be better to try and mitigate this risk by posting high-visible signage for vehicle traffic approaching and leaving the Park entrance, and by a 'bicycle awareness' education program made mandatory for the drivers of the large construction vehicles?

Table 4.2.1-1 shows initial beach nourishment to reinstate beach to 2005 conditions. However, this shoreline is not shown on any of the maps, rather, October 2003 reference shoreline is presented. The maps are difficult to read and the lines are so close together it is hard to make out predicted changes either way. Would it be possible to provide finer-detail maps that perhaps only show a portion of the park, so that it is easier to comprehend potential changes?

Impact MR-REC-1 states that the eventual conversion of 1.13 acres of grassy lawn to beach is a significant Class I impact, and that there is no mitigation available. Please remember that there are other parks within the County that contain ample grassy lawns, but there are few beach parks. I believe that visitors come to Goleta Beach to enjoy the ocean view and walk along the water, not because there is a lawn. Moreover, this impact is offset by creation of a larger sandy beach under a managed retreat scenario. In my mind there are many other impacts that are much more significant than this one (impacts to subtidal habitat from dredging/sand movement, for example) but yet this impact is deemed Class I. This appears as a bias from the writer's perspective and may not represent the views of all Park users.

Finally, on page 4.1-31 the fifth paragraph states that the distance from Campus Point to the east end of More Mesa is 8 miles. By my rough calculations it is closer to four miles; perhaps this changes the results of the numerical modeling?

In summary, I want to reiterate that the DEIR needs extensive revision to account for the points raised in this letter, including the overlooked role of eelgrass habitat in general and the relative importance of the bed in Goleta Bay as a significant proportion of the eelgrass existing within the County, and the unexamined potential for and risks due to movement of imported sediment in the littoral zone that might affect eelgrass and kelp habitats, an important vessel anchorage, valuable fishing grounds and a valuable and irreplaceable surf break, Poles.

Thank you for your time.

Jessie Altstatt
102 Orange Ave
Goleta, CA 93117
jessie@sbck.org

Attachment #9

PEPPERDINE UNIVERSITY
Seaver College
NATURAL SCIENCE DIVISION
310-506-4808
kmartin@pepperdine.edu
May 14, 2007

Coleen Lund
Santa Barbara County Parks Department
610 Mission Canyon Road
Santa Barbara, CA 93105

Greeetings,

I collaborate with a group of beach managers and equipment operators in an effort to increase ecological management of beaches. Our group calls itself the "Ecologically Sensitive Beach Management Working Group," a name chosen by the beach managers. This working group meets twice a year and includes staff from Santa Barbara City and Santa Barbara County parks. I applaud the efforts to enhance Goleta Beach in an environmentally responsible manner.

The California grunion *Leuresthes tenuis* is an endemic marine fish with a narrow shoreline distribution centered in Southern California. It is rare north of Pt. Conception or south of Ensenada. The sandy beach habitat is the only place where spawning and incubation of the eggs takes place. Grunion are particularly vulnerable to human interference during these critical life stages of spawning and of embryonic development because of their use of the terrestrial habitat. Thus sandy beaches within the grunion range are considered Essential Fish Habitat according to the USFWS and are subject to protective measures.

Recreational fishing for grunion is a cultural tradition but it soon became apparent that overharvesting was a serious problem, so take has been regulated since 1927 by a closed season and by gear restrictions after. The adults are present on shore for only a few minutes at a time, but the eggs and embryos remain in the sand on shore for almost two weeks until they hatch. During their incubation the grunion embryos are cryptic since they are buried. They have no means of escape from conditions and may be unintentionally impacted by human activities such as vehicular traffic, beach grooming, digging, or deep burial by additional sand. Previous unpermitted human disturbances to grunion spawning areas at Broad Beach in Malibu have resulted in legal action by the Coastal Commission, indicating that grunion spawning beaches are treated as ESHAs.

In addition to their role in human recreation, grunion are important ecologically as food for marine mammals, nesting seabirds, squid, and other fish. The eggs are consumed by shorebirds and invertebrates. Juvenile grunion are preferentially preyed upon by nesting shorebirds, including the endangered least tern and skimmers, because their slender bodies fit easily into the small chick gullets. We know that birds in Santa Barbara utilize the young grunion that result from local spawning runs from examining dropped fish that the adults carry back to their nests. In addition adult grunion have many predators before

24255 Pacific Coast Highway, Malibu, California 90263-4321 • 310-506-4321 . Fax 310-506-4785

and during a run, including California halibut, shovelnose guitarfish, great blue herons, snowy egrets, and pelicans, as well as marine mammals including sea lions and dolphins.

The mitigation for avoiding harm to grunion eggs is to avoid contact with the grunion eggs. Grunion spawning season may start in March and continue into August. In Santa Barbara the runs continue into August and therefore eggs have been present in the sand as late as the first weeks of September on area beaches. Mitigation should require avoidance of the spawning area through the first half of September if eggs are present.

The best mitigation for these projects, as indicated, is avoidance of the grunion spawning season. Biological monitoring the area for grunion runs would be necessary if work within the sandy intertidal zone of the beach takes place from March through early September. Although grunion runs are patchy, if they were to run within the work area then that work should be suspended until after the embryos hatch and return to the ocean.

Please feel free to contact me for additional information or further discussion.

Sincerely,

Karen Martin

Karen Martin, Ph.D.
Frank R. Seaver Professor of Biology

Attachment #10

COASTAL TECH
COASTAL TECHNOLOGY CORPORATION

COASTAL . ENVIRONMENTAL . CIVIL . ENGINEERING AND PLANNING
3625 20TH STREET, VERO BEACH, FLORIDA 32960
PHONE: (772) 562-8580 FAX (772) 562-8432

May 12, 2007

Ms. Coleen Lund
Santa Barbara County Parks Department
610 Mission Canyon Road
Santa Barbara, CA 93105

Re: Goleta Beach long-term Protection Plan draft Environmental Impact Report

Dear Ms. Lund:

This letter is in response to a request from Brian Trautwein of the Environmental Defense Center (EDC) to the *Surfrider Foundation* Environmental Issues Team (EIT) for review and comment relative to the referenced Plan and Report. This letter is rendered on behalf of the Santa Barbara Chapter of the *Surfrider Foundation* and solely reflects my professional opinions as a coastal engineer based on review of documents as provided by EDC and as referenced below.

Santa Barbara County Parks has released a March 28, 2007 "*Notice of Availability of and Public Hearing on the Draft Environmental Impact Report for the Proposed Goleta Beach County Park Long-Term Protection Plan*" ("*Notice*"). The "Project Description" in the *Notice* states:

> "Santa Barbara County Parks proposes to implement and construct a long term project at Goleta Beach County Park with the goal of providing a wide sandy beach and protection of park infrastructure and other resources. Two projects are studied in this EIR on a co-equal basis: Managed Retreat & Beach Stabilization/Permeable Groin."

The opinions stated herein are directed in response to the *Notice* and these two "co-equal" projects under consideration by Santa Barbara County Parks.

The following provides comments relative to questions posed by EDC (in bold text) as posed in their April 11, 2007 memo request:

1. **Under the Beach Stabilization project will repeat dredge and fill operations be required to replace sand washed away by storms (e.g., SE storms) and/or to prevent down-coast impacts of the groin?**

   Response: Yes, over the long term, repeat dredge and fill operations are likely to be required to both (a) mitigate down-coast erosion attributable to the groins, and (b) maintain a wide sandy beach – seaward of what might occur with "No- Project" or the Retreat alternative. This opinion is based upon the following:

   a) The EIR cites:
      - A total of 500,000 cubic yard of sand is proposed as part of the Beach Stabilization to "pre-fill" the groin [2.3.2.1; page 2-4].
      - "...it is possible that until equilibrium is reached at the 10 year period, some additional sand may be trapped upcoast of the pile groin that exceeds the 500,000 cubic yard estimate." [4.1.4.3; page 4.1-30]

- "…the County will be required to monitor the downcoast beach for erosion and, if any erosion has been determined to occur, nourish the beach at a rate at least equal to the rate of sand loss documented by monitoring." [4.1.4.3; page 4.1-30]
- "The net longshore sediment transport rate in the 20-year future for No Project" (i.e. existing conditions projected into the future) under average wave conditions is 192,990 cy/yr to the east, while the rate is predicted to be 183,678 cy/yr for the proposed Project, for a difference of 4.8 percent." [4.1.4.3; page 4.1-33: This difference corresponds to a decrease in the amount of sand reaching the down-coast beaches; any such decrease would induce erosion of down-coast beaches.]
- Figure 2.3-1 (page 2-3) illustrates the "Projected New Equilibrium Mean Higher High Water Shoreline" and an envelope of expected "Long-term Shoreline Fluctuation". [When the shoreline fluctuates landward – assumed to occur in response to significant storm events, in the absence of "dredge and fill operations" to re-fill the groin, the groin will trap sand, deprive sand to the down-coast beaches, and increase erosion of the down-coast beaches.]

b) Numerous examples of pre-filled groins exist throughout the U.S. including Monmouth County, New Jersey, Palm Beach, Florida, and Galveston, Texas. In each of these examples, a fundamental longshore transport deficit exists, as for Goleta Beach, and the "pre-fill" sand has eroded by cross-shore and longshore transport processes, requiring the groins to be periodically re-filled to maintain a beach and reduce erosion effects upon down-coast beaches.

2. **What frequency and magnitude of repeat dredge and fill operations will be required to avoid all down-coast impacts of the Beach Stabilization project?**

<u>Response</u>: Based upon the estimates of longshore transport to down-coast beaches for "average wave conditions" cited in the EIR [4.1.4.3; page 4.1-33], it may be reasonably expected that 9,312 cubic yards of sand should be placed on the down-coast beaches every year to offset the impacts of the Beach Stabilization Project [9,312 cy/yr = 192,990 cy/yr -183,678 cy/yr].

Based upon the sediment budget quantities cited in Figure 3.4-7, it may be reasonably estimated that 30,000 to 60,000 cubic yards of sand should be placed on down-coast beaches every year to offset erosion generally attributable to a regional longshore sediment deficit that would be translated east by the Beach Stabilization Project. Note that, from the perspective of a sediment budget for the region depicted in Figure 3.4-7, 30,000 to 60,000 cubic yards of sand should be placed on Goleta Beach or down-coast beaches every year to offset erosion – that would be expected to occur – no matter what alternative may be selected.

Following storm events, during which the shoreline west of the groin migrates landward, the groin would very likely trap greater amounts of sand, and greater quantities may be required during such years.

However, on the other hand, Figure 13 of the report titled, "*Long-Term and Storm Event Changes to the Beaches of Isla Vista, California – Final Report to UCSB Shoreline Preservation Fund*", by David Revell and Dr. Gary Griggs, indicates the beaches from Campus Point to Goleta Beach generally accreted during the period from 1947 to 1975 – prior to the more recent period of erosion from 1975 to 1997. During such periods of natural accretion on Goleta Beach, the groin would be expected to naturally "fill"; after becoming filled (completely impounded), the filled groin would allow for sediment to move uninterrupted along the beach – without any adverse down-coast impacts. This report identifies that: "There is evidence that the Pacific Decadal Oscillation, a ~25 year climate cycle may play an important role in regulating the changes in beach width, with calmer La Niña dominated time periods widening beaches and more energetic El Niño conditions narrowing beaches." In general, the above cited report leads to the expectation that, over the long-term, the need for dredge and fill operations to offset down-coast impacts of the groin (a) will not be a steady-state or continuous requirement, (b) will be dependent upon the magnitude of longshore sediment transport moving east around Campus Point, and (c) may not even be warranted during periods of natural accretion. In addition, the report suggest that if Goleta Beach fluctuations are driven by the Pacific Decadal Oscillation, Goleta Beach may widen naturally from its present configuration in the near future.

Note that periodic beach nourishment would fulfill most of the Project Objectives cited in the EIR [2.2; page 2-2] - generally as well as the other alternatives under consideration; however an accessible beach associated with periodic beach nourishment would be more vulnerable to storm events whereas an adequate beach width may not exist after a storm until the beach may be re-nourished. Similarly, beach nourishment with Managed Retreat (without the backstop revetment) would also fulfill the project objectives.

3. **Will ongoing dredge and fill activities be required to offset down-coast impacts of the Managed Retreat project? Please compare and contrast the frequency and magnitude of any ongoing dredge and fill activities needed to support the Managed Retreat project with the ongoing dredge and fill needed to support Beach Stabilization project.**

<u>Response</u>: Yes, "ongoing dredge and fill activities" <u>would</u> "be required to offset down-coast impacts of the Managed Retreat project". As identified above (see the 2nd paragraph in the response to question 2), there is a regional sediment transport deficit as reflected in Figure 3.4-7. The EIR identifies that for the Managed Retreat Project: "The existing eastern revetment would be left in place and lengthened to protect the restaurant and sewer outfall vault" [2.3.3.1; page 2-10]. This revetment would be expected to generally have a stabilizing effect upon the beaches to the west – comparable but less than the groin associated with the Stabilized Beach Project.

It is assumed that, consistent with the Project Objectives [2.2; page 2-2], it is desirable to avoid any increase in erosion of down-coast beaches. The regional sediment deficit inherently will lead to erosion of beaches east of "Campus Point" until the longshore transport reaches the transport potential – assumed at 310,000cy/yr as reflected in Figure 3.4-7. Due to the regional sediment deficit, the frequency and magnitude of dredge and fill activities needed to support the Managed Retreat project are expected to be nearly identical with the ongoing dredge and fill needed to support the Beach Stabilization project.

4. **Is it feasible to mitigate the Beach Stabilization groin's down-coast impacts? At what rate would sand have to be applied to Goleta Beach or down-coast beaches to fully offset impacts from the proposed groin? Are there other means to mitigate these impacts?**

   Response: Yes, it is "feasible to mitigate the Beach Stabilization groin's down-coast impacts". As identified above (see question 2), between 9,312 and 60,000 cubic yards of sand would have to be placed – every year - on Goleta Beach or down-coast beaches to fully offset impacts from the proposed groin. The only other means to offset these impacts would be to provide for comparable stabilization of the down-coast beaches via similar groin structures; however, theoretically, this may be a near-ending effort as the adverse effects "domino" down the coast.

   Note that although the groin's down-coast impacts can be mitigated, such impacts are unavoidable and are expected to be mitigated "after-the-fact" – after the impacts have occurred. Even with "pre-filling" of the groin, the groin is very likely to lose sand during storms associated with cross-shore transport; prior to re-filling of the groin by dredge and fill operations, the groin would adversely affect down-coast beaches. After such impacts to down-coast beaches, the dredge and fill operations would be required to place sand on down-coast beaches to offset or mitigate the groin effects.

5. **Does the draft EIR describe whether there is enough sand feasibly available to undertake repeat dredge and fill operations that may be necessary to mitigate all down-coast shoreline sand supply impacts for the Beach Stabilization project? For the Managed Retreat project? Does the draft EIR analyze the impacts associated with obtaining such sand supply?**

   Response: The EIR cites describes two potential sources for sand (a) an "offshore borrow site … located approximately one mile southeast of the Goleta Pier …in water depths ranging from approximately -60 to -75 feet, relative to MLLW" and (b) an "alternate source" at "West Beach located within Santa Barbara Harbor" [2.3.3.1; page 2-13]. It does not appear that the EIR clearly states the quantities of sand available to support either alternative. However, the dimensions cited for the offshore borrow site indicate about 700,000 cubic yards may be available from this site – assuming an average dredge "cut" of 10 feet. As cited in the EIR [2.3.2.1; page 2-4], 500,000 cubic yards of sand are estimated to be required to pre-fill the groin under Beach Stabilization; with up to 60,000 cy/yr required for long-term nourishment (see response to question 2), the sand available in the offshore borrow source might be expected to be adequate for about 3 years after initial construction [700,000cy ≈ 500,000cy + (3yrs X 60,000cy/yr)].

   The EIR does not appear to address the impacts associated with use of either sand source. Impacts would be expected in the borrow site and fill area - associated with removal/placement of sand and disturbance of benthic/infaunal communities and associated fisheries. Note that although the sand from the Harbor is likely beach compatible, additional data is needed to demonstrate that the offshore borrow area is beach compatible; such data should include (at minimum) (a) sufficient vibracores to define the stratigraphy of the borrow site, (b) grain-size analysis of representative samples from the vibracores and native beach, and (c) analysis to demonstrate the compatibility of the borrow site material with the native beach.

6. **Considering the draft EIR and your knowledge, will Beach Stabilization rob sand from down-coast beaches? Mitigation Measure BS-COAS-4 requires down-coast beach monitoring and implementation of beach nourishment once down-coast impacts are detected. Is it feasible to detect down-coast shoreline sand supply impacts and attribute those impacts to specific causes (e.g., natural variations and/or groins)? Once a down-coast sand supply deficit is detected, will the down-coast shoreline sand supply impact have already begun? Will the Beach Stabilization project rob down-coast beaches of sand on an ongoing or intermittent basis even with the proposed Mitigation Measure BS-COAS-4 described on page 4.1-36 & 37? Will this measure prevent or offset all down-coast impacts of Beach Stabilization's groin?**

   Response: Yes, the Beach Stabilization Project would effectively "rob" sand from down drift beaches by preventing or at least deterring erosion of the beaches west of the groin and thus depriving that eroded sand from (a) restoring longshore transport, and (b) feeding the down-coast beaches. Note that this effect is expected with any structure that might prevent beach erosion. In general, it is commonly held that "structures do not prevent erosion, structures only re-arrange erosion".

   It is my general understanding and assumption that the beaches east of the pier and further east beyond the mouth of Goleta Slough are generally stable – with more mild historical fluctuations than have been seen at the County park. Based upon this understanding, any significant down-coast shoreline sand supply impact (a) would be detected, and (b) would be attributable to the groin.

   During periods when the up-coast beach fillet of the groin is not completely filled (after initial construction and after significant storm events), the Beach Stabilization Project would effectively "rob" down-coast beaches of sand. During periods when the fillet is completely filled or "over-filled", the groin would have no adverse effect upon down-coast beaches. This results in an intermittent impact.

   The proposed Mitigation Measure, in concept, would offset all down-coast impacts of the Beach Stabilization's groin. However, the measure would not prevent impacts, but inherently mitigates the impacts – after the impacts have occurred.

7. **Under the Beach Stabilization project, the pilings may have to be fine-tuned to ensure they trap just the right amount of sand and do not rob down coast beaches (significantly). The EIR finds that after 1 to 2 years of fine-tuning the pilings can be**

covered with a deck, creating a wider Goleta Pier. Additional adjustments may be required over time. Once covered with a deck, additional fine-tuning of pilings may be difficult to accomplish. Is 1 – 2 years sufficient time to fine-tune the pilings to ensure no impacts to shoreline sand supply? Why or why not? Under a reasonable worst-case scenario, how many years may the fine tuning adjustments be required to ensure excessive sedimentation does not increase down-coast impacts?

Response: One to two years would likely be sufficient time to fine-tune the pilings to ensure no impacts to shoreline sand supply. However, provisions should be made to provide for future "tuning" in the event (a) the first one or two years constitute unusual conditions, or (b) conditions may change – such as associated with sea-level rise, sediment discharge through Goleta Slough. Under a reasonable worst-case scenario, fine-tuning adjustments should be required for the duration of the existence of the groin; however, after initial adjustments within the first 2 years, further adjustments are not likely to be warranted for at least two years to allow for the littoral system to become in equilibrium with the adjusted groin.

8. **Will the beach resulting from Beach Stabilization be 8.6 acres as described on page 2-21? If the answer is no, please explain.**

   Response: Quantification of the beach area is beyond what I may reasonably assess in the context of this consultation. However, the methods used by the County's consultants to estimate the beach area appear reasonable.

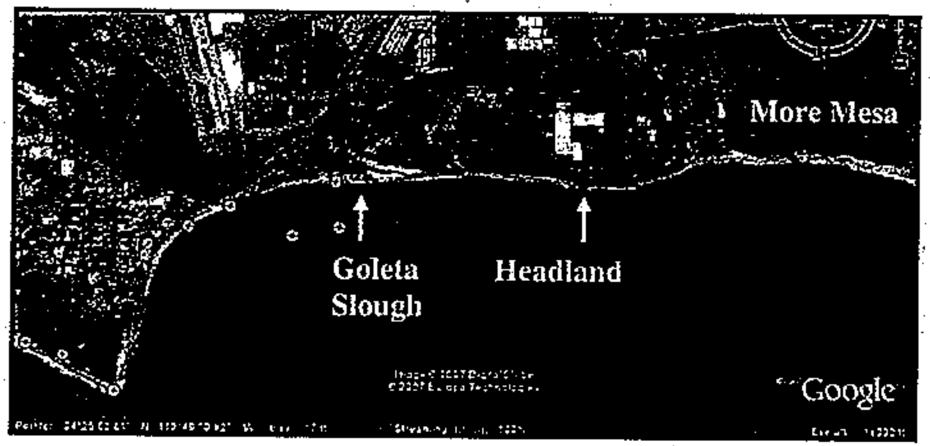
9. **Will the offshore borrow area trap sand from the littoral drift, potentially robbing down-coast beaches? Is the borrow area sufficiently below the closure depth and therefore not subject to receiving sand moving down-coast?**

   Response: The EIR cites the offshore borrow site "approximately one mile southeast of the Goleta Pier …in water depths ranging from approximately -60 to -75 feet, relative to MLLW" [2.3.3.1; page 2-13]. The values for "depth of closure" cited in the EIR "range from -14.8 feet to -17.4 feet MSL" [Coastal Resources Appendix 6.1.3; page 6-3]. Although greater "depth of closure" might be determined via other methods; the offshore borrow area would not trap sand associated with littoral drift. The borrow area is sufficient offshore and far seaward of the near-shore zone associated littoral drift.

10. **Will there be an increase in erosion at More Mesa's bluffs if (a) the Beach Stabilization groin robs sands from the littoral drift, and if (b) nourishment cannot feasibly fully mitigate the impact? Is this a geological safety hazard impact? Was the impact of bluff erosion as a public safety issue analyzed?**

    Response: It is not likely that there will "be an increase in erosion at More Mesa's bluffs" – no matter what alternative is selected.

Any longshore transport deficit that is translated to the down-coast beaches by the alternatives is likely to cause and be offset by increased erosion along that sandy shoreline between the eastern limits of the project (existing revetment for Managed Retreat; pier for Beach Stabilization) and an apparent headland (perhaps natural rock or a rock revetment) that exists between More Mesa and Goleta Slough, as reflected in the aerial below. This headland will likely dominate effects upon the beach and bluffs at More Mesa more than any of the alternatives. The headland likely traps sand on the beaches to the west and translates a corresponding longshore sediment deficit to the beaches at More Mesa, but the alternatives are not likely to affect the impacts upon More Mesa attributable to this headland. The headland likely dominates the causes of erosion at More Mesa.



The County's "Local Coastal Plan" cites (a) "landslides" as a "Geologic Hazard" and (b) "problems due to slope instability". Based upon this plan, a project that induces erosion and creates unstable bluffs can be construed to create a "Geologic Hazard".

The EIR does not appear to address the potential for an increase in bluff erosion and the public safety issues associated sudden collapse of eroded bluffs due to "slope instability". It appears that the EIR generally assumes down-coast erosion would be abated by (a) the 500,000 cubic yards of sand to pre-fill the groins, and/or (b) sand placement proposed in concert with monitoring of down-coast beaches. However, the unavoidable impacts of the groin (see response to question 4) include down-coast beach erosion, which would very likely lead to increased down-coast buff erosion between Goleta Slough and the headland (see photo above), where diminished beach width would allow for bluff erosion to occur during storms.

11. **Would the down-coast beach at More Mesa narrow slightly (compared to the ambient rate) for 7,200 feet west of Goleta Beach County Park under the Managed Retreat project? Please explain why the beach would or would not narrow at a rate exceeding the ambient rate under Managed Retreat. Can you quantitatively compare the down-coast effects of the Managed Retreat and Beach Stabilization projects?**

<u>Response</u>: See response to question 13 above.

Quantitative comparison of the down-coast effects of the Managed Retreat and Beach Stabilization projects is beyond what I may reasonably assess in the context of this consultation. From a qualitative perspective, both the groin and existing revetment are artificial headlands, the groin is proposed to extend significantly further seaward and as a result is expected to have significantly greater down-coast effects.

12. **Would the Full Revetment alternative result in significant down-coast beach narrowing considering the proposed 100,000 cubic yards / year of beach fill? Is it feasible to deliver 100,000 cubic yards / year to Goleta Beach? What are the impacts of such delivery?**

Response: No, with the proposed 100,000 cubic yards per year of beach fill, the Full Revetment alternative would not likely result in "significant down-coast beach narrowing". Beach fill at 100,000 cy/yr would be expected to offset the regional longshore transport deficit estimated at a maximum of 60,000 cy/yr; see response to question 2.

Yes it is it feasible to deliver 100,000 cubic yards per year to Goleta Beach. Comparable annual quantities are commonly placed to maintain beaches in other areas. However, it is very likely to be more economical to place larger quantities less frequently, for example, 200,000 cubic yards – every 2 years.

Impacts would be expected in the borrow site and fill area - associated with removal/placement of sand and disturbance of benthic/infaunal communities and associated fisheries. In addition, disruption of the use of the park during construction would occur.

13. **Would the Offshore Breakwater alternative require more than 500,000 cubic yards of pre-fill given the larger salient compared to Beach Stabilization that would result from the breakwater's construction? Considering the pre-fill and possible ongoing nourishment needed to minimize down-coast impacts, would long-term down-coast shoreline sand supply impacts result under the Offshore Breakwater alternative? If it is feasible to fully mitigate down-coast impacts of this alternative, at what rate and frequency (e.g., annually, monthly, constantly) would sand have to be applied?**

Response: The EIR cites that it is assumed that the Offshore Breakwater alternative would require "on the order of" 500,000 cubic yards of pre-fill – equal to the pre-fill cited for the Beach Stabilization Project [5.1.3; page 5.1-36]. It is likely that the larger salient associated with the breakwater – as compared to Beach Stabilization - would result from the breakwater's construction?

There is no doubt that the Offshore Breakwater alternative would cause long-term down-coast shoreline sand supply impacts due to the interruption of longshore transport – associated with trapping sand up-coast and depriving sand to down-coast.

In the worst scenario, a breakwater could become a total littoral barrier. On the order of 310,000 cubic yards of sand – every year- would then be necessary to offset the impacts to down-coast beaches; this estimate is based upon the estimated net transport – see the sediment budget quantities cited in Figure 3.4-7.

14. Would changes to bathymetry caused by the Offshore Breakwater alternative or the Beach Stabilization project affect wave conditions at the surf spot "Poles" .25 to .5 miles N by NE (down-coast) of Campus Point?

Response: Based upon experience and judgment, the changes to bathymetry caused by the Offshore Breakwater alternative or the Beach Stabilization project would likely only slightly "affect wave conditions at the surf spot 'Poles' .25 to .5 miles N by NE (down-coast) of Campus Point. The predicted bathymetry changes in this area are slight and do not appear to significantly affect the orientation of the shoreline relative to incipient waves - which dominates the desirable surfing conditions in this area.

15. Would you recommend feasible modifications to the Managed Retreat project that would avoid or substantially lessen any of the impacts associated with either the Beach Stabilization or Managed Retreat project as described in the draft EIR?

Response: In general, both alternatives are intended to offset a regional sediment deficit that largely is created by the natural and artificial headlands that exist at and to the west of Campus Point – as reflected in Figure 3.4-7. Any alternative must include periodic beach fill – in quantities equivalent to the longshore transport deficit - to offset the effects of these headlands and the stabilization structures (existing revetment or groin) which translate all or a portion of the deficit to down-coast beaches.

16. What other comments or criticisms do you have of the draft EIR's analysis of coastal process issues?

Response: The EIR should address the entire shoreline from at least Campus Point to the Harbor, which appears to be a total littoral barrier and which requires mechanical transfer of sand to down-coast beaches. In concert with this more broad regional approach, the sediment budget should be assessed for the region and sediment management practices should be developed to manage the entire shoreline in the region.

The EIR does not clearly quantify historical shoreline changes and volumetric losses (a) along Goleta Beach, or (b) along the down-coast beaches that may be affected by the alternatives.

17. Can you think of any other alternatives or mitigation measures that should be analyzed in the EIR?

Response: Based upon experience and judgment, I recommend that:

1. A regional sediment management project be evaluated in detail; such a project should:
    - entail the shoreline from Campus Point to Santa Barbara Harbor, and

- provide for stabilization of the entire shoreline via beach fill and/or structures.

2. A monitoring program should be implemented to provide for periodic (perhaps annually) surveys (from uplands to at least wading depth) of the shoreline from Campus Point to the Harbor. Profiles should be surveyed at reference monuments established at a maximum spacing of 1,000 feet along the shoreline.

If you have any questions, or if I may assist you further, please contact me.

Sincerely,
COASTAL TECH

Michael Walther

Michael Walther, M.S.
P.E. - FL, TX, LA, NC, AL

Attachment #11

Brian Trautwein

From: Ward, Dave
Sent: Monday, April 14, 2008 5:15 PM
To: Axelson, Erik; Beltranena, Juan
Subject: FW: Goleta Beach Pier Animations
Follow Up Flag: Follow up
Flag Status: Red
Attachments: animations.pps

From: Webb, Chris [mailto:cwebb@moffattnichol.com]
Sent: Friday, February 01, 2008 3:51 PM
To: Ward, Dave; Pat Saley
Cc: Martin, Anthony; Carale, Sandie
Subject: FW: Goleta Beach Pier Animations

Hi Dave and Pat – Attached is the first attempt at a graphic animation that shows existing and then future pier when you hit the space bar. Give it a try and let us know what you think. Lots of piles and not too pretty to be sure.

Thanks,
-Chris

Chris Webb, Senior Coastal Scientist
Moffatt & Nichol
3780 Kilroy Airport Way, Suite 600
Long Beach, CA 90806
Phone (562) 426-9551
Fax (562) 424-7489

From: Martin, Anthony
Sent: Friday, February 01, 2008 2:15 PM
To: Webb, Chris
Cc: 'Sandie Carale'; Vidyarthi, Depika
Subject: Goleta Beach Pier Animations

Hey Chris,

Here are the renderings. Hope these will work.

ANTHONY S. MARTIN
Graphic Designer / Marketing Coordinator
amartin@moffattnichol.com
MOFFATT & NICHOL

Attachment #12

Brian Trautwein

From: Brian Trautwein [btraut@edcnet.org]
Sent: Tuesday, June 23, 2009 11:20 AM
To: 'Steve Hudson'
Subject: FW: Questions re Park Reconfiguration Alternative Report

Hi Steve,

I followed up with PWA re the question about loss of the 1.3 acre buffer area for upland park use. PWA's engineers who crafted the plan do not agree with your assessment that the 1.3 acre buffer area necessarily needs to become sandy beach. Below, Dr. Revell notes that some portion of the 1.3 acre buffer area could become sandy beach BUT that it is "entirely up to the County" whether the area is revegetated with lawn or dunes. "So the acreage and use of that buffer could be determined by the County." Please note in the staff report that further clarification from the authors/engineers demonstrate that the 1.3 acre turf buffer should not be assumed to be sand and can be maintained/restored to turf by the County under PWA's alternative.

Please also note and clarify in the staff report that with regards to parking:

1) PWA concluded based on parameters approved by the County that the Park Reconfiguration Alternative provides all 594 parking spaces. PWA's parameters regarding parking spaces and areas were approved by the County staff in the context of PWA's work on the County's Managed Retreat plan. PWA did not change the Parking Plan and used the same parameters the County had ok'd for PWA's work on the County's managed retreat project analyzed in the County EIR. This includes removal of the ranger house and parking space size.

2) The EIR states that the ranger houses are planned to be removed – not retained for park hosts or other uses.

Thanks for your attention to these important details.

Kind Regards,
Brian

Brian Trautwein,
Environmental Analyst
Environmental Defense Center
906 Garden Street
Santa Barbara, CA 93101
btraut@edcnet.org
(805) 963-1622 X 108
(805) 962-3152 fax

From: David Revell [mailto:D.Revell@pwa-ltd.com]
Sent: Friday, June 05, 2009 12:17 PM
To: Brian Trautwein
Cc: Bob Battalio
Subject: RE: Questions re Park Reconfiguration Alternative Report

Hi Brian,
This could be a long answer or a short answer. I am going to give you the short answer.

Question 1 and 3. - The parking analysis did not change from the work that we did as the consultant the County in 2005. During the stakeholder process, we worked directly as the coastal engineers with the county on the upland cost estimating and parking work, using the cost estimate values and numbers that they provided. All of the assumptions, regarding the ranger house, etc were all the same as provided by the county. If they want to move the target to say that we missed, that is not something that we are in a position to nitpick over details at this point.

That would have to be the basis for preliminary design work to fully develop the alternative for environmental review. Our intent was to further flush out the PRA using the same design constraints provided by the county while we were under contract with them

Question 4 – the 4.2 acres of lawn includes the buffer area which following initial construction would be lawn. Over time if erosion occurs, some portion of that could be converted to beach, however the alongshore distance over which lawn and sand transitions remains the same (~1900 ft). Under the PRA, the adaptative mgt approach is to regrade the subsurface fill, cap with small amounts of sand, and revegetate. Whether that is lawn of native dune plants is entirely up to the county. So the acreage and the use of that buffer could be determined by the county.

Hope this helps.

=\dave

DAVID REVELL, PHD.
SENIOR ASSOCIATE
PWA | Philip Williams & Associates, Ltd.
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, CA 94108
T 415.262.2300 | **F** 415 262.2303
D 415 262.2312 | **C** 503 577.4515
d.revell@pwa-ltd.com | www.pwa-ltd.com

Brian

My recollection is that we worked cooperatively with the County Parks staff while under contract with them, and we reviewed the assumptions and decisions about parking. I don't recall a specific document but rather that the County staff reviewed and approved what we did, and provided some unit cost information, and provided guidance on land use revisions (e.g. the idea of removing the ranger's quarters). In general, then, what PWA produced was for and approved by the County including the specifically and explicitly the treatment of parking, including parking place size and number.

ROBERT (BOB) BATTALIO, PE
PRINCIPAL
PWA | Philip Williams & Associates, Ltd.
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, CA 94108
T 415 262.2300 | **F** 415 262.2303
D 415 262.2313 |
b.battalio@pwa-ltd.com | www.pwa-ltd.com

Brian Trautwein,
Environmental Analyst
Environmental Defense Center
906 Garden Street
Santa Barbara, CA 93101
btraut@edcnet.org
(805) 963-1622 X 108
(805) 962-3152 fax

Attachment #13

May 10, 2007

Comments by E.A. Keller,

Professor Environmental Studies and Earth Science, UCSB

Subject: **Goleta Beach Long-term Protection Plan DEIR**

I believe more attention needs to be given to several aspects of coastal processes. The dominant wave energy comes from the northwest and periodically produces large waves from storms, particularly during El Nino years, but the wave data is incomplete in not addressing the highest waves that are likely to strike Goleta Beach. The draft EIR analysis assumes that above average wave conditions are only 10% in height and 21% in energy greater than average wave conditions as measured over only a 4-year period (2002-2006). (Draft EIR at page 4.1-31) "Average wave conditions" does not mean much because most erosion is caused by large wave conditions. Substantially above-average wave conditions such as those I observed at Goleta Beach during the El Nino event in the early 1980s should be an important consideration in the analysis. These waves were considerably greater than 10% above average wave height. Table 3.4-2 shows a significant wave height data for deep-water waves seven miles off Goleta Beach, but does not address the height of breakers in the surf zone, which will cause erosion and impact the shoreline. During the El Nino of the early 1980's I observed large waves breaking approximately one-half mile off shore Goleta Beach and then reforming. The actual foam line of the surf zone was very close to the boards on Goleta pier. The draft EIR analysis should have considered this size of El Nino-driven waves; instead, the draft EIR uses an above average wave height condition that does not represent the reasonable (and observed) high-energy scenario.

The wave-approach information shown on Figure 3.4-3 only includes the years from 1995 to 2000, and does not consider waves coming from the south from storms generated in Mexico.[1] With global warming and more intense hurricanes likely these

[1] The Draft EIR notes that "large waves occasionally occur from the south to south east, but these are much less frequent (Moffet and Nichol 2002). As a result, the sediment transport is nearly unidirectional, from west to east, with occasional short-term (i.e., a few hours) reversals due to pre-frontal wind generated seas

waves should also be considered. They will also drive sediment to the west over relatively short periods of time that may be significant to a structure that blocks long shore transport. I will now consider the two alternatives

Beach Stabilization-Permeable Groin Project

The chosen position for the Permeable Groin is at Goleta Pier. As a result the shoreline will produce the predicted bulge of sand (salient) mostly to the west. Supposedly this will result in about 10 feet of new sediment around the pier and groin extending 200 feet offshore. (Draft EIR at page 4.1-38.) This project certainly would lead to a wider Goleta Beach but perhaps at the expense of the pier itself. Although the reports say the sand will stabilize the pier (Impact BS-COAS-6) this is only true in respect that the shoreline erosion will be minimized and the pilings will be buried deeper. The shallower water may lead to large waves actually lifting the decking boards off the pier. Thus the shoaling beneath the existing pier will cause waves of a given size to raise the water level higher relative to the pier. If this is the case then the project may endanger the pier.

In addition large waves of the kind that I observed and that sometimes arrive in El Nino years may be at such strength that the groin itself would be in danger of washing out. Thus I recommend a study that demonstrates that the largest storm waves that occur every few decades[2] would not severely damage the pier due to sand accretion caused by the groin. In addition in those years when storms and waves from Mexico reach the Goleta area additional sand will pile up on the east side of the groin. In my estimation accretion of sand around the pier will eventually lead to the need to dredge beneath the pier so that incoming waves won't damage it.

during winter storms." The draft EIR analysis does not, however, account for storms generated in the south which typically last substantially more than a few hours.

[2] While the project planning horizon is 20 years, impacts that may result after 20 years must be analyzed in the draft EIR.

While I do not support the groin due to potential impacts to the pier, high costs and potential environmental effects, relocating the proposed groin upcoast to the mid-park area may fulfill some of the project objectives without jeopardizing the pier. However, the beach could be expected to narrow down-coast periodically given the intermittent nature of beach nourishment as mitigation after down-coast impacts are detected. This could endanger the pier through beach erosion. Moreover, the pier is currently stable; introducing structures such as the proposed groin that could threaten the pier should be avoided if the project objectives can be fulfilled by other means. If any groins have been proposed adjoining piers, these examples should be described as relevant models for the Goleta Beach Park Beach Stabilization Project.

The Huntington Pier was used as an example of how pier pilings can create a salient. Is the Huntington Pier tall enough to escape wave damage potentially caused by waves riding up on the accumulated sand? To avoid potential wave damage to Goleta Pier under the proposed Beach Stabilization project, Goleta Pier's deck should be raised in elevation.

Another concern with the proposed groin is the potential for periodic down-coast shoreline sand supply impacts. While mitigation is intended to offset this impact, the impact cannot be entirely avoided. If down-coast beach narrowing is detected by monitoring proposed under Mitigation Measure BS-COAS-4, the impact of beach narrowing will have occurred. There is then a time lag before nourishment can be implemented and another time lag before nourishment at Goleta Beach refills the salient and replenishes down-coast beaches. The EIR states on page 4.1-27 that any increase in down-coast erosion is a significant impact. Therefore, given this threshold for defining significant impacts and given the inability to entirely avoid this impact (i.e. the time lag for mitigation) Beach Stabilization may result in a significant impact to coastal processes

The impact analysis does not properly consider Dave Revell's paper referenced in the draft EIR. For instance the EIR should consider the pending arrival at Goleta Beach of a slug of sand from upcoast, which has been measured by Revell. The arrival of this sand may moot or minimize the need for this expensive project. Considering the cyclical nature of beach widening and narrowing related to the cycles in the Pacific Ocean (Figure 3.4-5), implementing nourishment without a groin during times of narrow beaches is a feasible way to fulfill the project objectives in the interim until the beach naturally widens with the arrival of future slugs of sand.

Managed Retreat Project

The Managed Retreat Project has many positive aspects that minimize environmental effects and benefit the environment. In particular the movement of utilities, restrooms and parking lots mitigates the potential utility line (gas or sewer) rupture. The Managed Retreat project is in part a hard solution to beach erosion not flexible managed retreat. If you read it carefully there will be additional rock revetments which are a form of sea wall to the west of the pier. The east portion of the park is a fragile area at the mouth of valuable wetlands. In my estimation there should be no parking lot except perhaps adjacent to the restaurant. The eastern end parking lot could be removed and returned to a more natural landscape where the migrating mouth of the slough is present. This is perhaps the most scenic part of Goleta Beach Park and right now it is an unsightly parking lot protected by revetments. The cars are parked very near the ocean and any leakage of oil, coolant, brake fluid, power steering fluid and gasoline will quickly pollute the beach and marine environment when it rains and runoff occurs. The parking lot and revetments built over the years to protect the parking lot cause environmental impacts, including impacts to the Goleta Slough habitat. The east revetment is proposed to be approved as part of the proposed project. To mitigate the ongoing impacts of this part of the project, the eastern end of the sandspit should be returned to a more natural environment where people could observe tidal processes while walking the beach in a very scenic location. There is a problem in that the number of parking spaces would be further reduced. Alternative parking scenarios were not considered in the EIR but are feasible ways to mitigate the project's environmental impacts. In general it has been my observation that a parking shortage only occurs the days when the beach is heavily used. During those days I believe there should be some additional parking away from the beach perhaps even out of the park with a shuttle service. People in Los Angeles walk fairly long distances to park their cars at coastal beaches and it seems to be working fine. You would need a drop off place for people to let people off and then provide parking, closer perhaps to the airport.

What I object to the most with respect to the Managed Retreat option is the construction of a hidden rock revetment or sea wall approximately 50 feet back from the beach. In my estimation this is a waste of money at this time. If we go for a Managed Retreat option we will observe over a period of years that there will be periodic erosion and deposition on the beach. If the study by Revel and Griggs (2005) published in Shore and Beach is correct then periodically Goleta Beach will receive a pulse of sediment that will lead to natural widening of the beach. We may be in a time when sand flow is less now, but it could increase in the future. Spending huge amounts of money for a hidden sea wall doesn't make much sense to me at this time. Should sea levels rise rapidly and erosion greatly increase then we could revisit the need of structural control. At this time the buried backstop revetment would simply add a lot of money to the project. An important question is concerning the cost of the buried rock revetment versus periodic beach nourishment. I am not aware of anyone who has attempted to bury a large rock revetment back from the shoreline and I wonder about the rationality of such a decision. With the restrooms and other facilities moved further back a sufficient buffer from coastal erosion is present except perhaps at the western end of Goleta beach. With ongoing beach nourishment, there is no need for a buried backstop revetment under Managed Retreat. Therefore, to feasibly mitigate the impacts of the buried seawall, including future passive erosion and beach access impacts once the wall is exposed on the beach, the Managed Retreat project should be modified to (1) eliminate the buried backstop revetment, and (2) continue ongoing beach nourishment as needed.

Summary

I generally favor the Managed Retreat Option but not including the new or even existing rock revetment at the eastern end or the buried rock revetment buried behind the beach itself. I think these add a lot of money to the expense of the project and should large waves attack the beach probably would be washed out as past rocks and other sea walls in other beaches have. The rocks would have to be very large and carefully placed so that large storm waves during El Nino conditions would not move them. Furthermore it seems to be a waste of money to excavate a large area and bury a sea wall under a plan of Managed Retreat. Once a seawall is placed it is almost never removed, but commonly is replaced over a period of years by bigger, more expensive seawalls. Seawalls never are to save a beach but to save unwise coastal development.

Final Statement About Coastal Processes

The coastal zone is one of the most unstable and changing environments of the world. Absolute control of coastal processes generally only comes at a loss of the beach itself. Even then structures composed in the coastal zone are vulnerable to destruction by infrequent high intensity wave energy. Should the permeable pile groin be built it would be vulnerable to very large waves and the pier itself might be in jeopardy. With the Managed Retreat Option, sea walls (reconstructed rock revetment) at the eastern end of the park would be vulnerable to washing out in high intensity storms. With respect to the buried revetment sea wall, it too could experience wave erosion over a period of years and be washed out. It would likely be replaced with a larger wall. There is no way to absolutely retain shorelines in their present configurations short of very heavy imbedded concrete structures that would lead to the destruction of Goleta Beach, as we know it. Therefore the Managed Retreat Option as well as the Permeable Pile Groin both have inherent dangers for their long-term stability. This is a risk we take when we choose to build and develop in the coastal zone. One advantage of Managed Retreat is that we have the chance to address erosion problems as they occur over a period of years. We don't have a crystal ball so we can't say when really large storm waves from an El Nino will strike the shoreline. What we can say is that they eventually will. As a result we may go for a few years or maybe a decade without any major problems. Therefore it seems to me some sort of periodic replenishment of sand makes more sense and is environmentally superior to and more feasible than spending large sums of money to try to control processes over which we may not have ultimate control given the park's setting. Concerning the restaurant it was built in a poor location to begin with given its present design. Take a look at the Yacht Club at Santa Barbara Harbor that is built upon stilts well above the water level. Should at some time in the future the restaurant be heavily damaged such an option should certainly be considered. That is rebuilding the restaurant at a higher elevation that would be above wave over wash.

Attachment #14

Brian Trautwein

From: Mark Holmgren [maholmgren@yahoo.com]
Sent: Saturday, May 30, 2009 11:51 AM
To: Brian Trautwein; Jonna Engel
Subject: Rookery at Goleta Beach

To: sbcobirding@yahoogroups.com
From: maholmgren@yahoo.com
Date: Fri, 29 May 2009 20:25:40 -0700
Subject: [sbcobirding] Rookery at Goleta Beach

This evening, 29 May 09, I made three counts of nests in the heron rookery at Goleta Beach and came up with the following.
Empty big nests that were probably used this year: 5;
active Great Blue Heron nests: 14;
active Great Egret: 5;
active Double-crested Cormorant: 11.
An adult Red-tailed Hawk delivered food to at least 1 dependent 'brancher' about 100m E of the rookery.

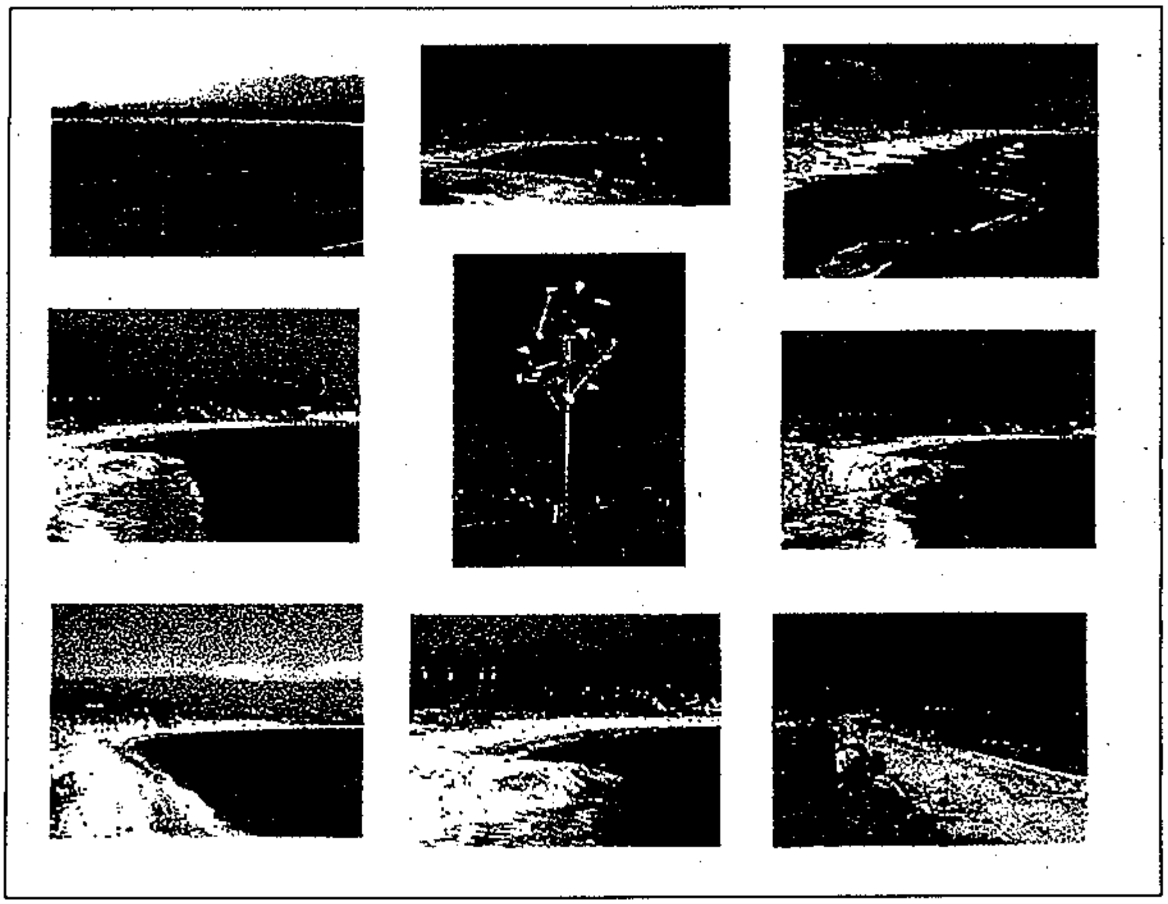
Mark Holmgren
San Marcos Pass

Attachment #15

Goleta Beach County Park

Long Term Protection Plan Implementation Study

DRAFT



Prepared by:
Santa Barbara County
County Executive Office
Parks Department
Planning & Development Department

October 2007

Open Space and Park Districts

Regional park and open space districts can use special taxes and general obligation bonds for capital improvements and to acquire property by purchase or eminent domain. Some of these districts have their own directly-elected boards of directors; county supervisors govern others, ex officio.

District boundaries could be set County-wide or area specific. Similar to the Recreation Demand Areas set up for the establishment of Quimby recreation mitigation fees, an area specific open space and park district would include an area within which park visitors would be willing to travel to and/ or benefit from the use of Goleta Beach.

Regional Park, Park and Open-Space, and Open-Space Districts are governed by Cal. Pub. Resources Code §§ 5500 et seq. There is a specific statute which may be used to form regional districts in Santa Barbara County, found in Pub. Resources Code § 5506.11. Among other things, that section provides that a proceeding for the formation of a regional district in Santa Barbara County may be initiated by resolution of the Board of Supervisors containing certain specifications. The Board of Supervisors would then call an election within the proposed district for the purpose of determining whether the district should be created, and, if necessary, for the purpose of electing the first board of directors. The Board of Supervisors would provide notice of the election to LAFCO.

The Recreation and Park District Law, Pub. Resources Code §§ 5780 et seq., provides the authority for the organization and powers of recreation and park districts. A recreation and park district may acquire, construct, improve, maintain, and operate recreation facilities, including but not limited to parks and open space, both inside and beyond the district's boundaries.

A proposal to form a new recreation and park district may be made by the adoption of a resolution of application by the legislative body of any county or city that contains the territory proposed to be included in the district. A proposal to form a new district may also be made by petition. The petition must be signed by a minimum of 25% of the registered voters residing in the area to be included in the district, as determined by the local agency formation commission. LAFCO then proceeds with the formation proposal.

User Fees

A user fee is a fee or charge to users of a service. Camping parks, swimming pools, and toll roads, for example, are paid for by those who benefit rather than by broad-based taxes. Cal. Govt. Code § 50402 provides, in part, that to the extent feasible, charges for similar uses or services imposed by a governing body shall be uniform throughout its area of jurisdiction. In addition, Cal. Pub. Resources Code § 5162 provides, in part, that any beach recreation area owned by a county shall be open to all members of the public upon the same terms, fees, charges and conditions as are applicable to the residents of the county.

The potential for revenue generation through a user fee currently exists at Goleta Beach for group area picnic reservations and a small charge for launching boats from the crane located on Goleta Pier. A larger fee for service, not yet implemented in the County day-use park system is a per vehicle parking fee.

Parking Fees

A parking fee program at Goleta Beach County Park could be implemented similar to many other local and state jurisdictions. The fee can be set up hourly or as a specific amount paid upon entry into the park. The following Table 1 shows the potential for fees to be collected at various coastal county parks at varying entry fee amounts. Table 2 is provided as a cost comparison of parking fees that other jurisdictions have currently implemented.

TABLE 1 ESTIMATED REVENUES FOR BEACH PARKING FEES

Estimated Annual Revenue for Beach Parking Fee Program*

Note: All numbers are rounded to hundreds ($00).

	Current Annual Vehicle Count	Estimated Payer Percent** 50%	Vehicle Fee Per Day $ 1.00	Vehicle Fee Per Day $ 2.00	Vehicle Fee Per Day $ 3.00	Vehicle Fee Per Day $ 4.00	Vehicle Fee Per Day $ 5.00	Vehicle Fee Per Day $ 6.00	Vehicle Fee Per Day $ 7.00	Vehicle Fee Per Day $ 8.00
South County Parks										
Goleta Beach	616,500	308,300	$ 308,300	$ 616,600	$ 924,900	$ 1,233,200	$ 1,541,500	$ 1,849,800	$ 2,158,100	$ 2,466,400
Arroyo Burro Beach	364,000	182,000	$ 182,000	$ 364,000	$ 546,000	$ 728,000	$ 910,000	$ 1,092,000	$ 1,274,000	$ 1,456,000
Rincon Beach	156,900	78,500	$ 78,500	$ 157,000	$ 235,500	$ 314,000	$ 392,500	$ 471,000	$ 549,500	$ 628,000
Lookout Beach	126,900	63,500	$ 63,500	$ 127,000	$ 190,500	$ 254,000	$ 317,500	$ 381,000	$ 444,500	$ 508,000
Subtotal	1,264,300	632,300	$ 632,300	$ 1,264,600	$ 1,896,900	$ 2,529,200	$ 3,161,500	$ 3,793,800	$ 4,426,100	$ 5,058,400
North County Parks										
Ocean Beach	20,900	10,500	$ 10,500	$ 21,000	$ 31,500	$ 42,000	$ 52,500	$ 63,000	$ 73,500	$ 84,000
Rancho Guadalupe Dunes	49,500	24,800	$ 24,800	$ 49,600	$ 74,400	$ 99,200	$ 124,000	$ 148,800	$ 173,600	$ 198,400
Subtotal	70,400	35,300	$ 35,300	$ 70,600	$ 105,900	$ 141,200	$ 176,500	$ 211,800	$ 247,100	$ 282,400
Total	1,334,700	667,600	$ 667,600	$ 1,335,200	$ 2,002,800	$ 2,670,400	$ 3,338,000	$ 4,005,600	$ 4,673,200	$ 5,340,800
Estimated Costs for Beach Parking Fee Program										
One-Time Start-Up Costs (prchs & instln of ksks)			$ 217,800	$ 217,800	$ 217,800	$ 217,800	$ 217,800	$ 217,800	$ 217,800	$ 217,800
Annual Operating Costs (extr hp ksk attndnts)			$ 244,500	$ 244,500	$ 244,500	$ 244,500	$ 244,500	$ 244,500	$ 244,500	$ 244,500
Total First-Year Costs			$ 462,300	$ 462,300	$ 462,300	$ 462,300	$ 462,300	$ 462,300	$ 462,300	$ 462,300
Net First-Year Revenue			$ 205,300	$ 872,900	$ 1,540,500	$ 2,208,100	$ 2,875,700	$ 3,543,300	$ 4,210,900	$ 4,878,500
Net Ongoing Revenue			$ 423,100	$ 1,090,700	$ 1,758,300	$ 2,425,900	$ 3,093,500	$ 3,761,100	$ 4,428,700	$ 5,096,300

*Includes a "first-90 minutes free" parking feature.

**Assumes, based on previous user surveys, that 50% of current park users would pay the fee due to: (1) loss of some park users due to the new fee; (2) some users would use adjacent streets; (3) 90-minute free parking feature.

TABLE 2 - BEACH PARKING FEE COMPARISIONS

Location	Fees	Collection System	Amenities
City of Santa Barbara Waterfront/Beach Parking	$1.50/hr.	Summer & winter fee programs are different (kiosk/attendant vs. honor system)	Pier, harbor, bike path, restaurants,
	$9.00 all day	Prices vary among parking areas (ie wharf parking, boat ramp parking)	restrooms, bbq pits & picnic areas
	$4.00 (disabled)	Large vehicles over 20 feet pay additional fee	
City of Ventura (Ventura State Beach)	$1.00/hr. (any portion of)	Kiosk/attendant (machine dispenses tickets w/time stamp - pay upon exit)	Pier, bike path, boardwalk, restaurants,
	$5.00 all day		beach concessions, Surfer's Point &
			restrooms
City of Port Hueneme Beach Park	$.50/half-hr. (any portion of)	Machine dispenses pre-pay tickets w/time stamp (no kiosk/attendant)	Pier, bike path, restaurant, restrooms,
	$5.00 all day	Parking enforcement patrol needed to issue citations to violators	bbq pits, picnic areas & play equipment
	(open until 10 pm)		
City of Oxnard Beach Park	$1.00/hr. (any portion of)	Fees charged only in certain area of parking lot	Bike path, restrooms, bbq pits & picnic
	$5.00 all day	Machine dispenses pre-pay tickets w/time stamp (no kiosk/attendant)	areas
	(open until 9 pm)	Parking enforcement patrol needed to issue citations to violators	
State Beaches - Channel Coast District (Carpinteria,	$4.00 all day (regular)	Kiosk/attendant (pre-pay day use pass issued upon entry)	Bike paths, hiking trails, restrooms, bbq
El Capitan, Gaviota & Refugio)	$3.00 all day (seniors)		pits, picnic areas & shower facilities
	$2.00 all day (disabled)		
McGrath State Beach (Oxnard)	$4.00 all day (regular)	Kiosk/attendant (pre-pay day use pass issued upon entry)	Bike paths, hiking trails, restrooms, bbq
	$3.00 all day (seniors)		pits, picnic areas & shower facilities
	$2.00 all day (disabled)		

Parking Meters / Pay Stations

County Code Chapter 23B contains rules about Parking Meters that would likely apply to parking fees proposed at Goleta Beach study. The following sections from Chapter 23B are provided:

Sec. 23D-1. Authority and title.

This chapter is enacted pursuant to authority granted by sections 22508 of the California Vehicle Code. This chapter may be referred to as the parking meter program. (Ord. No. 4543, §1)

Sec. 23D-2. Definitions.

"Parking Meter" shall mean any device controlled by the county which is designed, upon the lawful deposit of a fee, to measure in minutes or hours the period of time during which a vehicle may be parked in the parking space for which the fee was deposited, and so constructed or equipped that the same will, upon expiration of the time for which such fee was deposited, indicate such expiration of time. **Parking meter shall include pay station devices that control multiple parking spaces**. (Ord. No. 4543, § 1) (Emphasis added.)

Sec. 23D-3. Zones.

Parking meter zones are hereby established for the following areas:
(a) Isla Vista Downtown Commercial Area:
(1) The Embarcadero Loop: Both sides of Embarcadero Del Mar and Embarcadero Del Norte, bounded by Pardall Road;
(2) Both sides of Trigo Road, bounded on the east by Embarcadero Del Mar and extending approximately two hundred sixty feet to the west;
(3) The north side of Trigo Road, bounded on the west by Embarcadero Del Norte and extending approximately two hundred sixty feet to the east;
(4) The south side of Trigo Road, bounded on the west by Embarcadero Del Norte and extending approximately one hundred eighty feet to the east;
(5) Both sides of Seville Road, bounded on the east by Embarcadero Del Mar and extending approximately two hundred forty feet to the west;
(6) Both sides of Seville Road, bounded on the west by Embarcadero Del Norte and extending approximately one hundred fifty feet to the east;
(7) Both sides of Madrid Road, bounded on the east by Embarcadero Del Mar and extending approximately one hundred sixty feet to the west;
(8) Both sides of Madrid Road, bounded on the west by Embarcadero Del Norte and extending approximately one hundred seventy feet to the east;
(9) Both sides of Pardall Road, bounded on the east by Embarcadero Del Mar and extending approximately two hundred sixty feet to the west;
(10) The north side of Pardall Road, bounded on the west by Embarcadero Del Norte and extending approximately three hundred thirty feet to the east;
(11) The south side of Pardall Road, bounded on the west by Embarcadero Del Norte and extending approximately two hundred fifty feet to the east;
(12) Both sides of Pardall Road, bounded on the west by Embarcadero Del Mar and Embarcadero Del Norte on the east;
(13) Both sides of Embarcadero Del Mar, bounded on the south by Pardall Road and extending approximately one hundred seventy feet to the north; and
(14) Both sides of Embarcadero Del Norte, bounded on the south by Pardall Road and extending approximately two hundred ten feet to the north.
All measurements are estimated from the center-line of the corresponding street, and are approximations. (Ord. No. 4543, § 1)

Lund, Coleen

From: Yates, Edward
Sent: Wednesday, September 26, 2007 4:40 PM
To: Jayasinghe, John; Lund, Coleen; Hufschmid, Joy
Cc: Rierson, Anne
Subject: RE: CEQA for parking fees
Signed By: Eyates@co.santa-barbara.ca.us

I think Coleen is correct but I need to take a closer look. Right now, I think it would be better to separate the two for now and issue a Categorical Exemption for the fees later.

I cannot attend tomorrow, I have a meeting with P&D until 12.

From: Jayasinghe, John
Sent: Wednesday, September 19, 2007 3:55 PM
To: Lund, Coleen; Hufschmid, Joy
Cc: Yates, Edward
Subject: RE: CEQA for parking fees

Coleen, we need to check this out with Ed prior to finalizing our recommendations for the study.

From: Lund, Coleen
Sent: Wednesday, September 19, 2007 2:17 PM
To: Hufschmid, Joy; Jayasinghe, John
Subject: CEQA for parking fees

I don't think our project would be considered under (5) (b) as we certainly are not expanding our system at Goleta Beach - while for other parks it may be the case, for GB it looks like an exemption to me.

15273. Rates, Tolls, Fares, and Charges

(a) CEQA does not apply to the establishment, modification, structuring, restructuring, or approval of rates, tolls, fares, or other charges by public agencies which the public agency finds are for the purpose of:
(1) Meeting operating expenses, including employee wage rates and fringe benefits,
(2) Purchasing or leasing supplies, equipment, or materials,
(3) Meeting financial reserve needs and requirements,
(4) Obtaining funds for capital projects, necessary to maintain service within existing service areas, or
(5) Obtaining funds necessary to maintain such intra-city transfers as are authorized by city charter.
(b) Rate increases to fund capital projects for the expansion of a system remain subject to CEQA. The agency granting the rate increase shall act either as the Lead Agency if no other agency has prepared environmental documents or the capital project or as a Responsible Agency if another agency has already complied with CEQA as the Lead Agency.
(c) The public agency shall incorporate written findings in the record of any proceeding in which an exemption under this section is claimed setting forth with specificity the basis for the claim of exemption.
Note: Authority cited: Section 21083, Public Resources Code; Reference: Section 21080(b)(8), Public Resources Code.

Lund, Coleen

From: Rierson, Anne
Sent: Thursday, August 16, 2007 9:54 AM
To: Jayasinghe, John; Lund, Coleen; Gibson, Mike; Paul, Mark
Subject: Goleta Beach study - County Code sections on Parking Meters

Good morning,

I don't know if you are already aware of this, but County Code Chapter 23B contains rules about Parking Meters that likely apply to the parking fee section of the Goleta Beach Implementation study. Here is a link to the County Code: http://bpc.iserver.net/codes/stbarb/. In case the link does not work, here are some of the applicable sections:

Sec. 23D-1. Authority and title.

This chapter is enacted pursuant to authority granted by sections 22508 of the California Vehicle Code. This chapter may be referred to as the parking meter program. (Ord. No. 4543, §1)

Sec. 23D-2. Definitions.

"Parking Meter" shall mean any device controlled by the county which is designed, upon the lawful deposit of a fee, to measure in minutes or hours the period of time during which a vehicle may be parked in the parking space for which the fee was deposited, and so constructed or equipped that the same will, upon expiration of the time for which such fee was deposited, indicate such expiration of time. **Parking meter shall include pay station devices that control multiple parking spaces**. (Ord. No. 4543, § 1) (Emphasis added.)

Sec. 23D-3. Zones.

Parking meter zones are hereby established for the following areas:
(a) Isla Vista Downtown Commercial Area:
(1) The Embarcadero Loop: Both sides of Embarcadero Del Mar and Embarcadero Del Norte, bounded by Pardall Road;
(2) Both sides of Trigo Road, bounded on the east by Embarcadero Del Mar and extending approximately two hundred sixty feet to the west;
(3) The north side of Trigo Road, bounded on the west by Embarcadero Del Norte and extending approximately two hundred sixty feet to the east;
(4) The south side of Trigo Road, bounded on the west by Embarcadero Del Norte and extending approximately one hundred eighty feet to the east;
(5) Both sides of Seville Road, bounded on the east by Embarcadero Del Mar and extending approximately two hundred forty feet to the west;
(6) Both sides of Seville Road, bounded on the west by Embarcadero Del Norte and extending approximately one hundred fifty feet to the east;
(7) Both sides of Madrid Road, bounded on the east by Embarcadero Del Mar and extending approximately one hundred sixty feet to the west;
(8) Both sides of Madrid Road, bounded on the west by Embarcadero Del Norte and extending approximately one hundred seventy feet to the east;
(9) Both sides of Pardall Road, bounded on the east by Embarcadero Del Mar and extending approximately two hundred sixty feet to the west;
(10) The north side of Pardall Road, bounded on the west by Embarcadero Del Norte and extending approximately three hundred thirty feet to the east;
(11) The south side of Pardall Road, bounded on the west by Embarcadero Del Norte and extending approximately two hundred fifty feet to the east;
(12) Both sides of Pardall Road, bounded on the west by Embarcadero Del Mar and Embarcadero Del Norte on the east;
(13) Both sides of Embarcadero Del Mar, bounded on the south by Pardall Road and extending approximately one hundred seventy feet to the north; and
(14) Both sides of Embarcadero Del Norte, bounded on the south by Pardall Road and extending approximately two hundred ten feet to the north.
All measurements are estimated from the center-line of the corresponding street, and are approximations. (Ord. No. 4543, § 1

Sec. 23D-5. Fees.

Parking meter fees shall be forty cents per fifteen minutes. The maximum amount of meter time that may be purchased at a time is forty-five minutes, except that parking meter controlled parking spaces reserved for coastal access parking shall allow four hours of time to be purchased at a time. Signs shall clearly designate parking meter controlled spaces that are reserved for coastal access parking. (Ord. No. 4543, § 1)

California Vehicle Code Section 22508 states:

22508. Local authorities shall not establish **parking** meter zones or fix the rate of fees for such zones except by ordinance. An ordinance establishing a **parking** meter zone shall describe the area which would be included within the zone.

Local authorities may by ordinance cause streets and highways to be marked with white lines designating **parking** spaces and require vehicles to park within the **parking** spaces.

No ordinance adopted by any local authority pursuant to this section with respect to any state highway shall become effective until the proposed ordinance has been submitted to and approved in writing by the Department of Transportation. The proposed ordinance shall be submitted to the department only by action of the local legislative body and the proposed ordinance shall be submitted in complete draft form.

Any ordinance adopted pursuant to this section establishing a **parking** meter zone or fixing rates of fees for such a zone shall be subject to local referendum processes in the same manner as if such ordinance dealt with a matter of purely local concern.

We can discuss these sections at our next meeting. I am still working on the other questions that you asked me.-Anne

Attachment #16

Marine Environmental Research 66 (2008) 395–403

Contents lists available at ScienceDirect

Marine Environmental Research

journal homepage: www.elsevier.com/locate/marenvrev

Hard coastal-defence structures as habitats for native and exotic rocky-bottom species

Stefano Vaselli [a,b], Fabio Bulleri [b,*], Lisandro Benedetti-Cecchi [b]

[a] Laboratory of Coastal Biodiversity, Centro Interdisciplinar de Investigação Marinha e Ambiental, Rua dos Bragas, 289, 4050-123 Porto, Portugal
[b] Dipartimento di Biologia, Via A. Volta, 6, I-56126 Pisa, Italy

A R T I C L E I N F O

Article history:
Received 28 March 2008
Received in revised form 9 June 2008
Accepted 11 June 2008

Keywords:
Coastal zone
Artificial habitats
Coastal-defence
Wave-exposure
Biological invasions
Caulerpa racemosa
Codium fragile ssp. tomentosoides

A B S T R A C T

The use of hard coastal-defence structures, like breakwaters and seawalls, is rapidly increasing to prevent coastal erosion. We compared low-shore assemblages between wave-protected and wave-exposed habitats on breakwaters along a sandy shore of Tuscany (North-Western Mediterranean). Assemblages were generally characterized by a low diversity of taxa, with space monopolized by *Mytilus galloprovincialis* and *Corallina elongata* on the seaward side of breakwaters and by filamentous algae on the landward side. Assemblages in wave-protected habitats were characterized by greater temporal stability than those in exposed habitats and supported non-indigenous macroalgae such as *Caulerpa racemosa* and *Codium fragile ssp. tomentosoides*. Hence, the introduction of hard coastal-defence structures in otherwise soft-bottom dominated areas, attracting native and exotic rocky-bottom species, should be of great concern for the conservation of marine biodiversity at local and regional scales and for the management of biological invasions.

1. Introduction

More than 60% of the human population is living in coastal zones and projections for the next decades foresee a further increase, with this fraction exceeding 75%, as a consequence of the ongoing demographic expansion and tendency to migrate towards coastal areas (EEA, 1999; Airoldi and Beck, 2007). The need to protect the coast from erosion and flooding have increased the use of man-made structures like breakwaters, groynes and seawalls (Bulleri, 2006; Airoldi and Beck, 2007). A further increment in the presence of hard coastal-defence structures is predicted to happen in response to sea level rise and to increases in the intensity and frequency of storms (Bray and Hooke, 1997; Valiela, 2006). Nonetheless, in contrast to terrestrial environments, artificial marine habitats have received little attention by ecologists and our understanding of their ecological value and functioning remains limited (Bulleri, 2006). Only in recent years have the importance and advantages of including ecological criteria into the design and management of man-made structure been recognized (Glasby, 1999; Glasby and Connell, 1999; Davis et al., 2002; Bacchiocchi and Airoldi, 2003; Chapman, 2003; Airoldi et al., 2005a; Moreira et al., 2007).

Much of the research in this field has been done on artificial structures deployed on hard-bottoms. A number of studies has compared benthic assemblages on different types of artificial habitats (Connell and Glasby, 1998; Connell, 2001) or have assessed the extent to which artificial structures can be considered as surrogates of natural rocky habitats, focusing on assemblages of algae, invertebrates or fish (Connell and Glasby, 1998; Glasby, 1999; Davis et al., 2002; Chapman, 2003, 2006; Chapman and Bulleri, 2003; Guidetti, 2004; Clynick, 2006). To our knowledge, very few studies have instead assessed the ecological implications of introducing hard coastal-defence structures into areas where soft-bottoms are predominant (but see Davis et al., 2002; Bacchiocchi and Airoldi, 2003; Moschella et al., 2005; Pinn et al., 2005; Gacia et al., 2007). Impacts caused by their deployment have been mainly evaluated in terms of the changes caused to assemblages living in the surrounding sedimentary habitats. Changes in water flow, illumination and rates of sedimentation due to the introduction of built structures can be, in fact, detrimental for plants (e.g. seagrasses) and animals living in or on soft-bottom substrata (Davis et al., 1982; Barros et al., 2001; Martin et al., 2005). Less attention has, in contrast, been given to the implications these structures may have in attracting a suite of rocky-bottom organisms (Bulleri, 2005); although this function is widely acknowledged for artificial reefs that are actually built with the primary objective of functioning as aggregating devices or as tools for the rehabilitation of endangered or over-exploited species (Collins et al., 1994; Carr and Hixon, 1997). Provision of hard substrata by man-made structures can facilitate the expansion of a number of hard-bottoms species, including those that are non-indigenous, in areas that otherwise

* Corresponding author. Tel.: +39 050 22 11 415; fax: +39 050 22 11 410.
E-mail address: fbulleri@biologia.unipi.it (F. Bulleri).

0141-1136/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marenvres.2008.06.002

lack suitable habitats (e.g. natural hard-bottoms) (Glasby and Connell, 1999; Davis et al., 2002; Bacchiocchi and Airoldi, 2003; Bulleri and Airoldi, 2005; Glasby et al., 2006), with important implications for biodiversity at local and regional scales (Bulleri, 2005).

Some types of hard coastal-defence structures, such as breakwaters, not only introduce hard substrata in otherwise sandy-dominated bottoms, but can also provide sheltered habitats along wave-exposed coasts. Wave-exposure is an important determinant of the structure of benthic assemblages (Denny, 1995). Thus, the availability of sheltered habitats can allow the development of assemblages very different from those occurring on nearby wave-exposed habitats and create, directly or indirectly, opportunities for the establishment, reproduction and spread of non-indigenous species (Bulleri and Airoldi, 2005; Bulleri et al., 2007).

At odds with the ubiquitous presence of coastal-defence schemes and with the pressing need to improve our understanding of their impacts on natural assemblages at a variety of spatial scales and of their role as surrogates of natural rocky habitats (Bulleri, 2006), very few studies (Bacchiocchi and Airoldi, 2003; Moschella et al., 2005; Pinn et al. 2005; Gacia et al., 2007) have investigated patterns of distribution of epibiota they support and, in particular, assessed differences between wave-exposed and wave-sheltered habitats (Davis et al., 2002).

This study, by assessing patterns of abundance and distribution of epibiota on breakwaters along sandy stretches of coastline in Tuscany (NW Mediterranean), is an attempt in that direction. Specifically, we tested the hypotheses that low-shore assemblages would differ between the landward (wave-sheltered) and the seaward (wave-exposed) side of breakwaters. The generality of patterns was evaluated by making these comparisons on four occasions, over a period of 15 months. Furthermore, because knowledge about the stability of assemblages, either in space or time, is important to predict the susceptibility of assemblages to the establishment of exotic species (Davis et al., 2000), we tested the hypothesis that temporal and spatial variation of the assemblages would be different between the landward and the seaward side of breakwaters.

2. Methods

2.1. Study site

The study was done on hard coastal-defence structures at Marina di Pisa, about 14 km north of Livorno, Tuscany (Italy), in the North-Western Mediterranean (Fig. 1). The coast is sandy, exposed to westerly winds and extends from the mouth of the Arno River for about 15 km south. During the mid-60s', several offshore breakwaters running parallel to the coast were deployed to prevent the erosion of sandy shores. These are about 200 m in length and are made of granite blocks of irregular shape (major axis varying between 2 and 3 m). Breakwaters extend about 2–3 m below the mean low water level (hereafter MLWL), are between 30 and 50 m offshore and separated by narrow channels, about 5 m in width (Fig. 1). The spatial arrangement of breakwaters creates a calm internal water body on the landward side, characterized by soft-bottoms and highly frequented by people from May to October (authors' personal observation).

2.2. Sampling design

In October 2006, we started a preliminary survey to assess patterns of distribution and abundance of algae and invertebrates present on breakwaters. Two breakwaters were haphazardly selected (100 s of m apart) along 2.5 km of coastline. Both the landward (wave-sheltered) and the seaward (wave-exposed) sides of

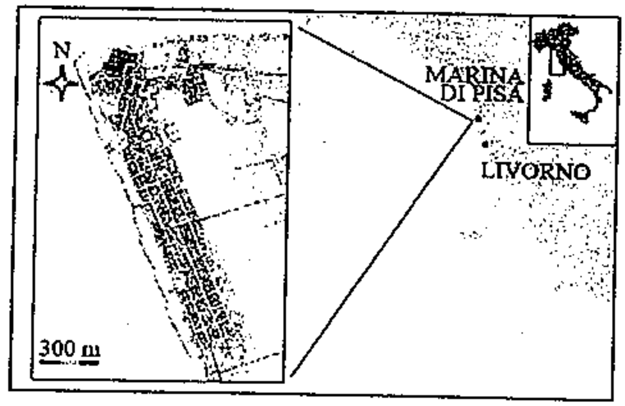


Fig. 1. Map of the study area, showing the strength of shores where breakwaters have been deployed.

breakwaters were sampled at low-shore levels (between 0 and 0.3 m below the MLWL). Three areas (about 5 m long and 10 s of m apart) were then randomly selected within each side of each breakwater. The cover of sessile organisms and bare rock was quantified visually in five randomly placed 20 × 20 cm quadrats in each area, subdivided into 25 sub-quadrats (4 × 4 cm). A score from 0% to 4% was given to each taxon in each sub-quadrat and the percentage cover was obtained by summing over the entire set of sub-quadrats (Dethier et al., 1993). When possible, organisms were identified in the field to species or genus; when it was not possible, taxa were lumped into morphological groups (Steneck and Dethier, 1994).

In December 2006, a greater number of breakwaters were included in our sampling design in order to improve our ability to estimate variation in assemblages at this spatial scale (i.e. among breakwaters). Thus, four breakwaters were randomly selected from a larger number available and, on each of these, two areas (about 5 m long and 10 s of m apart) were randomly identified on both the landward and the seaward side. Different areas were selected for each time of sampling (December 2006, May and October 2007), to ensure data independence (Underwood, 1997). Within each area, low-shore assemblages were sampled in five replicate quadrats with the same procedures previously described.

2.3. Data analysis

To test for differences in the structure of assemblages between exposures, data from the first time of sampling (October 2006) were analysed by permutational multivariate analysis of variance (PERMANOVA, Anderson, 2001). The analysis included the following factors: (i) exposure, fixed, two levels (landward and seaward side of breakwaters); (ii) breakwater, random, two levels, crossed with exposure; (iii) Area, random, three levels, nested within the interaction of the other factors. Student's t-test was used for multivariate *pairwise a posteriori* comparisons.

Multivariate patterns were displayed graphically by plotting the centroids of areas in a nMDS (non-metric multidimensional scaling) based on Euclidean distances. In order to obtain centroids of each area for each date of sampling, we first calculated a dissimilarity matrix based on the Bray–Curtis index among all the observations. Because Bray–Curtis is a semi-metric index, centroids cannot be obtained simply as arithmetic averages of these dissimilarities (Anderson 2001). Thus, we first calculated principal coordinates from the Bray–Curtis dissimilarity matrix. This places the observations into a Euclidean space without altering the Bray–Curtis measure: i.e. the distance between any pair of observations based on the principal coordinates is equivalent to the dissimilarity between those observations obtained from the original variables. Centroids were then obtained as arithmetic averages of the principal coordinates over the five replicates of each area in each date of sampling.

The abundance of common taxa were analysed with analysis of variance (ANOVA), following the same design used for the PERMANOVA. Prior to analyses, Cochran's C-test was used to assess the assumption of homogeneity of variances and data were $Ln(x+1)$-transformed, if necessary (Underwood, 1997). Student – Newman – Keuls (SNK) tests were used for *pairwise a posteriori* comparisons of means.

Data from the subsequent three times of sampling were analysed with the same multivariate and univariate techniques, but with a slightly different design. This included the following factors: (i) date, random, three levels; (ii) breakwater, random, four levels, crossed with date; (iii) exposure, fixed, two levels (landward and seaward side of breakwaters), crossed with both date and breakwater; (iv) area, random, two levels, nested within the interaction of the other factors. Furthermore, SIMPER analysis (Clarke, 1993) was used to identify those taxa that most contributed to Bray–Curtis dissimilarities between the seaward and landward sides of breakwaters at each date of sampling.

Univariate methods for partitioning variation among factors have been successfully extended to multivariate data, providing new insights into assemblage heterogeneity in marine environments (Terlizzi et al., 2007). Estimates of temporal variation in structure of assemblages were obtained by running a two-way PERMANOVA including the factors time (random, three levels) and Area (random, two levels and nested in time), separately for each combination of breakwater and wave-exposure. The multivariate pseudo-variance components for each term in the model were then calculated using multivariate analogues to the univariate ANOVA estimators (e.g. Searle et al., 1992; Terlizzi et al., 2007). Observed mean squares were equated to the expected mean square derived from the linear model of the analysis (Underwood, 1997). This procedure generated a total of eight replicate measures of temporal variation, four for each of the seaward and the landward sides of breakwaters. Estimates of spatial variation between areas were obtained using a similar procedure; for each date of sampling, a one-way PERMANOVA was performed for each breakwater and wave-exposure, providing four measures of spatial variation between areas for each side of breakwaters. Occasionally, negative estimates of pseudo-variance were obtained. In these cases, variances were set to zero, assuming that they were sample underestimates of small or zero variances (Searle et al., 1992; Underwood, 1996).

3. Results

The multivariate analysis on data collected in October 2006 showed significant differences in the structure of assemblages between the landward and the seaward side of breakwaters (Table 1). In the nMDS, symbols representing assemblages on the landward side were segregated from those representing assemblages on the seaward side of breakwaters (Fig. 2).

Although there was a marked trend for the cover of *Mytilus galloprovincialis* and *Corallina elongata*, to be greater on the seaward than on the landward side of breakwaters, the ANOVAs failed to detect significant effects of wave-exposure, likely due to the lack of power of the relevant test and to heterogeneity of variances (Table 2, Fig. 3A and B, respectively). In contrast, the covers of filamentous algae and *Caulerpa racemosa* and the amount of bare rock were significantly greater on the landward than on the seaward side of breakwaters (Table 2, Fig. 3C, D and E, respectively), while the cover of encrusting corallines did not vary according to wave-exposure (Table 2, Fig. 3F). All analysed taxa, excluding *C. racemosa* and *C. elongata*, showed significant variability among areas. The number of taxa was generally small and did not differ significantly between exposures (Table 2, Fig. 5).

For the three subsequent dates of sampling, when more breakwaters were included in the survey, multivariate analyses showed significant differences in the structure of assemblages between landward and seaward side of breakwaters that were consistent through time (*t*-tests for the interaction date × exposure Table 3, Fig. 4). SIMPER analyses showed that these differences were consistently caused by filamentous algae, *C. elongata* and *M. galloprovincialis*, explaining together 79%, 75% and 70% of the differences, in date 1, 2 and 3, respectively. Interestingly, in date 3 (October 2007), *C. racemosa* also contributed to differences between the landward and seaward side of breakwaters, explaining 11% of the differences.

Univariate analyses showed the dominance of *M. galloprovincialis* and *C. elongata* on the seaward side, and although to a different extent among sampling dates, that of filamentous algae on the landward side of breakwaters (SNK tests in Table 4, Fig. 3A, B and C). The cover of *C. racemosa* varied markedly among dates of sampling. The alga was absent in May 2007 while it was found exclusively on the landward side of breakwaters in December 2006 and in October 2007, with a greater cover at the latter time of sampling (Table 3, Fig. 3D). The cover of encrusting corallines, despite largely

Table 1
PERMANOVA testing for the effects of wave-exposure and breakwaters on the structure of low-shore assemblages in October 2006

Source of variation	d.f.	MS	PseudoF	P	Permutable units and denominator for F
Exposure = E	1	91242.0	44.10	0.008	4 E × B cells
Breakwater = B	1	4010.9	1.44	0.235	12 Replicate areas
E × B	1	2068.8	0.74	0.549	12 Replicate areas
Area (E × B)	8	2771.1	4.13	0.001	60 Replicate obs
Residual	48	670.1			

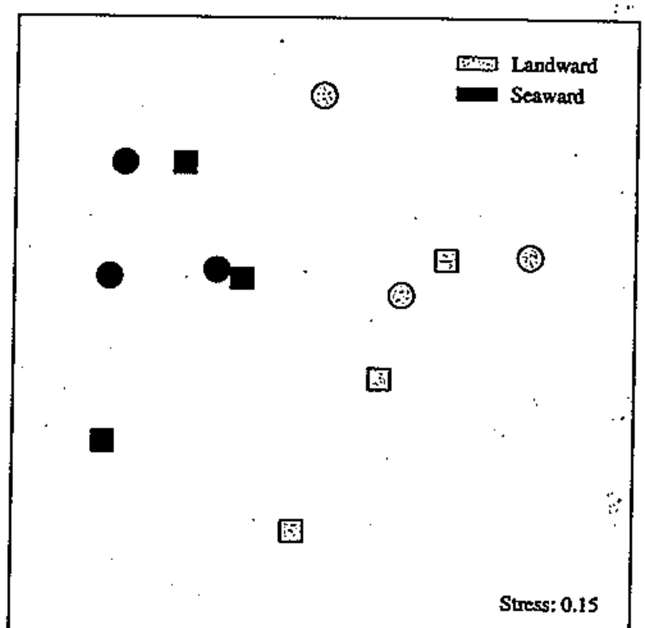


Fig. 2. nMDS plot comparing assemblages on different side of breakwaters during October 2006. Different symbols (quadrats and circles) represent the two breakwaters; each of these is a centroid of each area within each breakwater.

Table 2
ANOVAs testing for the effects of wave-exposure and breakwaters on the abundance of common taxa in October 2006

Source of Variability	d.f	*Caulerpa racemosa*		Filamentous algae		*Corallina elongata*		Encrusting corallines		*Mytilus galloprovincialis*		Bare rock		Number of Taxa	
		MS	F	MS	F	MS	F	MS	F	MS	F	MS	F	MS	F
Exposure = E	1	8954.81[a]	20.43**	286.97	410.64*	69292.01	50.47	0.71	4.71	17442.15	9.91	26.99[a]	8.70*	0.01	0.00
Breakwater = B	1	432.01	0.99	33.47	1.53	1450.41	2.35	0.06	0.05	1760.41	2.22	4.83	1.56	0.15	0.04
E x B	1	268.81	Eliminated	0.67	0.03	1372.81	2.23	0.15	0.12	1760.41	2.22	1.30	Eliminated	8.81	2.18
Area (E × B)	8	438.21	1.90	21.89	7.39***	616.10	1.50	1.27	2.36*	792.28	3.59**	3.10	2.87*	4.05	2.33*
Residual	48	230.10		2.96		411.45		0.53		220.49		1.08		1.74	
Cochran's test		C = 0.50**		C = 0.27		C = 0.49**		C = 0.25		C = 0.31*		C = 0.19		C = 0.15	
Transformation		None		Sqrt(x + 1)		None		Ln(x + 1)		None		Ln(x + 1)		None	

When necessary, pooling procedures were applied according to Underwood (1997).
[a] Tested on area(E × B).
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

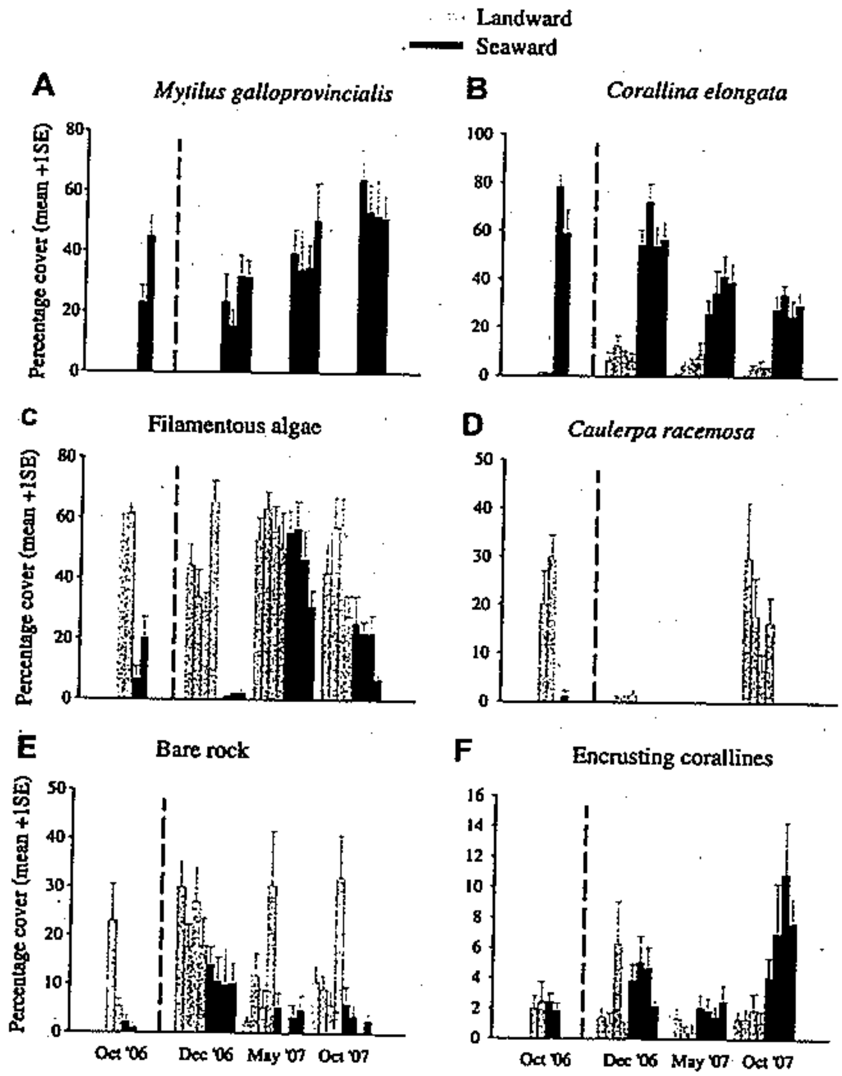


Fig. 3. Abundance of common taxa and bare rock at each date of sampling. Bars are the average value for each breakwater (mean + SE, $n = 15$ in October 2006 and $n = 10$ in December 2006, May 2007 and October 2007, data averaged across replicates and areas). The dotted line represents the start of the implemented design.

varying through time, was greater on the seaward than on the landward side of breakwaters (Table 3, Fig. 3F), while the opposite pattern was detected for the amount of free space (Table 3, Fig. 3E). No significant differences were detected between sides of breakwaters in the number of taxa (Table 3, Fig. 5).

Visual inspection of graphs indicates that temporal variation in the structure of assemblages was greater in assemblages on the seaward side than those on the landward side of breakwaters (Fig. 6A). In contrast, variation within breakwaters, at the scale of 10 s of m, did not vary according to wave-exposure (Fig. 6B).

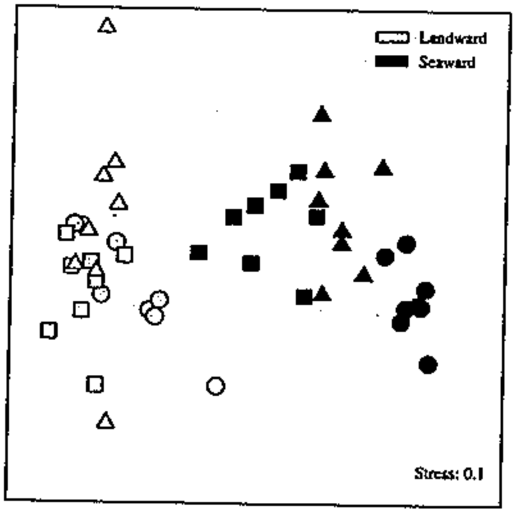


Fig. 4. nMDS plots comparing assemblages on different sides of breakwaters in December 2006 (circles), May 2007 (quadrats) and October 2007 (triangles). Each symbol is a centroid of an area.

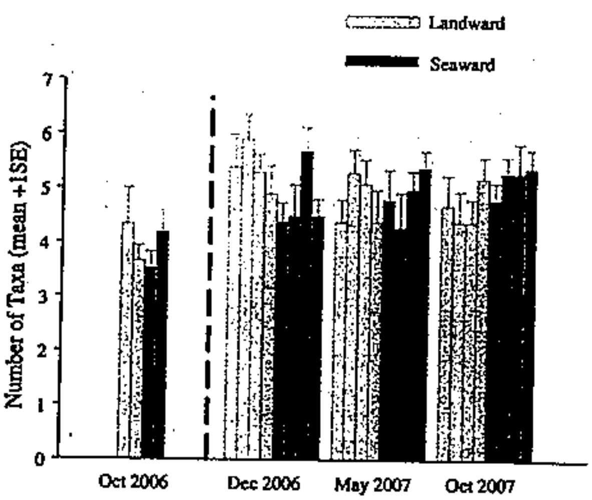


Fig. 5. Number of taxa at each date of sampling. Bars are the average value for each breakwater (mean + SE, $n = 15$ in October 2006 and $n = 10$ in December 2006, May 2007 and October 2007, data averaged across replicates and areas). The dotted line represents the start of the implemented design.

4. Discussion

Low-shore assemblages on artificial structures, either on landward or seaward sides of breakwaters, were characterized by a low number of taxa, in accordance with patterns documented on breakwaters along other sedimentary coasts in the Mediterranean and in the North-East Atlantic (Bacchiocchi and Airoldi, 2003; Moschella et al., 2005; Pinn et al., 2005; Gacia et al., 2007). These patterns are not surprising given that artificial structures, being generally located in urban or industrial areas, are commonly subjected to poor environmental conditions (e.g. release of pollutants and nutrients, high rates of sedimentation), which are known to affect negatively macroalgal diversity (Krause-Jensen et al., 2007).

At low-shore levels, the artificial habitats we investigated supported a smaller number of taxa (mean ± SE = 4.45 ± 0.09; $n = 240$) than nearby rocky shores, located about 15 km south (11.16 ± 0.18; $n = 192$; Benedetti-Cecchi et al., unpublished data). Assemblages on artificial structures represented a subset of the regional pool of hard-bottom species, as all the species they supported were common on local rocky shores. This would indicate that a relatively large number of species is not able to establish viable populations on these surfaces. Severe sand scouring during swells may reduce the number of species able to recruit and/or survive on these structures. Alternatively, lack of supply of larvae, spores or propagules for colonization could explain the low species diversity. This is, however, unlikely to occur, given the relatively short distance between this site and natural rocky shores or reefs. Our results, in accordance with those of other studies (Bacchiocchi and Airoldi, 2003; Moschella et al., 2005; Pinn et al., 2005; Gacia et al., 2007) would suggest that these artificial habitats do not represent surrogate habitats for many rocky-bottom species, allowing few "opportunistic" organisms to achieve dominance.

Variation between the landward and the seaward side of breakwaters was mainly caused by four taxa, with encrusting corallines, *C. elongata* and *M. galloprovincialis* more abundant on the seaward side of breakwaters and filamentous algae on the landward side. Other studies have reported similar patterns of distribution of organisms around breakwaters (Bacchiocchi and Airoldi, 2003; Bulleri and Airoldi, 2005; Moschella et al., 2005; Gacia et al., 2007). Mussels and barnacles have been repeatedly found to be more abundant on wave-exposed sides of artificial structures (Bacchiocchi and Airoldi, 2003; Moschella et al., 2005; Gacia et al., 2007). At our study sites, the landward side of breakwaters was completely free from mussels. This could be the result of poor circulation of water reducing the supply of food or enhancing the deposition of fine sediments on the surface of blocks. In accordance

Table 3
PERMANOVA testing for the effects of date of sampling, breakwater and wave-exposure on the structure of low-shore assemblages

Source of variation	d.f.	MS	PseudoF	P	Permutable units and denominator for F
Date = *D*	2	22141.00			
Breakwater = *B*	3	1844.80	0.64	0.843	12 *D* × *B* cells
Exposure = *E*	1	212090.00			
D × *B*	6	2870.10	0.93	0.581	48 Replicate areas
D × *E*	2	11630.00	7.87	0.001	24 *D* × *B* × *E* cells
B × *E*	3	1475.00	0.99	0.489	24 *D* × *B* × *E* cells
D × *B* × *E*	6	1476.60	0.48	0.985	48 Replicate areas
Area(*D* × *B* × *E*)	24	3066.80	3.24	0.001	240 Replicate obs.
Residual	192	944.95			

Pairwise test for interaction "*D* × *E*" for pair levels of factor "exposure"

Groups	*t*	*P*(perm)
Date 1: *L*, *S*	7.09	0.001
Date 2: *L*, *S*	7.09	0.001
Date 3: *L*, *S*	7.71	0.001

Whenever the analysis showed a significant interaction, the pseudoF for the main effect and lower order interactions of relevant factors are not reported as these are not logically interpretable (Underwood 1997). *L* = Landward; *S* = Seaward.

Table 4
ANOVAs testing for the effects of date of sampling, breakwater and wave-exposure on the abundance of common taxa

Source of Variability	*Caulerpa racemosa*			Filamentous algae		*Corallina elongata*		Encrusting corallines		*Mytilus galloprovincialis*		Bare rock		Number of taxa	
	d.f	MS	F	MS	F	MS	F	MS	F	MS	F	MS	F	MS	F
Date = D	2	2003.85		17813.78		6973.13		7.53	10.99**	4421.02		25.73	9.47*	1.13	0.79
Breakwater = B	3	138.29	0.90	579.98	0.38	579.49	1.81	0.62	0.91	278.90	1.15	6.00	2.21	1.47	1.02
Exposure = E	1	2287.83		39835.27		77868.04		37.95[a]	20.34*	97364.82		77.24[a]	46.21*	0.00[a]	0.00
Area(D × B × E)	24	415.93	7.38***	1148.95	2.80**	441.68	1.74*	1.43	2.41***	1564.01	5.78***	2.81	1.79*	4.38	2.44***
D × B	6	153.90	0.37	2089.29	1.82	319.54	0.72	0.68	0.48	242.23	0.15	2.71	0.97	1.44	0.33
D × E	2	2003.85	13.02**	5453.55	6.85*	3371.78	30.27***	1.86	3.01	4421.90	18.25**	1.67	0.61	6.41	2.54
B × E	3	138.29	0.90	567.01	0.71	140.79	1.26	0.36	Eliminated	278.90	1.15	1.71	Eliminated	2.54	Eliminated
D × B × E	6	153.90	0.37	796.18	0.69	111.39	0.25	0.61	0.43	242.23	0.15	2.73	0.97	2.52	0.58
Residual	192	56.32		409.81		253.56		0.59		270.78		1.56		1.72	
Cochran's test		C = 0.48***		C = 0.07		C = 0.09		C = 0.07		C = 0.10		C = 0.05		C = 0.07	
Transformation		None		None		None		Ln(x + 1)		None		Ln(x + 1)		None	
SNK test for "D × E"		Date 1: L = S		Date 1: L > S		Date 1: L < S				Date 1: L < S					
		Date 2: L = S		Date 2: L = S		Date 2: L < S				Date 2: L < S					
		Date 3: L > S		Date 3: L > S		Date 3: L < S				Date 3: L < S					
S.E.:		1.9615		4.4615		1.6688				2.4609					

Whenever the analysis showed a significant interaction, the F-ratio for the main effect and lower order interactions of relevant factors are not reported as these are not logically interpretable (Underwood 1997). When necessary, pooling procedures were applied according to Underwood (1997). L = Landward; S = Seaward.
[a] Tested on D × E.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

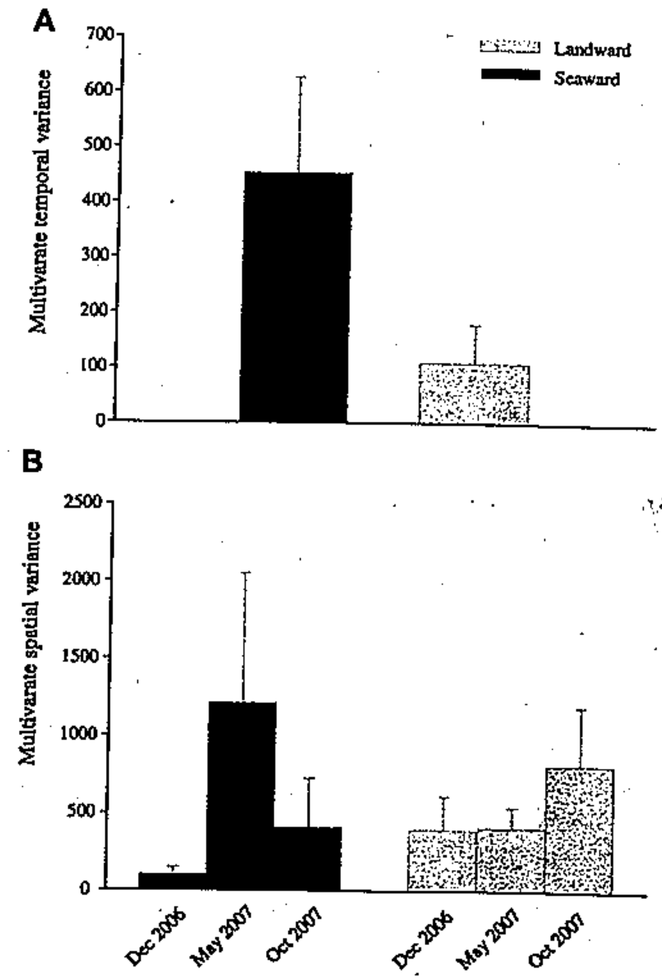


Fig. 6. Multivariate temporal (A) and spatial (B) variance illustrating differences between exposures. Bars are the average values (+SE) across breakwaters ($n = 4$) (see text for further details).

with Gacia et al. (2007), much of the free space on the landward side of breakwaters was indeed covered by a thick layer of sediment (F. Bulleri, personal observation). High sedimentation rates can cause smothering of filter-feeders like barnacles and mussels, favouring the dominance by filamentous or turf-forming algae (Airoldi, 2003). Interestingly, throughout the duration of the study there was a trend for *M. galloprovincialis* to progressively monopolize space at the expense of *C. elongata*. This could indicate an ongoing process of recovery of space by mussel beds after a particularly severe storm disrupted their integrity or, alternatively, could reflect a successful event of recruitment. In contrast to patterns documented by Airoldi et al. (2005b) in the northern Adriatic Sea, recreational harvesting of mussels is not a common practice at our study site.

The main space-occupiers on the seaward side of breakwaters, *M. galloprovincialis* and *C. elongata*, are commonly found on nearby wave-exposed natural rocky shores (Livorno, about 15 km south), but never at such high values of percentage cover (Menconi et al., 1999; Benedetti-Cecchi, 2001). Either physical features of artificial habitats (e.g. size and topography of the blocks and their spatial arrangement) or water quality could have contributed to determine their dominance at our study site. The proximity of breakwaters to the mouth of the Arno River might have create highly suitable conditions for the recruitment and growth of mussels (i.e. supply of suspended organic matter). Great similarity between assemblages in wave-exposed habitats on these breakwaters and those on a rocky shore influenced by the Magra River, about 50 km north, (i.e. dominance of mussels; Benedetti-Cecchi et al., 2000) would suggest a strong influence of inputs of freshwater at our study site. The relatively large cover of *C. elongata*, a stenohaline species (Doty and Newhouse, 1954), suggests however, that factors other than the proximity to a river contribute to regulate the structure of low-shore assemblages on these structures.

Filamentous algae were present on the seaward side of breakwaters, but exclusively as epiphytes of mussels and *C. elongata* and with temporally variable percentage cover, greater in summer/autumn and close to zero in winter. In contrast, filamentous algae dominated wave-sheltered habitats consistently through time. Here, it is worth stressing that, while mosaics of patches occupied by mussels or *C. elongata* have been documented in the region (Benedetti-Cecchi et al., 2000), persistent domination of space by filamentous forms has not been previously reported on open coasts. The provision of sheltered habitats may therefore generate physical conditions leading to the monopolization of space at low-shore levels by opportunistic forms and, ultimately, to the persistence of assemblages very different from those observed on natural rocky substrata in the region. If assemblages on the seaward side of breakwaters resemble, to some extent, those found on rocky shores in the region that are subjected to a similar influence of freshwater inputs, those on the landward side are to be considered habitats of their own, with artificial patterns and processes (Bulleri, 2005).

Assemblages on landward and seaward sides of breakwaters also differed in terms of temporal stability. Mechanical disturbance by waves is likely to vary greatly in intensity and frequency between exposed and sheltered habitats. Availability of bare space was greater on the landward than on the seaward side of breakwaters, consistently through time, suggesting that factors other than the wave-generated removal of biomass produced the observed patterns. Great availability of empty space has been previously documented on rip-rap seawalls built in wave-sheltered areas of San Diego Bay, in southern California (Davis et al., 2002). Due to poor water exchange, conditions on the landward side of breakwaters could be sufficiently harsh (e.g. high rates of deposition of sediments) to allow the persistence of few species, with little temporal variation in their covers. Indeed one single functional group, the filamentous algae, and, to a lesser extent, one exotic species, *C. racemosa*, were able to hold space consistently through time. Both of these are highly tolerant to sedimentation (Airoldi, 2003; Piazzi et al., 2007). Filamentous forms generally formed dense mats, making identification to species or genus unfeasible in the field. The same species were, however, found at different times of the year, suggesting low species turnover within this functional group (authors' personal observation). Variation between assemblages on the landward and the seaward side of breakwaters did not, in contrast, differ at the scale of 10 s of m (i.e. between areas). This would indicate that although the factors influencing the distribution of organisms in these contrasting habitats are likely to differ (i.e. wave-action and sedimentation, in exposed and sheltered habitats, respectively), they operated consistently within breakwaters.

Dominance by filamentous algae, associated with large availability of unoccupied space, on the landward side of breakwaters, may acquire great importance when considering the ecology of invasive species. In this study, we found a high cover of the introduced macroalga *C. racemosa* on the landward side of breakwaters. Although this alga is able to colonize a variety of natural substrata (Piazzi et al., 2005), here, it was not found on sandy bottoms sheltered by breakwaters. *C. racemosa* can tolerate high rates of sedimentation (Piazzi et al., 2007) and its colonization and spread are facilitated by the presence of algal turfs (Ceccherelli et al., 2002; Bulleri and Benedetti-Cecchi, in press). Hence, domination by algal turfs in wave-sheltered habitats could have favoured the establishment of this invader. Importantly, this species is commonly found on exposed coasts and its distribution does not seem to be regulated by wave-exposure (Bulleri and Benedetti-Cecchi, in press). Hence, lack of this species on the seaward side of breakwaters may suggest that organisms that occupied space on these surfaces were somehow effective in preventing its establishment. Recent experimental work has shown that the spread and growth of *C. racemosa* is enhanced on complex surfaces (Bulleri and Benedetti-Cecchi, in press); according to these findings, mussel beds would represent suitable surfaces for *C. racemosa*, favouring the attachment of its prostrate stolons. Mussels and organisms intimately associated with them, such as epiphytes or those interstitially, are susceptible to dislodgement by waves. This mechanism is, however, unlikely to explain the complete absence of *C. racemosa* in wave-exposed artificial habitats.

Greater stability of assemblages on the landward side of breakwater could foster the persistence of *C. racemosa*. In the Mediterranean Sea, this alga shows strong seasonal fluctuations and, on the closest shallow natural rocky substrata (3–6 m in depth), it virtually disappears from November to March, to grow back in early spring and peak in abundance in September–October (Bulleri and Benedetti-Cecchi, in press). Here, *C. racemosa* showed a similar trend, but its cover was still very high in early winter, a time of the year at which it has generally undergone a considerable decrease (Bulleri and Benedetti-Cecchi, in press). Thus, wave-sheltered artificial habitats may not only provide suitable hard substrata for this species within an otherwise sandy area, but would also enhance its persistence through time. This may, in turn, enable this species to generate more biomass and produce more and bigger fragments, enhancing its long distance dispersal.

Although its cover did not reach values worth of formal analysis, a second non-indigenous species, the green alga *Codium fragile* spp. *tomentosoides*, was recorded on the landward side of breakwaters in December 2007. The results of this study, documenting the lack of *C. fragile* ssp. *tomentosoides* on the seaward side of breakwaters, confirm that wave-sheltered artificial habitats represent ideal habitats for this species (Bulleri and Airoldi, 2005; Bulleri et al., 2007). Since in contrast to *C. racemosa*, the recruitment of parthenogenetic zygotes *C. fragile* ssp. *tomentosoides* is enhanced on primary substrata (Bulleri and Airoldi, 2005), the large availability of unoccupied space on the landward side of the breakwaters at Marina di Pisa let us predict a further increase in the local abundance of this species.

In summary, the results of this study suggest that the deployment of hard coastal-defence structures, attracting a suite of rocky-bottom species, has the potential to alter patterns of abundance and distributions of species at local and regional scale (Bulleri, 2005). These structures can function as "stepping stones" (*sensu* Glasby and Connell, 1999), enabling species to disperse across areas lacking of suitable habitat, disrupting natural patterns of dispersion and influencing gene flow, with potential evolutionary consequences. In particular, the provision of wave-sheltered surfaces determines the occurrence of assemblages different from those that can be found on comparable natural hard substrata. These are characterized by low functional diversity (one morphological group of algae), large availability of free space and great temporal stability. These features can have positive implications for the establishment and spread of exotic species (Davis et al., 2000; Stachowicz et al., 2002). This study, documenting the presence of two of the most widespread invasive seaweeds (Williams and Smith, 2007), strengthen the results of previous works that have identified man-made structures as important corridors for the expansion of introduced species (Glasby and Connell, 1999; Bulleri and Airoldi, 2005).

In this light, further research on the ecological impacts and ecological role of these structures, whose presence is predicted to increase due to climatic and socio-economic reasons, is urgently needed to plan strategies for the conservation of marine biodiversity and for the management of biological invasions. Our study suggests that the provision of sheltered habitats should be of particular concern when planning the deployment of hard coastal-defence structures. Alternative options in the design of these structures may minimize their impacts. For instance, deploying structures that allow higher circulation of water around landward surfaces would serve to improve physical conditions, enabling the development of assemblages more similar to those occurring on natural rocky coasts. Achieving these goals requires, however, the integration of ecological criteria into the decision-making process which is, at present, mostly based on social and economic objectives.

Acknowledgements

We sincerely thank I. Bertocci, E. Maggi and L. Tamburello for their help in the field. This study was partially supported by the Comune di Pisa and it is publication number MPS-8039 of MARBEF Network of Excellence. Procedures used in the present study comply with Italian laws.

References

Airoldi, L., 2003. The effects of sedimentation on rocky coast assemblages. Oceanography and Marine Biology: An Annual Review 41, 161–263.
Airoldi, L., Beck, M.W., 2007. Loss status and trends for coastal marine habitats of Europe. Oceanography and Marine Biology: An Annual Review 45, 345–405.
Airoldi, L., Abbiati, M., Beck, M.W., Hawkins, S.J., Jonsson, P.R., Martin, D., Moschella, P.S., Sundelöf, A., Thompson, R.C., Åberg, P., 2005a. An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. Coastal Engineering 52, 1073–1087.
Airoldi, L., Bacchiocchi, F., Cagliola, C., Bulleri, F., Abbiati, M., 2005b. Impact of recreational harvesting on assemblages in artificial rocky habitats. Marine Ecology Progress Series 299, 55–66.
Anderson, M.J., 2001. A new method for non-parametric multivariate analysis of variance. Austral Ecology 26, 32–46.
Bacchiocchi, F., Airoldi, L., 2003. Distribution and dynamics of epibiota on hard structures for coastal protection. Estuarine Coastal and Shelf Science 56, 1157–1166.
Barros, F., Underwood, A.J., Lindegarth, M., 2001. The influence of rocky reefs on the structure of benthic macrofauna in nearby soft-sediments. Estuarine Coastal and Shelf Science 52, 191–199.
Benedetti-Cecchi, L., 2001. Variability in abundance of algae and invertebrates at different spatial scales on rocky sea shores. Marine Ecology Progress Series 215, 79–92.
Benedetti-Cecchi, L., Bulleri, F., Cinelli, F., 2000. The interplay of physical and biological factors in maintaining mid-shore and low-shore assemblages on rocky coasts in the north-west Mediterranean. Oecologia 123, 406–417.
Bray, M.J., Hooke, J.M., 1997. Prediction of soft-cliff retreat with accelerating sea level rise. Journal of Coastal Research 13, 453–467.
Bulleri, F., 2005. The introduction of artificial structures on marine soft- and hard-bottoms: ecological implications of epibiota. Environmental Conservation 32, 101–102.
Bulleri, F., 2006. Is it time for urban ecology to include the marine realm? Trends in ecology and Evolution 21, 658–659.
Bulleri, F., Airoldi, L., 2005. Artificial marine structures facilitate the spread of a nonindigenous green alga, *Codium fragile ssp. tomentosoides*, in the North Adriatic Sea. Journal of Applied Ecology 42, 1063–1072.
Bulleri, F., Benedetti-Cecchi, L., in press. Facilitation of the introduced green alga, *Caulerpa racemosa*, by resident algal turfs: experimental evaluation of underlying mechanisms. Marine Ecology Progress Series.
Bulleri, F., Branca, G.M., Abbiati, M., Airoldi, L., 2007. Development of reproductive structures in the introduced green alga, *Codium fragile ssp. tomentosoides*, in the northern Adriatic Sea. European Journal of Phycology 42, 137–144.
Carr, M.H., Hixon, M.A., 1997. Artificial reefs: the importance of comparisons with natural reefs. Fisheries 22, 28–33.
Ceccherelli, G., Piazzi, L., Balata, D., 2002. Spread of introduced *Caulerpa* species in macroalgal habitats. Journal of Experimental Marine Biology and Ecology 280, 1–11.
Chapman, M.G., 2003. Paucity of mobile species on constructed seawalls: effects of urbanization on biodiversity. Marine Ecology Progress Series 264, 21–29.
Chapman, M.G., 2006. Intertidal seawalls as habitats for molluscs. Journal of Molluscan Studies 72, 247–257.
Chapman, M.G., Bulleri, F., 2003. Intertidal seawalls-new features of landscape in intertidal environments. Landscape and Urban Planning 62, 19–172.
Clarke, K.R., 1993. Non-parametric multivariate analyses of changes in community structure. Austral Journal of Ecology 18, 117–143.
Clynick, B.G., 2006. Assemblages of fish associated with coastal marinas in north-western Italy. Journal of the Marine Biological Association of the United Kingdom 86, 847–852.
Collins, K.J., Jensen, A.C., Lockwood, A.P.M., Lockwood, S.J., 1994. Coastal structures, waste materials and fishery enhancement. Bulletin of Marine Science 55, 1240–1250.
Connell, S.D., 2001. Urban structures as marine habitats: an experimental comparison of the composition and abundance of subtidal epibiota among pilings, pontoons and rocky reefs. Marine Environmental Research 52, 115–125.
Connell, S.D., Glasby, T.M., 1998. Do urban structures influence local abundances and diversity of subtidal epibiota? A case study from Sydney Harbour, Australia. Marine Environmental Research 47, 373–387.
Davis, N., Vanblaricom, G.M., Dayton, P.K., 1982. Man-made structures on marine sediments: effects on adjacent benthic communities. Marine Biology 70, 295–303.
Davis, M.A., Grime, J.P., Thompson, K., 2000. Fluctuating resources in plant communities; a general theory of invasibility. Journal of Ecology 88, 528–534.
Davis, J.L.D., Levin, L.A., Walther, S.M., 2002. Artificial armored shorelines: sites for open-coast species in a southern California Bay. Marine Biology 140, 1249–1262.
Denny, M., 1995. Predicting physical disturbance: mechanistic approaches to the study of survivorship on wave-swept shores. Ecological Monographs 65, 371–418.
Dethier, M.N., Graham, E.S., Cohen, S., Tear, L.M., 1993. Visual versus random-point percent cover estimations: 'Objective' is not always better. Marine Ecology Progress Series 110, 9–18.
Doty, M.S., Newhouse, J., 1954. The distribution of marine algae into estuarine waters. American Journal of Botany 41, 508–515.
EEA, 1999. Coastal and marine zones. Environment in the European Union at the Turn of the Century. State of Environment Report No. 1/1999. Copenahagen: EEA (Chapter 3.14). Available from: <http://reports.eea.eu.int/92-9157-202-0/en>.
Gacia, E., Satta, M.P., Martin, D., 2007. Low crested coastal defence structures on the Catalan coast of the Mediterranean Sea: how they compare with natural rocky shores. Scientia Marina 71, 259–267.
Glasby, T.M., 1999. Differences between subtidal epibiota on pier pilings and rocky reefs at marinas in Sydney, Australia. Estuarine Coastal and Shelf Science 48, 281–290.
Glasby, T.M., Connell, S.D., 1999. Urban structures as marine habitats. Ambio 28, 595–598.
Glasby, T.M., Connell, S.D., Holloway, M.G., Hewitt, C.L., 2006. Nonindigenous biota on artificial structures: could habitat creation facilitate biological invasions? Marine Biology 151, 887–895.
Guidetti, P., 2004. Fish assemblages associated with coastal defence structures in south-western Italy (Mediterranean Sea). Journal of the Marine Biological Association of the United Kingdom 84, 669–670.
Krause-Jensen, D., Carstensen, J., Karsten, D., 2007. Total and opportunistic algal cover in relation to environmental variables. Marine Pollution Bulletin 55, 11–125.
Martin, D., Bertasi, F., Colangelo, M.A., de Vries, M., Frost, M., Hawkins, S.J., Macpherson, E., Moschella, P.S., Satta, M.P., Thompson, R.C., Ceccherelli, V.U., 2005. Ecological impact of coastal defence structures on sediments and mobile infauna: evaluating and forecasting consequences of unavoidable modifications of native habitats. Coastal Engineering 52, 1027–1051.
Menconi, M., Benedetti-Cecchi, L., Cinelli, F., 1999. Spatial and temporal variability in the distribution of algae and invertebrates on rocky shores in the northwest Mediterranean. Journal of Experimental Marine Biology and Ecology 233, 1–23.
Moreira, J., Chapman, M.G., Underwood, A.J., 2007. Maintenance of chitons on seawalls using crevices on sandstone blocks as habitat in Sydney Harbour, Australia. Journal of Experimental Marine Biology and Ecology 347, 134–143.
Moschella, P.S., Abbiati, M., Åberg, P., Airoldi, L., Anderson, J.M., Bacchiocchi, F., Bulleri, F., Dinesen, G.E., Frost, M., Gacia, E., Granhag, L., Jonsson, P.R., Satta, M.P., Sundelof, A., Thompson, R.C., Hawkins, S.J., 2005. Low-crested coastal defence structures as artificial habitats for marine life: using ecological criteria in design. Coastal Engineering 52, 1053–1071.
Piazzi, L., Meinesz, A., Verlaque, M., Akçali, B., Antolić, B., Argyrou, M., Balata, D., Ballesteros, E., Calvo, S., Cinelli, F., Cirik, S., Cossu, A., D'Archino, R., Djellouli, S.A., Javel, F., Lanfranco, E., Mifsud, C., Pala, D., Panayotidis, P., Peirano, A., Pergent, G., Petrocelli, A., Ruitton, S., Žuljević, A., Ceccherelli, G., 2005. Invasion of *Caulerpa racemosa* var. *cylindracea* (Caulerpales, Chlorophyta) in the Mediterranean Sea: an assessment of the early stages of spread. Cryptogamie Algologie 26, 189–202.
Piazzi, L., Balata, D., Foresi, L., Cristaudo, C., Cinelli, F., 2007. Sediment as constituent of Mediterranean benthic communities dominated by *Caulerpa racemosa* var. cylindracea. Scientia Marina 71, 129–135.
Pinn, E.H., Mitchell, K., Corkill, J., 2005. The assemblages on groynes in relation to substratum age aspect and microhabitat. Estuarine Coastal and Shelf Science 62, 271–282.

Searle, S.R., Casella, G., McCulloch, C.E., 1992. Variance components. John Wiley & Sons Inc., New York.
Stachowicz, J.J., Fried, H., Osman, R.W., Whitlatch, R.B., 2002. Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. Ecology 83, 2575–2590.
Steneck, R.S., Dethier, M.N., 1994. A functional group approach to the structure of algal-dominated communities. Oikos 69, 476–498.
Terlizzi, A., Anderson, M.J., Fraschetti, S., Benedetti-Cecchi, L., 2007. Scales of spatial variation in Mediterranean subtidal sessile assemblages at different depths. Marine Ecology Progress Series 332, 25–39.
Underwood, A.J., 1996. Spatial patterns of variability in density of intertidal populations. In: Floyd, R.B., Sheppard, A.W., De Barro, P.J. (Eds.), Frontiers of Population Ecology. CSIRO Publishing, Melbourne, pp. 369–389.
Underwood, A.J., 1997. Experiments in Ecology. Their logical design and interpretation using analysis of variance. Cambridge University Press.
Valiela, I., 2006. Global Coastal Change. Blackwell Publishing, Singapore.
Williams, S.L., Smith, J.E., 2007. A global review of the distribution, taxonomy, and impacts of introduced seaweeds. Annual Review of Ecology, Evolution and Systematics 38, 327–359.

Journal of Applied Ecology 2005
42, 1063–1072

Artificial marine structures facilitate the spread of a non-indigenous green alga, *Codium fragile* ssp. *tomentosoides*, in the north Adriatic Sea

FABIO BULLERI* and LAURA AIROLDI

Centro Interdipartimentale di Ricerca per le Scienze Ambientali in Ravenna, Università di Bologna, Ravenna, I-48100, Italy; and Dipartimento di Biologia Evoluzionistica e Sperimentale, Università di Bologna, Italy

Summary

1. Artificial structures have become ubiquitous features of coastal landscapes. Although they provide novel habitats for the colonization of marine organisms, their role in facilitating biological invasions has been largely unexplored.

2. We investigated the distribution and dynamics of the introduced green alga, *Codium fragile* ssp. *tomentosoides*, at a variety of spatial scales on breakwaters in the north Adriatic Sea, and analysed experimentally the mechanisms underlying its establishment. We assessed the provision of sheltered habitats by breakwaters, the role of disturbance (e.g. from recreational harvesting and storms) acting at different times of the year, and the interactions between *Codium* and the dominant native space-occupier, the mussel *Mytilus galloprovincialis*.

3. *Codium fragile* ssp. *tomentosoides* has established viable populations on artificial structures along the shores investigated. The density, cover and size (length, branching and weight) of annual erect thalli of *Codium* was enhanced in sheltered conditions, resulting in the monopolization of landward low-shore habitats of breakwaters.

4. On the landward sides of breakwaters, disturbance enhanced recruitment of *Codium*. The time when bare space was provided within mussels beds was crucial. Removal of mussels in April or January did not affect the recruitment of *Codium*, whereas harvest in August, shortly before *Codium* gamete release, doubled its success. On the seaward sides of breakwaters, the effects of disturbance were more complex because mussels both inhibited recruitment of *Codium* and provided shelter from wave action to adult thalli.

5. *Synthesis and applications*. Artificial structures can provide suitable habitats for non-indigenous marine species and function as corridors for their expansion. Physical (wave exposure) and biotic (resident assemblages) features of artificial habitats can be important determinants of their susceptibility to biological invasions. Alternative options in the design of artificial structures and effective management of native assemblages could minimize their role in biological invasions. In particular, increased water motion and retention of space by mussels in spring–summer would be effective in reducing the ability of *C. fragile* ssp. *tomentosoides* to persist on the breakwaters investigated in this study.

Key-words: biological invasions, *Codium fragile* ssp. *tomentosoides*, facilitation, hard coastal defence structures, recruitment, urbanization, wave exposure

Journal of Applied Ecology (2005), 42, 1063–1072
doi: 10.1111/j.1365-2664.2005.01096.x

Introduction

Natural patterns of migration and dispersal of species are dramatically disrupted by human activities, so that the introduction of non-indigenous species into new regions, accidental or deliberate, has become a common

*Correspondence and present address: Fabio Bulleri, Dipartimento di Scienze dell'Uomo e dell'Ambiente, Università di Pisa, Via A. Volta 6, I-56126, Pisa, Italy (fax +39 05049694; e-mail fbulleri@discau.unipi.it).

occurrence. As a consequence, biological invasions are acknowledged to be among the most severe threats to terrestrial and marine biodiversity (Kareiva 1996; Williamson 1996; Vitousek *et al.* 1997; Grosholz 2002).

Although studies have assessed the changes caused by the introduction of non-indigenous species on native assemblages (Simberloff & Von Holle 1999; Grosholz 2002), less effort has been devoted to understanding the mechanisms by which these species succeed in getting established within a recipient assemblage. This issue is pivotal to improving our ability to predict pathways of invasion and susceptible locales (Mack *et al.* 2000) and thus prevent and manage invasions (Grosholz 2002; Levin *et al.* 2002). Life-history traits of the invader along with physical (Ceccherelli & Cinelli 1999; Byers 2002; Stachowicz *et al.* 2002) and biological attributes (Kennedy *et al.* 2002; Stachowicz *et al.* 2002; Meiners, Cadenasso & Pickett 2004) of invaded environments have been advocated as determinants of successful establishment in new regions.

Artificial habitats, such as breakwaters, jetties, seawalls, floating pontoons and pier pilings, have become common hard substrata along entire coastlines (Bacchiocchi & Airoldi 2003; Bulleri & Chapman 2004), bays (Sammarco, Atchison & Boland 2004) and estuaries (Connell & Glasby 1999; Chapman & Bulleri 2003). Although such structures often support non-indigenous species (Holloway & Keough 2002; Lambert & Lambert 2003; Thornber *et al.* 2004; Bulleri, Abbiati & Airoldi, in press), their susceptibility to biological invasions remains largely unexplored. However, artificial structures could not only provide suitable habitat for some invaders but also enhance their further spread, by functioning as corridors across areas of unsuitable habitat (e.g. across sandy or muddy areas). Under future global climate change scenarios, the intensity of storms and height of sea level are predicted to increase, augmenting the need for hard coastal defence structures (e.g. breakwaters and seawalls). Under these scenarios, a comprehensive understanding of patterns of biological invasion in coastal areas requires consideration of the role of artificial structures as suitable habitats for non-indigenous species.

Hard structures for coastal protection in the northern Adriatic Sea have been colonized by the introduced green alga *Codium fragile* (Sur.) Harriot ssp. *tomentosoides* (van Goor) Silva, hereafter referred to as *Codium* (Bulleri, Abbiati & Airoldi, in press). This alga, native to east Asia, has become an important component of low intertidal and shallow subtidal assemblages of many temperate rocky shores around the world (Trowbridge 1998), with dramatic ecological consequences on native assemblages (Carlton & Scanlon 1985; Scheibling & Anthony 2001; Chapman, Scheibling & Chapman 2002; Levin *et al.* 2002).

The present study investigated the distribution and dynamics of *Codium* on breakwaters at a variety of spatial scales along the north-east coast of the Adriatic Sea, and identified some of the mechanisms underlying its successful establishment. First, we assessed the regional distribution of *Codium*, integrating the existing information with a field survey. Secondly, as colonization of *Codium* seems to be enhanced in wave-sheltered conditions (Trowbridge 1995, 1999; Bégin & Scheibling 2003) we compared the abundance and morphology of *Codium* between the landward and seaward sides of breakwaters to test whether artificial, sheltered habitats offer particularly favourable conditions for this species. Thirdly we investigated the role of disturbance in regulating the interaction between *Codium* and the main native space-occupier, the mussel *Mytilus galloprovincialis* Lamarck. Therefore, we experimentally disturbed mussel beds and tested whether the effects on recruitment of *Codium* varied between the landward and seaward sides of breakwaters and in relation to the time of the year at which the disturbance occurred. Finally, since stressful physical conditions tend to favour positive interactions among species (Bertness & Callaway 1994), we tested whether mussels could facilitate the survival of *Codium* in artificial, wave-exposed habitats on the seaward sides of breakwaters through stabilization of the thallus.

Study system

The north-east coast of the Adriatic Sea (Italy) is a flat, alluvional system that extends, almost uninterrupted, for more than 300 km. The area is moderately exposed to wave action and the few limestone rocky shores occurring in the region (at Gabicce and Ancona) generally offer few naturally sheltered habitats. The area is subject to a relatively large tidal excursion (about 80 cm) in comparison with other regions of the Mediterranean basin, and receives inputs of freshwater and nutrients from the Po River. Severe erosion, together with poor coastal defence policies, has led to the proliferation of hard structures over more than 60% of the shoreline (Cencini 1998). This has resulted in more than 190 km of breakwaters, groynes, seawalls and jetties (Bondesan, Calderoni & Dal Cin 1978). The construction of hard structures along the coast was particularly intensive during the 1970s and 1980s, but is still ongoing. Other characteristics of the region are described in Bacchiocchi & Airoldi (2003) and references therein.

The regional survey covered a variety of coastal structures at several locations, from Trieste to Porto Recanati, while local studies and experiments were done on breakwaters at Cesenatico (Table 1). Breakwaters built with large blocks of quarried rock (long axis ranging from 1 to 3 m) are deployed on shallow sediments at a distance of about 220 m from the shore, with an average length of 100 m, and are separated by gaps of about 20 m. Breakwaters extend about 2–3 m below and above the mean level of low water (MLLW), thus providing both subtidal and intertidal habitats for marine life (Bacchiocchi & Airoldi 2003).

The mussel *M. galloprovincialis* monopolizes low intertidal and shallow subtidal habitats of breakwaters, generally forming multilayered thick beds on the landward sides and thinner beds (one or two layers) on the

Journal of Applied Ecology, 42, 1063–1072

Table 1. Occurrence of *Codium fragile* ssp. *tomentosoides* on artificial (exposed and sheltered habitats) and natural (only exposed, because sheltered natural rocky habitats are not available in the region) substrata along the north-east coast of the Adriatic Sea. Latitude and longitude are reported for each of the study locations. The source of information is specified and includes: direct field sampling in July 2004 (locations in italics), information from the literature, personal communications and data from previous field observations (L. Airoldi & F. Bulleri, unpublished data). When indicated, percentage covers represent average values from 30 replicates (10 quadrats on each of three breakwaters); +, *Codium* present; NA, type of habitat not available

Location	Latitude (N)	Longitude (E)	Type of substratum: Natural	Artificial sheltered	Artificial exposed
Trieste	45°39′	13°46′	+*	+†	Not found†‡
Lagoon of Venezia	45°26′	12°19′	+§	+§	+§
Lido delle Nazioni (LN)	44°44′	12°14′	NA	+	Not found
Casal Borsetti (CB)	44°33′	12°17′	NA	+	+
Lido Adriano (LA)	44°23′	12°19′	NA	13%	+
Cesenatico	44°11′	12°24′	NA	48%	6%
Gabicce (GB)	43°58′	12°46′	+	33%	+
Falconara (FL)	43°37′	13°24′	NA	29%	+
Monte Conero (MC)	43°32′	13°37′	+¶	Not found¶	Not found¶
Porto Recanati (PR)	43°25′	13°40′	NA	Not found	Not found

*Bressan, Trebbi & Babbini (2000).
†A. Falace, personal communication.
‡F. Bulleri & L. Airoldi, personal observations in September 2003 and June 2004.
§Sfriso (1987) and A. Sfriso personal communication.
¶F. Bulleri & L. Airoldi, personal observations in May 2003, March, June and August of 2004.

seaward sides. Other common sessile invertebrates include oysters (*Ostrea edulis* Linnaeus and, to a less extent, the introduced *Crassostrea gigas* Thunberg), barnacles and the limpet *Patella caerulea* Linnaeus. *Ulva intestinalis* Linnaeus and several filamentous forms (i.e. *Cladophora* spp., *Polysiphonia* spp. and *Ceramium* spp.) are common macroalgae on both primary and secondary substrata. Breakwaters also host dense stands of *Codium*. First sighted in 1950 in the north-west Mediterranean Sea, this alga attained peak densities in the 1960s but regressed afterwards (Boudouresque 1994). The ability of *Codium* to achieve a world-wide distribution has been attributed to its life-history traits (reviewed by Trowbridge 1998). In many regions, although macroscopic thalli generally disappear during winter months, holdfasts are perennial and can regenerate new plants when environmental conditions improve (Trowbridge 1995, 1996). Sexual reproduction has not been observed and the alga reproduces parthenogenetically, enhancing its ability to establish even when at low densities (Trowbridge 1998). It is also able to propagate vegetatively through fragments of the thallus, vegetative buds, single utricules and medullary filaments (Borden & Stein 1969). These are likely to play a key role in long-distance dispersal (Trowbridge 1998). Undifferentiated filaments, generally referred to as the vaucherioid stage, have been observed forming mats on a variety of hard surfaces, including rock, shells and floating debris (Trowbridge 1998 and references therein).

Materials and methods

REGIONAL DISTRIBUTION OF *CODIUM*

The current distribution of *Codium* on hard human-made structures along the north-east coast of the Adriatic Sea was assessed by integrating information from recent studies available in the literature with data from previous field observations (L. Airoldi *et al.*, unpublished data; F. Bulleri *et al.*, unpublished data) and through an *ad hoc* field survey in July 2004 (Table 1). Because of the peak in abundance and size of *Codium* at this time of the year (Bulleri, Abbiati & Airoldi, in press), chances of discovering small populations were high. The occurrence of *Codium* on natural rocky shores was also assessed where these were present (i.e. at Trieste, Gabicce and Monte Conero). Whenever possible, observations were carried out in at least three independent structures or areas (Table 1), which were thoroughly searched to verify the presence of *Codium*. Where *Codium* was common, its percentage cover was quantified in 10 randomly placed 20 × 20-cm quadrats.

DISTRIBUTION, DYNAMICS AND MORPHOLOGY OF *CODIUM* ON BREAKWATERS

Between May 2003 and December 2004, the distribution, morphology and dynamics of *Codium* at low intertidal levels (0·2–0 m above the MLLW) were analysed at monthly intervals on three breakwaters (several hundred metres apart), selected at random among those available at Cesenatico. In order to test whether *Codium* would be favoured on the sheltered landward sides of breakwaters compared with the seaward exposed sides, the density and cover of the alga were quantified in five replicate 20 × 20-cm quadrats on each of three randomly identified blocks on each side of the breakwaters. The quadrats were sampled visually, using a plastic grid with 25 subquadrats. Percentage cover was estimated by giving a score from 0% to 4% to each subquadrat (Dethier *et al.* 1993), while density was estimated as the

Journal of Applied Ecology, 42, 1063–1072

total number of thalli. Ten thalli were also collected at random from each block and brought back to the laboratory, where wet weight, length (as the maximum length of each frond) and degree of branching (as the maximum number of dichotomies) were measured according to Trowbridge (1996). Ten to 15 thalli among the 30 available for each side of the breakwaters were further examined under a dissecting microscope to assess the reproductive status of the alga. After each sample, the blocks were marked using epoxy putty (Veneziani Subcoat, Yacht Systems s.v.l., Trieste, Italy) to avoid resampling and guarantee independence of data through time (Underwood 1997).

The cover, density, length, degree of branching and weight of thalli of *Codium* were analysed by four-factor ANOVAs, including the factors time (random and crossed), breakwater (random and crossed), exposure (fixed and crossed) and block (random and nested within the interaction time × breakwater × exposure). Heterogeneity of variances was checked by means of Cochran's test and data were appropriately transformed when necessary (Underwood 1997). When homogeneity of variances could not be achieved by transformation, data were analysed nonetheless, as analysis of variance is robust for departure from this assumption when there are many independent replicates and sizes of samples are equal (Underwood 1997). Results were, however, interpreted with caution by judging significance more conservatively ($\alpha = 0{\cdot}01$). The SNK test was used for a posteriori comparison of the means (Winer, Brown & Michels 1991).

EFFECTS OF DISTURBANCE TO MUSSEL BEDS ON RECRUITMENT OF *CODIUM*

Although parthenogenic gametes of *Codium* (hereafter referred to as gametes) can settle and germinate on a variety of secondary substrata (e.g. shellfish, coralline algae, serpulid polychaetes and solitary tunicates; Trowbridge 1998), there is evidence that colonization of *Codium* can be enhanced in habitats with large amounts of unoccupied space (Trowbridge 1998). In the north Adriatic Sea, thalli of *Codium* are not perennial and are fertile in late summer–early autumn (Bulleri, Abbiati & Airoldi, in press). Further, the breakwaters are frequently disturbed by a variety of factors that remove mussels and open patches of unoccupied space, the most relevant of which include spring and autumn storms and recreational harvesting of mussels during summer (Bacchiocchi 2004; Airoldi *et al.* 2005). Therefore, the interaction between timing of disturbance and gamete release could be crucial in determining the recruitment success of *Codium*, as observed for other species (Sousa 1979; Reed, Laur & Ebeling 1988; Airoldi 2000; Benedetti-Cecchi 2000). This hypothesis was tested by experimentally disturbing mussels beds in spring, summer and autumn, respectively before, during and after the release of gametes of *Codium*.

In March 2003, 16 blocks more than 3 m apart were selected at random on each of three haphazardly chosen breakwaters (several hundred metres apart). Subsets of four blocks were randomly assigned to the control treatment (mussels left untouched) and to each of three different times of removal of mussels: April 2003 (before gamete release), August 2003 (during gamete release) and January 2004 (after gamete release). Because of logistic and time constraints, we did not provide an estimate of the potential variability of the effects of removals of mussels within each period and the results should be interpreted accordingly. The average covers of mussels on the landward and seaward sides of breakwaters were 81% and 87% in April 2003, 62% and 71% in August 2003 and 31% and 56% in January 2004. The manipulation was intended to simulate natural (storms) or human (harvesting) disturbances, which generally cause the removal of mussels from most of the surface of blocks (F. Bulleri, personal observation). Mussels were removed by means of paint-scrapers, paying attention not to alter the topography of the substratum through the production of crevices and cracks. Propagules of *Codium* are released in late summer–early autumn but recruits become macroscopic in the spring. Therefore, effects of treatments were evaluated in the following May (2004) when recruits of *Codium* became clearly visible. Because of the small size and high density of thalli, counts of individual recruits were difficult and recruitment of *Codium* was estimated as percentage cover in four replicate 20 × 20-cm quadrats for each block, as previously described. Percentage cover data were analysed by a four-way ANOVA, including the factors breakwater (random and crossed), exposure (fixed and crossed) treatment (fixed and crossed) and block (random and nested within the interaction breakwater × exposure × treatment).

A further study was designed to differentiate the relative contribution to *Codium* regeneration arising from the settlement and germination of new propagules from the water column and the vegetative regrowth of the remnants of perennial holdfasts, vaucherioid filaments or other resting stages on the rock beneath mussel beds. In June 2003, the density of thalli of *Codium* was quantified in four replicate quadrats on each of the blocks from which mussels had been removed in April 2003 or left untouched (control). As, presumably, no significant release of propagules occurred between April and June 2003 (because *Codium* is fertile at the end of the summer), differences between treatments should reflect the responses of resting vaucherioid filaments, holdfasts or propagules trapped beneath mussels. Covers of juvenile thalli of *Codium* were analysed by means of the same four-way ANOVA model used to analyse data in May 2004, but the factor treatment included only two levels (April removal and control).

EFFECTS OF MUSSELS ON THE SURVIVAL OF *CODIUM* IN WAVE-EXPOSED HABITATS

Following the observation that, on the seaward sides of breakwaters, a large proportion (> 92%) of thalli c

Codium was embedded within a tight matrix of mussels covering their stipes for most of the length, we hypothesized that survival of *Codium* in such wave-swept environments could be facilitated by stabilization of the holdfast and stipe by mussels (Benedetti-Cecchi, Nuti & Cinelli 1996). To test this hypothesis, in May 2003, six blocks were randomly selected on the seaward sides of three breakwaters, at low intertidal levels. On each block, the position of 10–12 thalli of *Codium*, randomly chosen, was recorded as the distance from two fixed screws for later identification. Three of the blocks were then left unmanipulated (control treatment), while on the other three, mussels packed around the stipes of *Codium* were removed within a radius of about 2 cm (removal treatment). Mussels were carefully removed with forceps, paying attention not to damage the plants. In order to control for potential artefacts of the manipulation, mussels adhering to thalli on control blocks were pulled gently with forceps to loosen their attachment, without provoking their dislodgement. After 2 days, these mussels had been able to re-attach firmly to the substratum (both thalli of *Codium* and adjacent mussels). The number of surviving thalli was recorded 10 days after the beginning of the experiment. The experiment was repeated on different blocks of the same breakwaters the following year, in May 2004 (surviving thalli were recorded after 8 days). Survival data (as percentage) were analysed by means of a three-way ANOVA, including the factors start (random and crossed), breakwater (random and crossed) and treatment (fixed and crossed).

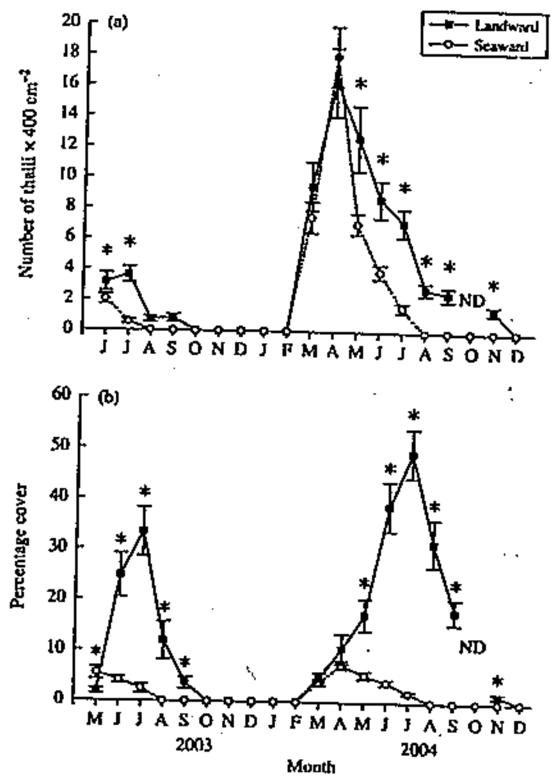


Fig. 1. Density of thalli (a) and percentage cover (b) of *Codium* on the landward and seaward sides of breakwaters in Cesenatico from May 2003 to December 2004. Data are averages (± 1 SE) from 45 independent replicates (five quadrats on each of three blocks on either landward or seaward sides of each of three breakwaters). ND, no data. Asterisks indicate significant differences between landward and seaward sides (SNK tests).

Results

REGIONAL DISTRIBUTION OF *CODIUM*

In the north Adriatic Sea, *Codium* is an important component of low-shore assemblages on the sheltered, landward sides of breakwaters and other human-made structures at most locations from Trieste in the north, to Monte Conero in the south, reaching peak covers at Cesenatico (Table 1). *Codium* has also been reported as an abundant species on both artificial substrata and natural consolidated sediments in the sheltered lagoon of Venezia (Table 1). Conversely, *Codium* was sparse on both natural and artificial exposed substrata. Although present at most locations, populations at exposed habitats generally consisted of few, small, scattered individuals, reaching measurable cover only at Cesenatico. *Codium* was not found on breakwaters in Porto Recanati, the southernmost location included in this study.

DISTRIBUTION, DYNAMICS AND MORPHOLOGY OF *CODIUM* ON BREAKWATERS

Densities and covers of *Codium* were generally greater on landward than seaward sides of breakwaters (Fig. 1 and Table 2). Despite the variation between years and breakwaters (Table 2), a consistent trend was evident, with *Codium* colonizing the landward and seaward sides of the structures to a similar extent in spring and early summer. With the progression of the summer, densities and covers of *Codium* quickly declined on the seaward sides, to virtually disappear in August in both 2003 and 2004. Conversely, *Codium* persisted longer on the landward sides, some thalli surviving until September–November (Fig. 1a). In contrast to the few small thalli remaining on the seaward sides of breakwaters, thalli on the landward sides attained significantly greater sizes (>>14 cm in length), degree of branching and weight (Fig. 2 and Table 2), resulting in average peak covers of about 32% and 48% in July 2003 and 2004, respectively (Fig. 1b).

EFFECTS OF DISTURBANCE TO MUSSEL BEDS ON RECRUITMENT OF *CODIUM*

In May 2004, the percentage cover of *Codium* was significantly larger on blocks where mussels had been removed in August 2003, compared with the other treatments. Effects were consistent between the landward and seaward sides of breakwaters and were detected despite the large variation among breakwaters and blocks (Fig. 3 and Table 3a).

There was a significant effect of removing mussels in spring (April 2003) on the percentage cover of *Codium* in early summer (June 2003), although its direction

Table 2. ANOVAs of the effects of time, breakwater, exposure and block on density, percentage cover, maximum length, degree of branching and wet weight of thalli of *Codium* in Cesenatico. Whenever the analysis showed a significant interaction, the *F*-ratio for the main effect and lower order interactions of relevant factors are not reported, as these are not logically interpretable (Underwood 1997). †Degrees of freedom for the analyses of density of thalli; ‡degrees of freedom for the analysis of percentage cover; §degrees of freedom for the analyses of length, branching and weight. $^{**}P < 0{\cdot}01$; $^{***}P < 0{\cdot}001$

Source of variation	d.f.	Density of thalli MS	Density of thalli *F*	Percentage cover MS	Percentage cover *F*	Length MS	Length *F*	No. branching MS	No. branching *F*	Wet weight MS	Wet weight *F*
Time (T)	11†, 12‡, 6§	52·11		39·04		1997·58		1888·50		71 405·44	
Breakwater (B)	2	2·47		0·86	0·41	8·99	0·51	1·52	0·13	316·98	
Exposure (E)	1	67·66		395·68		2494·30		1069·78		234 677·10	
T × B	22†, 24‡, 12§	2·24	2·41**	2·09	1·56	17·78	1·94	11·42	2·10	4 664·91	
T × E	11†, 12‡, 6§	6·73	6·44***	29·14	16·37***	421·30	22·35***	211·65	19·44***	48 437·11	
B × E	2	1·12	1·07	0·02	0·01	9·11	0·48	9·65	0·89	271·92	0·08
T × B × E	22†, 24‡, 12§	1·05	1·13	1·78	1·32	18·85	2·06	10·89	2·00	3 290·51	4·92***
Block (B × E × T)	144†, 156‡, 84§	0·93	2·08***	1·34	1·40**	9·15	2·70***	5·44	2·16***	668·29	1·06
Residual	864†, 936‡, 1134§	0·45		0·96		3·39		2·52		630·76	
Cochran's test		$P > 0{\cdot}05$		$P > 0{\cdot}05$		$P < 0{\cdot}01$		$P < 0{\cdot}01$		$P < 0{\cdot}01$	
Transformation		ln(*x* + 1)		ln(*x* + 1)		None		None		None	

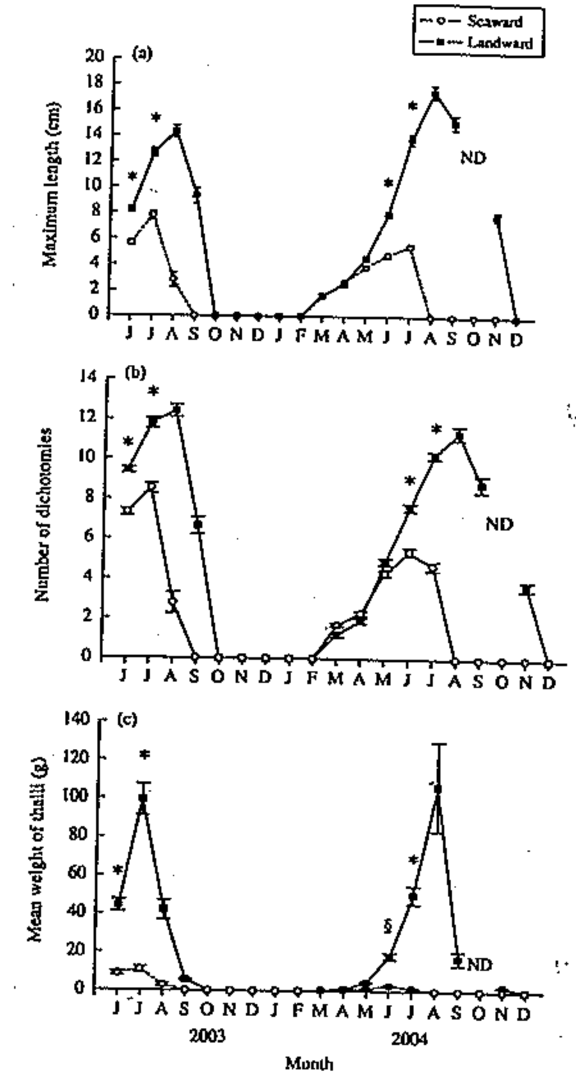


Fig. 2. Maximum length of fronds (a), degree of branching (b) and weight of thalli (c) of *Codium* on the landward and seaward sides of breakwaters in Cesenatico. Data are averages (± 1 SE) from 90 replicate thalli (10 thalli for each of three replicate blocks for each of three breakwaters); ND, no data. Asterisks indicate significant differences between the landward and seaward sides (SNK tests); § in (c) indicates that differences were significant on two of the three breakwaters. August 2003 was not included in the analyses because only 16 thalli could be found on blocks at the seaward sides of breakwaters.

varied between the landward and seaward sides of the breakwaters (Fig. 4 and Table 3b). The removal of mussels led to an increase in the percentage cover of *Codium* in landward habitats, while it caused a decrease in seaward habitats. These effects were consistent among breakwaters but not among blocks (Table 3b).

EFFECTS OF MUSSELS ON THE SURVIVAL OF *CODIUM* IN WAVE-EXPOSED HABITATS

The removal of mussels around the holdfast of thalli of *Codium* on blocks on the seaward sides of the breakwaters significantly decreased the survival of thalli after 8–10 days from the beginning of the experiment (Fig. 5 and Table 4).

Table 3. (a) ANOVA of the effects of breakwater, exposure, treatment (removal of mussels in April 2003 vs. August 2003 vs. January 2004 vs. control) and block on the percentage cover of *Codium* in May 2004; (b) ANOVA of the effects of breakwater, exposure, treatment (removal of mussels in April 2003 vs. control) and block on the percentage cover of *Codium* in June 2003. *$P < 0·05$; **$P < 0·01$; ***$P < 0·001$

Source of variation	(a)	d.f.	MS	*F*	(b)	d.f.	MS	*F*
Breakwater (B)		2	17·32	14·32***		2	1·75	0·65
Exposure (E)		1	9·30	2·50		1	1·77	
Treatment (T)		3	13·50	19·65**		1	0·00	
B × E		2	3·71	3·07		2	0·68	0·25
B × T		6	0·69	0·57		2	0·77	0·21
E × T		3	1·58	2·29		1	23·78	42·78**
B × E × T		6	0·69	0·57		2	0·56	0·21
Block (B × E × T)		72	1·21	2·95***		36	2·71	2·50***
Residual		288	0·41			144	1·08	
Cochran's test	$P > 0·05$				$P > 0·05$			
Transformation	ln(x + 1)				ln(x + 1)			
SNK tests	Treatment				Exposure × treatment			
	Aug03 > Control = Jan04 = Apr03				Landward: removal > control			
					Seaward: control > removal			

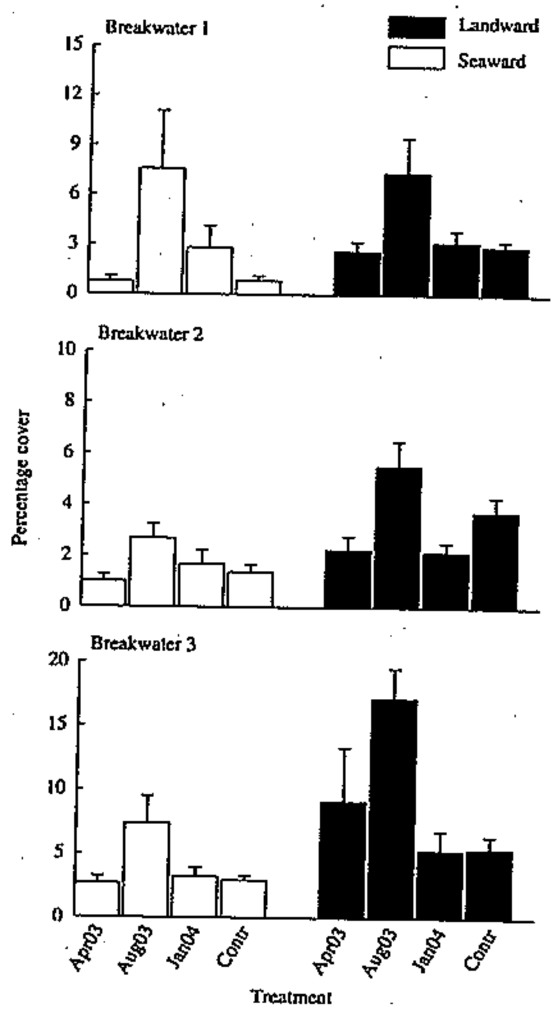


Fig. 3. Effects of the removal of mussels at different times of the year (April 2003, August 2003, January 2004 vs. control; Apr03, Aug03, Jan04, Contr. respectively) on the percentage cover of *Codium* in May 2004 on the landward and seaward sides of each of three breakwaters. Data are averages (+ 1 SE) from 16 replicate quadrats (four quadrats on each of four blocks). Note different y-axis scales.

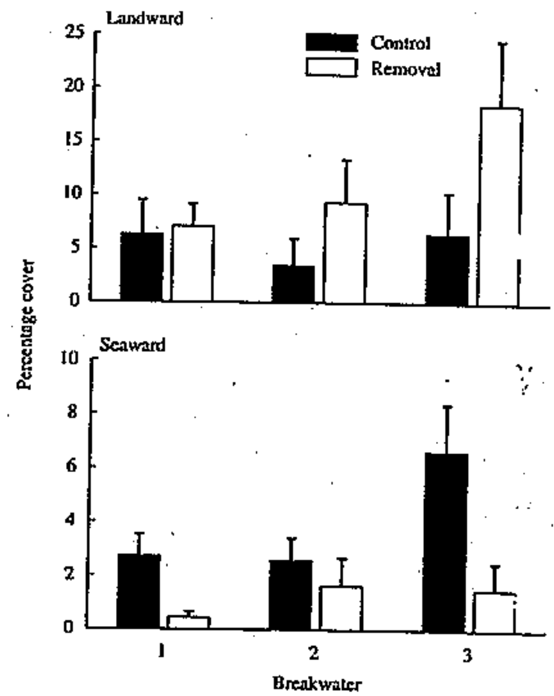


Fig. 4. Effects of the removal of mussels in April 2003 on the regeneration of macroscopic thalli of *Codium* (in June 2003), separately for the landward and the seaward sides of each of three breakwaters. Data are averages (+ 1 SE) from 16 replicate quadrats (four quadrats for each of four blocks). Note different y-axis scales.

The effects of the manipulation of mussels were consistent among breakwaters and between the two starts of the experiment, May 2003 and 2004 (Fig. 5 and Table 4).

Discussion

Codium has successfully established on coastal defence structures along the north-east coast of the Adriatic Sea, attaining covers comparable with those observed in the north-west Atlantic, where this species is spreading

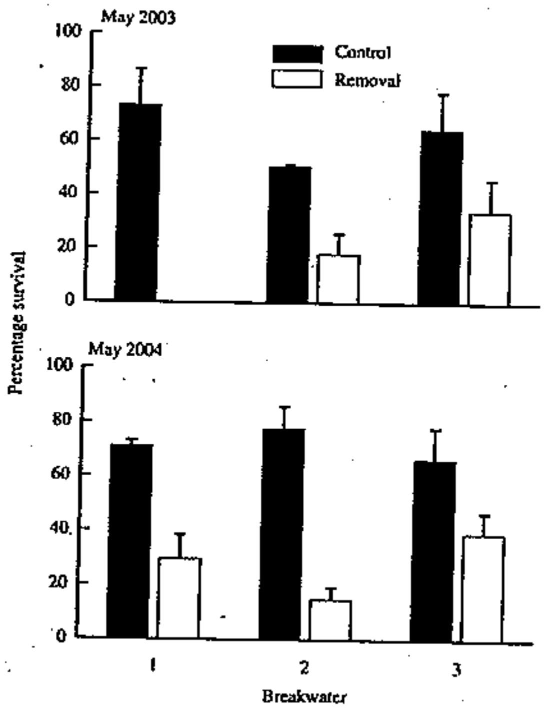


Fig. 5. Effects of the removal of mussels from thallus holdfasts on the survival of *Codium* on the seaward sides of each of three breakwaters, separately for the experiments started in May 2003 and May 2004. Survival (%) was calculated after 10 and 8 days, respectively, for May 2003 and 2004, on an initial number of 10–12 thalli. Data are averages (+ 1 SE) from three replicate blocks.

Table 4. Analysis of the effects of the removal of mussels on the percentage survival of *Codium* on the seaward sides of breakwaters, in May 2003 (Start 1) and May 2004 (Start 2). Pooling procedures were used according to Winer, Brown & Michels (1991); terms were eliminated when not significant at $P = 0.25$. *$P < 0.05$

Source of variation	d.f.	MS	*F*
Start (S)	1	845·84	9·52
Breakwater (B)	2	371·14	4·18
Treatment (T)	1	18010·53†	28·87*
S × B	2	88·87	0·38
S × T	1	5·06	Eliminated
B × T	2	623·83	0·86
S × B × T	2	727·85	3·12
Residual	24	233·26	
Cochran's test	$P > 0.05$		
Transformation	None		

†Tested against the interaction breakwater × treatment.

rapidly (Chapman, Scheibling & Chapman 2002; Levin *et al.* 2002; Bégin & Scheibling 2003). *Codium* was not previously reported among the components of marine flora along the coast included in our survey (Furnari *et al.* 2003), suggesting that the colonization of artificial habitats is recent and that this population is rapidly expanding. This is in contrast with trends of regression of *Codium* documented in other regions of the Mediterranean (Boudouresque 1994).

The north-eastern Adriatic has environmental characteristics that make it particularly susceptible to invasion (Occhipinti-Ambrogi 2001), including the presence of many potential sources (ports and aquaculture), a large variation in salinity and temperature and enrichment in nutrients. At the same time, the small availability of natural hard substrata suitable for the colonization of *Codium* in the region should have represented a natural barrier to its spread. The proliferation of defence structures has undeniably played a key role in the establishment and spread of *Codium* along the coasts of the north Adriatic Sea by providing suitable habitat for its settlement.

The sheltered, landward sides of breakwaters represent far better habitat for *Codium* than the seaward, exposed sides, in agreement with previous studies indicating that the colonization of this weed is enhanced in sheltered conditions, such as embayments and harbours (Trowbridge 1995, 1998; Trowbridge & Farnham 2004). In early spring, when the new generation of macroscopic thalli grows back, the density, percentage cover and morphology of *Codium* did not differ between the landward and seaward sides of breakwaters. Over the summer, however, more thalli persisted on landward than seaward sides and these could grow longer and more branched, forming dense canopies. Despite their small size, which should have reduced the probability of dislodgement (Blanchette 1997), only few scattered thalli of *Codium* survived in exposed habitats. After the peak of growth in July–August, the abundance and size of *Codium* also decreased in sheltered habitats, but sufficient thalli survived long enough to develop gametangia. The landward sides of breakwaters are therefore crucial for the persistence of *Codium* along the north-east coast of the Adriatic Sea, where sheltered hard substrata are naturally scarce.

The effects of local regime of disturbance on resident mussel beds also facilitated the persistence of *Codium* in sheltered habitats. Although *Codium* is able to settle on a variety of substrata, most adult thalli were directly attached to the rock. Juvenile thalli of *Codium* attached to mussels were found occasionally on the landward sides of breakwaters in the spring, but these were generally torn off the substratum as *Codium* reached a larger size (F. Bulleri *et al.*, unpublished data). The availability of bare space is therefore a limiting resource for *Codium* in these habitats, as also observed elsewhere (Trowbridge 1995; Trowbridge & Todd 1999; Levin *et al.* 2002). Because *Codium* releases gametes over a relatively narrow temporal window at the end of the summer (F. Bulleri *et al.*, unpublished data), the time at which patches of bare space were opened within mussel beds was crucial. Disturbance in April and January did not affect recruitment of *Codium*, but removal of mussels in August, shortly before gamete release, was effective in enhancing recruitment on both sides of breakwaters. In the study area, mortality of mussels on the landward sides of breakwaters is considerable over the summer because of a combination of illegal recreational harvesting of mussels, heat stress and wave effects (Airoldi *et al.* 2005). Such a regime of disturbance provides bare space for *Codium* at the right time of the year.

The effect of disturbance in regulating the interaction between mussels and *Codium* was more complex on the seaward sides of breakwaters. Although removal of mussels in August also had positive effects on recruitment of *Codium* at these exposed habitats, the subsequent survival of thalli was clearly dependent on facilitative effects of mussels. Under harsh physical conditions found on the seaward sides of breakwaters, facilitation tends to override competition (Bertness & Callaway 1994). Thus, overall effects of disturbance to mussel beds on *Codium* are probably negative and this could explain the poor performance of this weed in exposed habitats.

Codium rapidly responded to removal of mussels between April and June 2003. As presumably no significant release of propagules occurred at this time of the year, differences between treatments were attributed to resting vaucherioid filaments, holdfasts or propagules responding to the removal of the above matrix of mussels. Such responses were positive in sheltered habitats but negative in exposed habitats and may reflect the different structure of mussel beds. Mussels at the landward sides achieved larger sizes and formed thick beds that could prevent the regeneration of underneath resting stages of *Codium*. In contrast, mussels at the seaward sides were smaller and formed thinner beds that probably did not completely prevent the regrowth of thalli. Although resting stages can contribute over the short-term to the adult population of *Codium*, their contribution from one year to the next was negligible compared with that of propagules, as suggested by the lack of significant effects of April removals in the following May 2004.

Regardless of their invasibility in comparison with natural habitats, proliferation of artificial structures in the study area has created corridors for the dispersal of non-indigenous species across areas of unsuitable habitat. Under these circumstances, increasing our understanding of the role played by artificial structures in patterns of biological invasions is pivotal for predicting pathways and locales susceptible to invasions, according to the relevant life-history traits of potential invaders. Alternative management at regional and local levels could effectively minimize their importance as habitats for non-indigenous species. For example, the positioning of artificial structures along sandy or muddy coasts could be planned at a regional scale taking into account the dispersal ability of potential invaders (Airoldi *et al.* in press). A minimum distance between contiguous schemes of artificial structures greater than the maximum distance over which propagules of potential invaders can disperse would prevent artificial structures functioning as stepping stones. At local scales, alternative designs of artificial structures (e.g. type of substratum, complexity and heterogeneity) could enable compromises between the need to fulfil the primary economic and social goals for which they are built and environmental requirements. Chemical and physical attributes of artificial structures could be successfully controlled in order to decrease their suitability to potential invaders or promote the establishment of native assemblages more resistant to invasion. Finally, hun an usage of artificial habitats should be regulated according to similar principles driving protection and conservation of natural habitats (Airoldi *et al.* 2005); in the study area, preventing the harvesting of mussels from breakwaters during the summer could alone be effective at preserving the integrity of mussel beds and, hence, sensibly reducing recruitment of *Codium*.

Acknowledgements

This study was supported by the EU project DEL OS (EVK3-CT-2000-00041) and by the project COFIN (ex 40%). The authors were supported by an Assegno di Ricerca of the University of Bologna. We thank G. M. Branca, S. Santin, J. Silva and M. Carrera for assistance with fieldwork. We are grateful to A. Sfriso and A. Falace for providing information on the distribution of *Codium* and to L. Benedetti-Cecchi, I. Bertocci, P. Hulme, E. Maggi, S. Vaselli and two anonymous referees for valuable comments on earlier versions.

References

Airoldi, L. (2000) Responses of algae with different life histories to temporal and spatial variability of disturbance in subtidal reefs. *Marine Ecology Progress Series*, 195, 81–92.

Airoldi, L., Bacchiocchi, F., Cagliola, C., Bulleri, F. & Abbiati, M. (2005) Impact of recreational harvesting on assemblages in artificial rocky habitats. *Marine Ecology Progress Series*, 299, 55–66.

Airoldi, L., Abbiati, M., Beck, M.W., Hawkins, S.J., Jonsson, P.R., Martin, D., Moschella, P.S., Sundelöf, A., Thompson, R.C. & Åberg, P. (in press) An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. *Coastal Engineering*, in press.

Bacchiocchi, F. (2004) *Distribution, structure and variability of intertidal assemblages on human-made structures in the North Adriatic Sea*. PhD Thesis. University of Parma, Parma, Italy.

Bacchiocchi, F. & Airoldi, L. (2003) Distribution and dynamics of epibiota on hard structures for coastal protection. *Estuarine Coastal and Shelf Science*, 56, 1157–1166.

Bégin, C. & Scheibling, R.E. (2003) Growth and survival of the invasive green alga *Codium fragile* ssp. *tomentosoides* in tide pools on a rocky shore in Nova Scotia. *Botanica Marina*, 46, 404–412.

Benedetti-Cecchi, L. (2000) Priority effects, taxonomic resolution, and the prediction of variable patterns of colonisation of algae in littoral rock pools. *Oecologia*, 123, 265–274.

Benedetti-Cecchi, L., Nuti, S. & Cinelli, F. (1996) Analysis of spatial and temporal variability in interactions among algae, limpets and mussels in low-shore habitats on the west coast of Italy. *Marine Ecology Progress Series*, 144, 87–96.

Bertness, M.D. & Callaway, R. (1994) Positive interactions in communities. *Trends in Ecology and Evolution*, 9, 191–193.

Blanchette, C.A. (1997) Size and survival of intertidal plants in response to wave action: a case study with *Fucus gardneri*. *Ecology*, 78, 1563–1578.

Bondesan, M., Calderoni, G. & Dal Cin, R. (1978) Il litorale delle province di Ferrara e di Ravenna (Alto Adriatico). Evoluzione morfologica e distribuzione dei sedimenti. *Bollettino Della Società Geologica Italiana*, 97, 247–287.

Borden, C.A. & Stein, J.R. (1969) Reproduction and early development in *Codium fragile* (Suringar) Hariot: Chlorophyceae. *Phycologia*, 8, 91–99.

Boudouresque, C.F. (1994) Les espèces introduites dans les eaux côtières d'Europe et de Méditerranée: etat de la question et conséquences. *Introduced Species in European Coastal Waters* (ed. C.F. Boudouresque, F. Briand & C. Nolan), pp. 8–27. European Commission, Luxembourg.

Bressan, G., Trebbi, F. & Babbini, L. (2000) Variazioni di distribuzione batimetrica di macrophytobenthos nel parco marino di Miramare (Golfo di Trieste) in rapporto a condizioni edafiche. *Biologia Marina Mediterranea*, 7, 528–540.

Bulleri, F. & Chapman, M.G. (2004) Intertidal assemblages on artificial and natural habitats in marinas on the north-west coast of Italy. *Marine Biology*, 145, 381–391.

Bulleri, F., Abbiati, M. & Airoldi, L. (in press) The colonisation of artificial human-made structures by the invasive alga *Codium fragile* ssp. *tomentosoides* in the north Adriatic Sea (NE Mediterranean). *Hydrobiologia*, in press.

Byers, J.E. (2002) Physical habitat attribute mediates biotic resistance to non-indigenous species invasion. *Oecologia*, 130, 146–156.

Carlton, J.T. & Scanlon, J.A. (1985) Progression and dispersal of an introduced alga: *Codium fragile* ssp. *tomentosoides* (Chlorophyta) on the Atlantic coast on North America. *Botanica Marina*, 28, 155–165.

Ceccherelli, G. & Cinelli, F. (1999) A pilot study of nutrient enriched sediments in a *Cymodocea nodosa* bed invaded by the introduced alga *Caulerpa taxifolia*. *Botanica Marina*, 42, 409–417.

Cencini, C. (1998) Physical processes and human activities in the evolution of the Po delta, Italy. *Journal of Coastal Research*, 14, 774–793.

Chapman, M.G. & Bulleri, F. (2003) Intertidal seawalls: new features of landscape in intertidal environments. *Landscape and Urban Planning*, 62, 159–172.

Chapman, A.S., Scheibling, R.E. & Chapman, A.R.O. (2002) Species introductions and changes in the marine vegetation of Atlantic Canada. *Alien Invaders in Canada's Waters, Wetlands and Forests* (eds R. Claudi, P. Nantel & E. Muckle-Jeffs), pp. 133–148. Natural Resources Canada, Canadian Forest Service Science Branch, Ottawa, Canada.

Connell, S.D. & Glasby, T.M. (1999) Do urban structures influence local abundances and diversity of subtidal epibiota? A case study from Sydney Harbour, Australia. *Marine Environmental Research*, 47, 373–387.

Dethier, M.N., Graham, E.S., Cohen, S. & Tear, L.M. (1993) Visual versus random-point percent cover estimations: 'objective' is not always better. *Marine Ecology Progress Series*, 110, 9–18.

Furnari, G., Giaccone, G., Cormaci, M., Aloni, G. & Serio, D. (2003) Marine biodiversity of Italian coast: catalogue of the macrophytobenthos. *Biologia Marina Mediterranea*, 10, 1–482.

Grosholz, E. (2002) Ecological and evolutionary consequences of coastal invasions. *Trends in Ecology and Evolution*, 171, 22–27.

Holloway, M.G. & Keough, M.J. (2002) An introduced polychaete affects recruitment and larval abundance of sessile invertebrates. *Ecological Applications*, 12, 1803–1823.

Kareiva, P. (1996) Diversity and stability on the prairie. *Nature*, 379, 673–674.

Kennedy, T.A., Naeem, S., Howe, K.M., Knops, J.M.H., Tilman, D. & Reich, P. (2002) Biodiversity as a barrier to ecological invasion. *Nature*, 417, 636–638.

Lambert, C.C. & Lambert, G. (2003) Persistence and differential distribution of nonindigenous ascidians in harbors of the Southern California Bight. *Marine Ecology Progress Series*, 259, 145–161.

Levin, P.S., Coyer, J.A., Petrik, R. & Good, T.P. (2002) Community-wide effects of nonidigenous species on temperate rocky reefs. *Ecology*, 83, 3182–3193.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M. & Bazzaz, F.A. (2000) Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications*, 10, 689–710.

Meiners, S.J., Cadenasso, M.L. & Pickett, S.T.A. (2004) Beyond biodiversity: individualistic controls of invasion in a self-assembled community. *Ecology Letters*, 7, 121–126.

Occhipinti-Ambrogi, A. (2001) Transfer of marine organisms: a challenge to the conservation of coastal biocenoses. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 11, 243–251.

Reed, D.C., Laur, D.R. & Ebeling, A.W. (1988) Variation in algal dispersal and recruitment: the importance of episodic events. *Ecological Monographs*, 58, 321–335.

Sammarco, P.W., Atchison, A.D. & Boland, G.S. (2004) Expansion of coral communities within the northern Gulf of Mexico via offshore oil and gas platforms. *Marine Ecology Progress Series*, 280, 129–143.

Scheibling, R.E. & Anthony, S.X. (2001) Feeding, growth and reproduction of sea urchins (*Strongylocentrotus droebachiensis*) on single and mixed diets of kelp (*Laminaria* spp.) and the invasive alga *Codium fragile* ssp. *tomentosoides*. *Marine Biology*, 139, 139–146.

Sfriso, A. (1987) Flora and vertical distribution of macroalgae in the lagoon of Venice: a comparison with previous studies. *Giornale Botanico Italiano*, 121, 69–85.

Simberloff, D. & Von Holle, B. (1999) Positive interactions of nonindigenous species: invasional meltdown? *Biological Invasions*, 1, 21–32.

Sousa, W.P. (1979) Experimental investigations of disturbance and ecological succession in a rocky intertidal community. *Ecological Monographs*, 49, 227–254.

Stachowicz, J.J., Fried, H., Whitlatch, R.B. & Osman, R.W. (2002) Biodiversity, invasion resistance, and marine ecosystem function: reconciling pattern and process. *Ecology*, 83, 2575–2590.

Thornber, C., Kinlan, B.P., Graham, M.H. & Stachowicz, J.J. (2004) Population ecology of the invasive kelp *Undaria pinnatifida* in California: environmental and biological controls on demography. *Marine Ecology Progress Series*, 268, 69–80.

Trowbridge, C.D. (1995) Establishment of the green alga *Codium fragile* ssp. *tomentosoides* on New Zealand rocky shores: current distribution and invertebrate grazers. *Journal of Ecology*, 83, 949–965.

Trowbridge, C.D. (1996) Introduced versus native subspecies of *Codium fragile*: how distinctive is the invasive subspecies *tomentosoides*? *Marine Biology*, 126, 193–204.

Trowbridge, C.D. (1998) Ecology of the green macroalga *Codium fragile* (Suringar) Hariot 1989: invasive and non-invasive subspecies. *Oceanography and Marine Biology: An Annual Review*, 36, 1–64.

Trowbridge, C.D. (1999) *An Assessment of the Potential Spread and Options for Control of the Introduced Green Macroalga* Codium fragile *ssp.* tomentosoides *on Australian Shores*. Centre for Research on Introduced Marine Pests, Hobart, Australia.

Trowbridge, C.D. & Farnham, W.F. (2004) Spatial variation in littoral *Codium* assemblages on Jersey, Channel Islands (southern English Channel). *Botanica Marina*, 47, 501–503.

Trowbridge, C.D. & Todd, C.D. (1999) The familiar is exotic. II. *Codium fragile* ssp. *tomentosoides* on Scottish rocky intertidal shores. *Botanic Journal of Scotland*, 50, 161–17[illegible].

Underwood, A.J. (1997) *Experiments in Ecology: Their Logical Design and Interpretation Using Analysis of Variance*. Cambridge University Press, Cambridge, UK.

Vitousek, P.M., Mooney, H.A., Lubchenco, J. & Melillo, J.M (1997) Human domination of earth's ecosystems. *Science*, 277, 494–499.

Williamson, M.H. (1996) *Biological Invasions*. Chapman & Hall, London, New York.

Winer, B.J., Brown, D.R. & Michels, K.M. (1991) *Statistical Principles in Experimental Design*. McGraw-Hill, New York, NY.

Received 25 March 2005; final copy received 20 July 2005
Editor: Phil Hulme

Estuarine, Coastal and Shelf Science 79 (2008) 24–34

Contents lists available at ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Habitat modification in a dynamic environment: The influence of a small artificial groyne on macrofaunal assemblages of a sandy beach

Simon J. Walker, Thomas A. Schlacher*, Luke M.C. Thompson

Faculty of Science, Health & Education, University of the Sunshine Coast, Maroochydore DC, QLD 4558, Australia

ARTICLE INFO

Article history:
Received 9 January 2008
Accepted 7 March 2008
Available online 27 March 2008

Keywords:
coastal structures
beaches
impacts
sea walls
benthic infauna

ABSTRACT

Coastal armouring is the primary method used to combat beach erosion worldwide, and its use is likely to increase in response to accelerated coastal retreat and erosion caused by rising sea levels and storms. Yet, the ecological effects of coastal armouring structures are poorly understood, particularly for macrobenthic communities. We therefore quantified the effects of a small perpendicular groyne on the physical characteristics of a sandy beach and documented the consequences for the structure of macrobenthic communities on the beach intersected by the groyne. The groyne altered the dynamics of the physical environment, creating depositional conditions on one side of the structure, while causing some erosion on the opposite side. Changes in physical properties translated into marked spatial variations in macrofaunal diversity, abundance and species composition: ecological effects were strongest within 15 m of the groyne wall. Given that coastal armouring will become more widespread, environmentally sustainable beach management will need to encompass the ecological consequences of altering beach habitats via structural engineering interventions.

1. Introduction

Coastal armouring is society's principal defence against eroding coastlines and landward retreating beaches (Scavia et al., 2002; Charlier et al., 2005). In the 21st century, rising sea levels and increased intensity of storms as a result of climate change will accelerate beach erosion and inland retreat of coastlines (Cowell et al., 2006; Slott et al., 2006). Increased coastal erosion and retreat is likely to result in a substantial increase in coastal defence structures around the world to protect coastal developments and fragile coastlines (Schlacher et al., 2006, 2007a). Coastal ecosystems such as sandy beaches are already under threat from a multitude of human induced pressures that impact on their ecological structure and function (Schlacher et al., 2006, 2007a). Hard engineering interventions such as seawalls and revetments can have undesirable ecological consequences on sandy beaches (Dugan and Hubbard, 2006), therefore any increase in coastal defence structures may have considerable flow-on effects for the ecology of sandy beach ecosystems.

Coastal armouring, in particular the use of seawalls, groynes and jetties, alters the hydrodynamic regimes of the coastal zone (Martin et al., 2005), which can modify the sediment grain size and lead to a narrowing of beaches in front of seawalls (Fletcher et al., 1997; Runyan and Griggs, 2003). The sediment attributes and morphodynamic properties of beaches (e.g. slope, wave regimes and tidal range) are the principal structuring forces of ecological communities on most sandy beaches; biological interactions are generally less important than in other intertidal ecosystems (McLachlan et al., 1993, 1996; Defeo and McLachlan, 2005). Thus, given the strong links between morphodynamic properties and the composition of benthic macrofaunal assemblages (McLachlan et al., 1993; Defeo and McLachlan, 2005), changes to sediment attributes and beach morphodynamic properties caused by coastal armouring are likely to substantially modify the diversity, distribution and abundance of the benthic macrofauna.

Terrestrial and marine habitats are often susceptible to anthropogenic modifications such as coastal armouring, which can lead to substantial changes to the ecology of these ecosystems (Stephenson, 1999; James, 2000; Brown and McLachlan, 2002, Chapman and Bulleri, 2003; Moreira et al., 2006; Speybroeck et al., 2006; Schlacher et al., 2007b). The negative ecological impacts of seawalls can be substantial and include: (a) an overall loss of habitat, (b) loss and reduction of the intertidal zone, (c) altered wrack deposition and retention, and (d) reduced diversity and abundance of macroinvertebrates and birds (Dugan and Hubbard, 2006).

Furthermore, coastal armouring creates new hard-bottomed substrata within the soft-sedimentary seascape (Chapman and

* Corresponding author.
E-mail address: tschlach@usc.edu.au (T.A. Schlacher).

0272-7714/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ecss.2008.03.011

Bulleri, 2003). These new patches of hard substrata may allow sessile organisms to settle and grow where they were previously excluded due to the absence of suitable settlement surfaces (Chapman and Bulleri, 2003; Pinn et al., 2005).

Coastal armouring structures also disrupt hydrodynamic flow patterns creating a barrier for movement along the shore that can have a number of effects on macrofaunal communities that include altered patterns of larval supply and food availability (Pinn et al., 2005; Dugan and Hubbard, 2006). Hard engineered structures on sandy beaches can have indirect negative effects on the distribution and abundance of fish, turtles and birds through habitat modification and loss (Moiser and Witherington, 2002; Dugan and Hubbard, 2006; Rice, 2006).

Groynes are built perpendicular to the shoreline and, similar to seawalls, they are used to mitigate beach erosion except, rather than blocking inland shoreline progression, groynes disrupt longshore sand transport mechanisms (Bush et al., 2001; Charlier et al., 2005). The effects of these coastal armouring structures on the ecological attributes of sandy beaches are known to some degree for sea walls (i.e. parallel coastal armouring structures; Jaramillo et al., 2002; Dugan and Hubbard, 2006), but are unknown for groynes (i.e. structures built perpendicular to the coastline) on wave-exposed sandy beaches. Therefore, to the best of our knowledge, this is the first study to investigate the effects of a groyne on the diversity, distribution, and abundance of benthic macrofauna on a wave-exposed sandy beach.

Based on preliminary observations of water turbulence adjacent to the groyne at mid and high water, we predicted that the putative effects of the groyne on the physical characteristics and benthic macrofaunal assemblages would be stronger closer to the structure and weaker at greater distance. This hypothesis is reflected in the spatial sampling design where replicated transects were located both close to the groyne (within 10 m) and up to 250 m away.

2. Materials and methods

2.1. Study site

The effects of a small groyne on beach properties and macrobenthic assemblages were quantified on Palm Beach in southern Queensland, Australia (28°06.940′S; 153°28.271′E). The urban landscape adjacent to the beach is largely built directly on the dune system with only a thin strip of vegetation separating houses from the beach (Fig. 1). On this beach, a small (approximately 95 m long by 10 m wide) groyne, constructed 27 years ago of natural rock boulders, intersects perpendicular to the central part of the beach (Fig. 1). The structure extends 95 m from the base of the foredunes to the swash line at spring low tides and bisects the along shore transport of sediment, which naturally runs from south to north due to the prevailing hydrodynamic conditions.

2.2. Sampling design

Physical beach characteristics and the benthic macrofauna were quantified across 22 transects spaced alongshore on the northern and southern side of the groyne (Fig. 1). Replicate transects were located in close proximity to the groyne (1, 3, 5, and 10 m), and more distal to the groyne at distances of 15, 25, 50, 100, 150, 200 and 250 m. This spatial design was replicated on both the northern and southern sides of the groyne with 11 transects located in each section. The transects were orientated in a shore-normal direction, extending from the base of the foredune to the swash zone at low water spring tide (LWST). Each transect comprised 12 sampling levels, spaced 7–10 m apart across the shore depending on beach width.

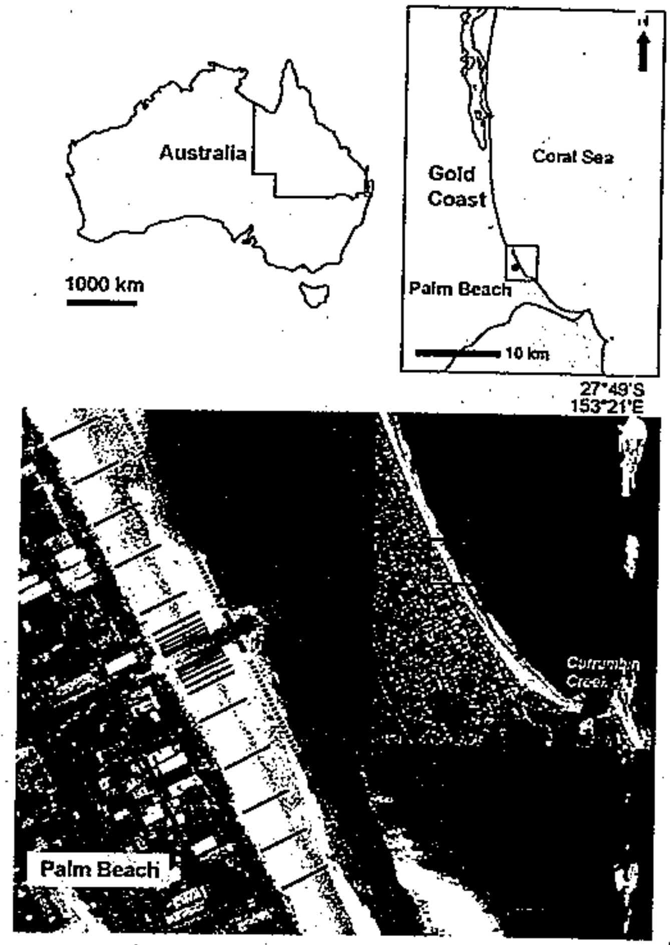


Fig. 1. Site map showing the location of the study site and position of sample transects distributed near the wall (proximal <10 m) and at distances up to 250 m from the groyne (distal >15 m).

2.3. Physical properties

Beach profiles were measured along each transect using a standard surveying methods with a theodolite. Swash zone width was calculated from the maximum up-rush and down-rush position of 10 consecutive swashes per transect. Wave period (s) was calculated from counts of the number of waves breaking in the surf zone over a 3-min period, and wave height (cm) was assessed visually. All measurements were done at the predicted time of low water spring tide (LWST). The position of the drift line, position of the effluent line, and swash zone boundaries were determined visually and mapped onto the beach profiles.

Sediment samples (cores of 30 mm diameter, 100 mm deep) were taken to determine sediment moisture content and granulometry. Triplicate cores (spaced ca. 1 m apart in a longshore direction) were taken at each of the 12 sampling levels per transect. Sediment moisture content was determined as total weight loss after drying to a constant weight (65 °C for 72 h). We measured granulometry by dry-sieving (15 min on an Endecott sieve shaker) through a nested series of mesh sizes (i.e. 4000, 2000, 1000, 500, 250, 125 and 63 μm). Granulometry statistics (mean grain size, sorting, skewness, kurtosis) were calculated according to the Folk and Ward method using the GRADISTAT software (Blott and Pye, 2001).

Zones of the shore (i.e. upper, middle, and lower beach) were identified from similarities in environmental variables across all levels sampled using group-average clustering based on normalised Euclidian distance (Clarke and Warwick, 2001). The five environmental variables included in this cluster analysis were: (1) position relative to effluent line (binary); (2) height above LWST (m); (3) mean sediment grain size (μm); (4) beach slope (°); and (5) sediment moisture content (%).

2.4. Benthic macrofauna

Benthic macrofauna was sampled by extracting replicate sediment cores (inner diameter 154 mm, 200 mm deep). Sampling began 3 h before spring low tides, starting at the foredune and working down the beach to the swash zone. At each sampling level of each transect, we took five cores placed at approximately 1 m intervals along the shore; these cores were pooled into a composite sample per level. To extract the macrofauna, bulk sand samples were washed in the swash zone through a mesh bag with 1 mm aperture size. Macrofauna was preserved in 80% ethanol in the field. In the lab, macrofaunal organisms were separated from any remaining sediment and identified to the lowest possible taxon, usually species or distinct morphospecies.

2.5. Data analysis

To examine the spatial differences in species richness, total abundance, diversity (Hills N_1 diversity index) and physical variables (grain size, sorting and sediment moisture content), we used a three-factor analysis of variance (ANOVA). The fixed factors included in this analysis were: (1) location (north/south), (2) distance from the groyne (proximal/distal – nested within location), and (3) shore zones (upper, middle, lower shore). A total of 144 samples were used for univariate analyses, which included 3 random samples from each of the three shore zones (based on cluster analyses of physical factors). Samples were selected from within the 4 proximal transects (1, 3, 5 and 10 m) and 4 distal transects (50, 100, 200 and 250 m), on either side of the groyne. Homogeneity of variance was checked with Cochran's test and data were either $x = \text{Log}_e(x+1)$ transformed (grains size, sorting), or arcsine-root transformed (moisture content) where required to stabilise heterogeneity. Where a significant main or interaction effect was found, multiple pair-wise comparisons were done using Student–Newman–Keuls post-hoc tests (Underwood, 1997).

We tested for differences in macrofauna community structure (species composition and abundance) using a 2-way nested analysis of similarity (ANOSIM) (Clarke, 1993), which included the design terms location (north vs. south) and transect (1–250 nested within location). This ANOSIM was run for (1) data pooled across all 12 levels within individual transects irrespective of zones, and (2) separately for each of the three zones (lower, middle, and upper shore).

Seriation is where the internal structure of data matrices are compared to ordered sequence in space or time (Clarke and Warwick, 2001). In our case, the test of interest was whether seriation in community structure was present as a function of increasing distance from the groyne. We tested seriation for data aggregated across all levels within individual transects as well as for each of the three zones separately.

We examined the influence of environmental variables on macrobenthic community structure using the BIO-ENV routine (Clarke and Ainsworth, 1993). Factors included in this analysis were: (1) distance from groyne wall; (2) height above LWST (m); (3) beach slope (°); (4) mean grain size (μm); and (5) sediment moisture content (%). Correlations between the different environmental variable were examined using draftsman plots prior to the analyses and no consistent correlations were found.

3. Results

3.1. Physical characteristics

The width of the beach face (Fig. 2) and the slope did not differ substantially between the northern and southern side of the groyne

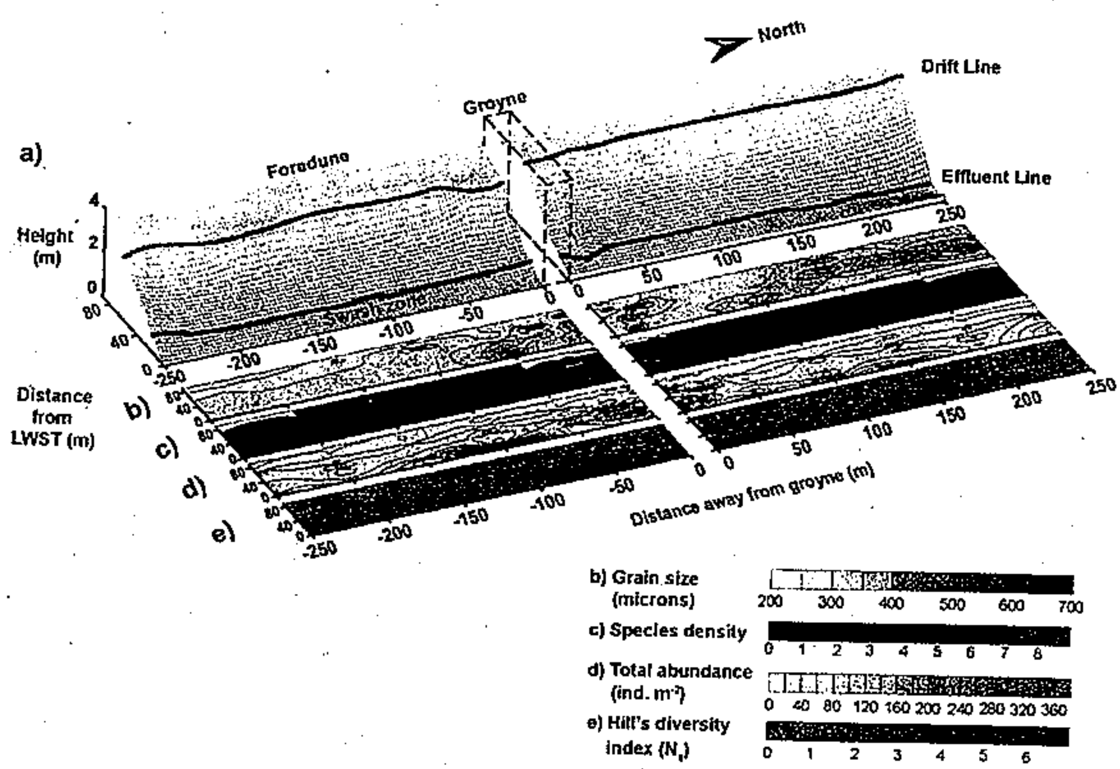


Fig. 2. Beach profile (a) for the areas surveyed 250 m on either side of the groyne, and contour maps for (b) mean grain size (μm), (c) average species density (number of species per sample), (d) total macrobenthos abundance (mean number of individuals per m^{-2}), and (e) the Hill's diversity index (N_1).

Table 1
Comparison of physical variables between beach sections located on the southern and northern side of the rock groyne at Palm Beach. Compound indices are for 11 transects surveyed on either side of the groyne (cf. Fig. 1)

Variable	Beach section					
	South of groyne			North of groyne		
	Mean	SEM	*n*	Mean	SEM	*N*
Slope (°)	2.2	0.14	132	2.1	0.11	132
Grain size (μm)	372	5.09	132	345	6.14	132
Beach index (BI)	2.1	0.01	11	2.2	0.01	11
Beach deposit index (BDI)	75	1.52	11	85	2.72	11
Dean's parameter (Ω)	2.0	0.03	11	2.3	0.07	11

(Table 1). However, some sand erosion was occurring on the southern side next to the wall, contrasted by deposition of sand on the northern side of the groyne (Fig. 2a). This differential pattern of erosion vs accretion was most pronounced on the middle and lower parts of the shore. On the upper shore there was evidence of a lowering of the beach profile by up to 75 cm within 50 m of the southern side of the groyne. Conversely, sediment accumulated adjacent to the northern side of the rock wall, raising the beach profile. The combined analysis of four physical factors (mean grain size (μm), sorting, sediment moisture content (%) and slope (°) showed that there was substantial seriation with increasing distance from both the southern (Rho = 0.61, $p = 0.001$) and northern (Rho = 0.59, $p < 0.01$) sides of the wall (Fig. 3). Based on these

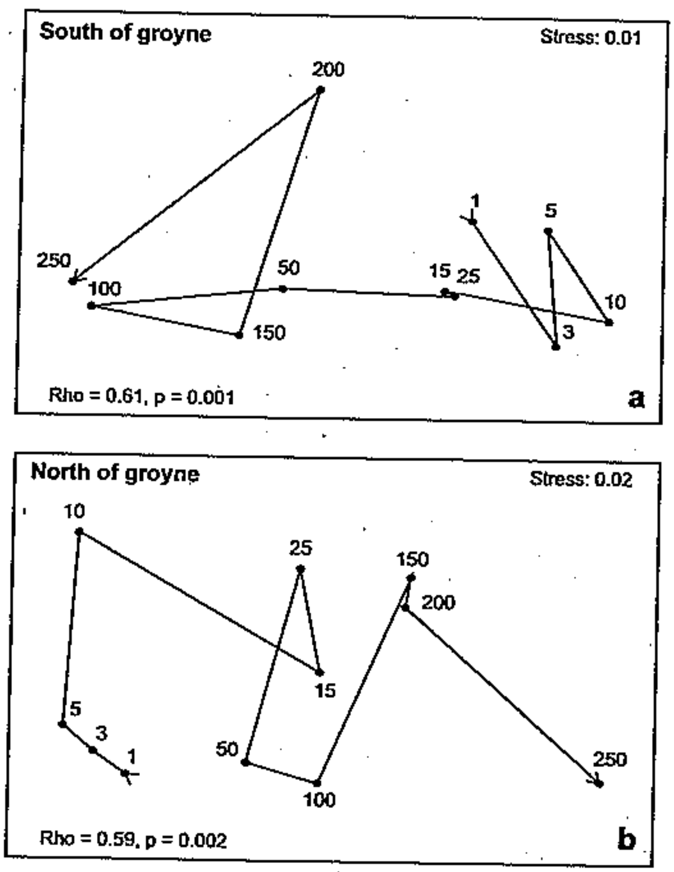


Fig. 3. NMDS ordinations of physical factors (distance from groyne wall, height above LWST (m), beach slope (°), mean grain size (μm), and sediment moisture content (%)) for transects located at increasing distance from the groyne. Rho (ρ) is the Spearman's rank correlation coefficient for a serial pattern of physical factors with increasing distance from the groyne wall.

analyses it appears that the groyne did not modify substantially the overall sediment properties or beach morphodynamics beyond 10–15 m from the groyne wall.

On the southern beach section, grain size (μm) became markedly coarser towards the groyne, and the effect was most pronounced on the middle and lower beach zones within 10 m of the groyne wall (Figs. 2b and 4; Table 2; ANOVA: $F_{4,132} = 4.08$, $p < 0.01$). Conversely, on the northern side of the wall, grain size was finer within 10 m of the wall, particularly in the mid-shore zone (Figs. 2b and 4). Overall, differences in the accretion–erosion dynamics in areas close to the groyne resulted in shifts in sediment parameters and beach elevations which were more pronounced 10–15 m from the structure than further away from the groyne wall.

3.2. *Macrobenthos assemblages*

Heterogeneity in macrobenthic assemblages was pronounced and displayed spatial structure attributable to elevation on the shore, distance from the groyne, and location (i.e north vs. south of groyne). A total of 26 taxa were identified, comprising isopods (2 species), amphipods (3 species), polychaetes (10 species), bivalves (6 species), 4 less abundant crustaceans (a mysid shrimp, two ocypodid crabs and a hermit crab) and insects. In areas close to the wall, there were consistently more species recorded on the northern side of the groyne (18 species), than on the southern side (13 species) and this trend occurred across the entire beach (Table 3). Further away from the wall, the difference between the two northern and southern sections was reduced (Table 3).

Species richness per sample was 35–59% greater in areas close to the northern side of the wall than in areas further away from the wall and in all of the southern section irrespective of distance from the groyne (Fig. 5; Table 4; ANOVA $F_{2,132} = 5.35$, $p < 0.01$, SNK). There were also differences in species richness and abundance across the shore, with more species found at greater density lower on the shore than higher up (Fig. 5; Table 4; ANOVA species density: $F_{2,132} = 155.18$, $p < 0.001$; total abundance $F_{2,132} = 90.99$, $p < 0.001$, SNK).

Species diversity (Hills N_1 diversity index) was higher in transects close to the groyne on the northern section (Fig. 5; Table 4; ANOVA $F_{4,132} = 2.65$, $p < 0.05$, SNK). Conversely, on the southern section, which experienced erosion close to the rock wall, assemblages close to the groyne were less diverse compared with more distant areas (Fig. 5). Species diversity was greatest low on the shore, compared with areas further up the shore (Fig. 5).

The structure of macrobenthic communities in the northern section displayed a clear serial pattern with increasing distance from the wall (nMDS Fig. 6; Rho = 0.68, $p = 0.001$). This pattern of spatially-structured changes in community structure in relation to the groyne was consistent across all zones of the beach, albeit somewhat reduced in the middle zone (nMDS Fig. 6; upper shore: Rho = 0.58, $p = 0.001$; mid shore: Rho = 0.29, $p = 0.03$; low shore zone: Rho = 0.61, $p = 0.001$). By comparison, in the southern section, there was no serial pattern with increasing distance from the wall (Rho = 0.20, $p > 0.05$), however a relatively weak serial pattern was found in the mid-shore zone (upper zone Rho = 0.20, $p = 0.090$; mid zone Rho = 0.29, $p = 0.020$; lower zone Rho = 0.16, $p = 0.155$). The spatial patterns of community structure along the shore differed between the northern and southern sections of beach (Rho = −0.09, $p = 0.7$).

The primary environmental variables contributing to differences in the macrofaunal assemblages on the northern side of the groyne were distance from groyne, height above LWST, and sediment moisture content (Rho = 0.51, $p = 0.001$). No single environmental variable or combination of variables could, however, explain spatial

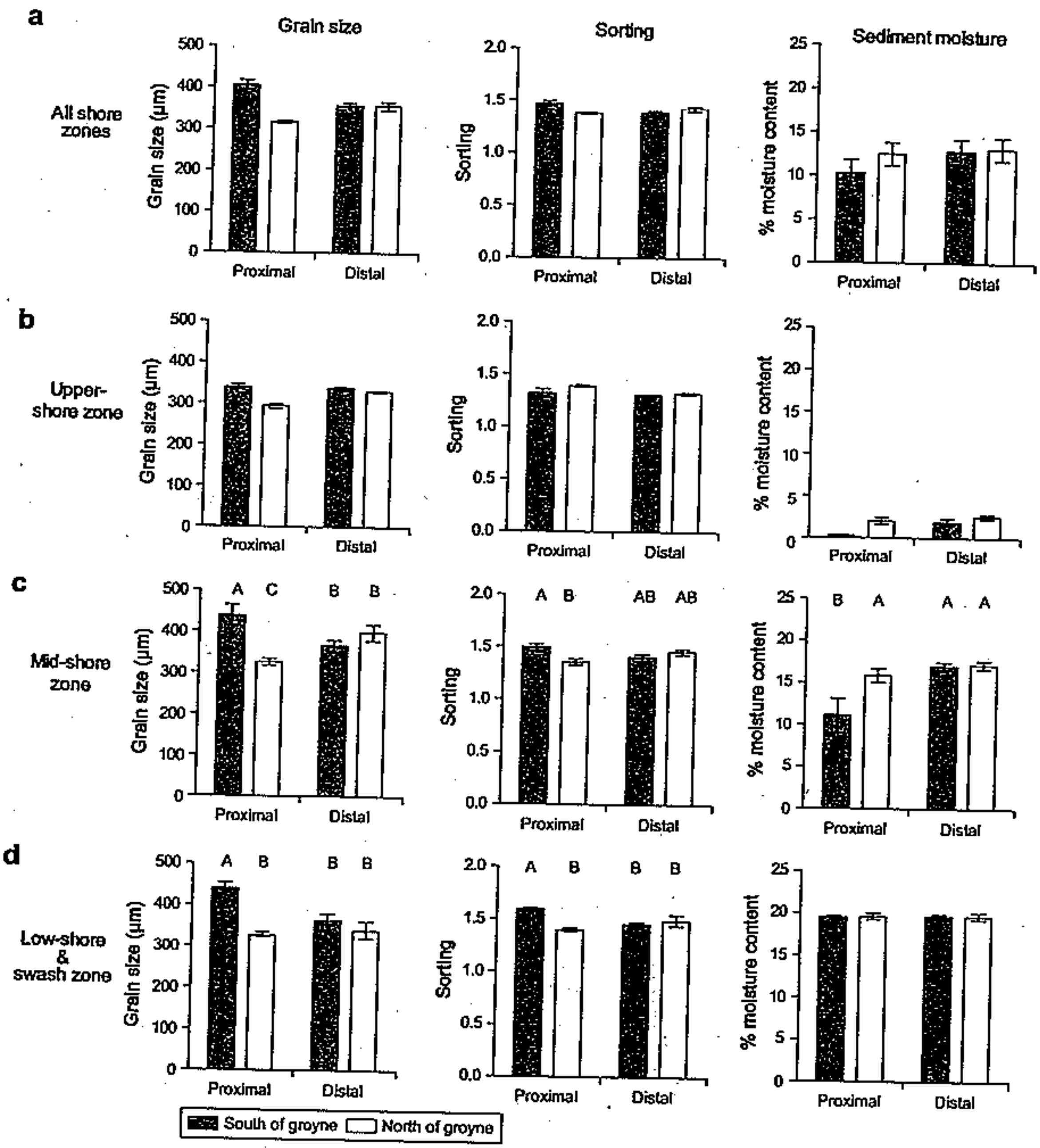


Fig. 4. Spatial variation of the primary sediment properties, mean grain size (µm; mean ± SE), sorting (mean ± SE) and sediment moisture content (mean % ± SE). Samples are grouped into near the groyne wall (proximal <10 m) and further away from the wall (distal >15 m), and separate zones of the shores (upper, middle and lower shore). Filled bars denote the southern part of the beach and open bars the northern beach. Superscripts (A and B) refer to homogenous groups identified by SNK tests following significant main and/or interaction terms in ANOVA (A > B).

Table 2
Summary of a 3-factor ANOVA testing for the differences in sediment parameters between locations (north vs. south), distance from the groyne (proximal vs. distal; nested within location), and shore zone (upper, middle, and lower beach). $^{**}p < 0.01$, $^{***}p < 0.001$

Source of variation	d.f.	Grain size		Sediment sorting		Sediment moisture	
		MS	F	MS	F	MS	F
Location	1	73299	37.42***	0.03	3.19	53.30	9.26**
Distance (location)	2	36816	18.80***	0.07	9.22***	59.88	10.40***
Zone	2	41777	21.33***	0.28	34.11***	4203.26	730.04***
Zone × location	2	5534	2.83	0.05	5.73**	16.82	2.92
Zone × distance (location)	4	7998	4.08**	0.04	4.67**	27.59	4.79**
Error	132	1959		0.01		5.76	

Table 3
Contrasts in species richness between beach sections north and south of the structure in (A) areas proximal (1–10 m), and (B) distal (15–250 m) to the groyne. Values in bold denote higher richness for a section

	(A) Proximal (<10 m from groyne)			(B) Distal (>10 m from groyne)		
	South (no. of species)	North (no. of species)	Ratio (south:north)	South (no. of species)	North (no. of species)	Ratio (south:north)
Upper shore	4	**5**	1:1.3	3	**6**	1:2.0
Mid shore	5	**10**	1:2.0	11	11	1:1.0
Lower shore and swash	11	**16**	1:1.5	15	**16**	1:1.1
All shore zones	13	**18**	1:1.4	17	**18**	1:1.1

differences in the macrofaunal assemblages on the southern side of the groyne (Rho = 0.32, $p > 0.05$).

To test our hypothesis that distance from the groyne affects the abundance and diversity of the macrobenthos, we grouped transects into either proximal (1–10 m from groyne wall) or distal (15–250 m) groups based on clustering of physical factors. The composition and abundance of macrofauna differed between the two sides of the wall (Fig. 7; ANOSIM location: $R = 0.19$, $p = 0.001$; transects:

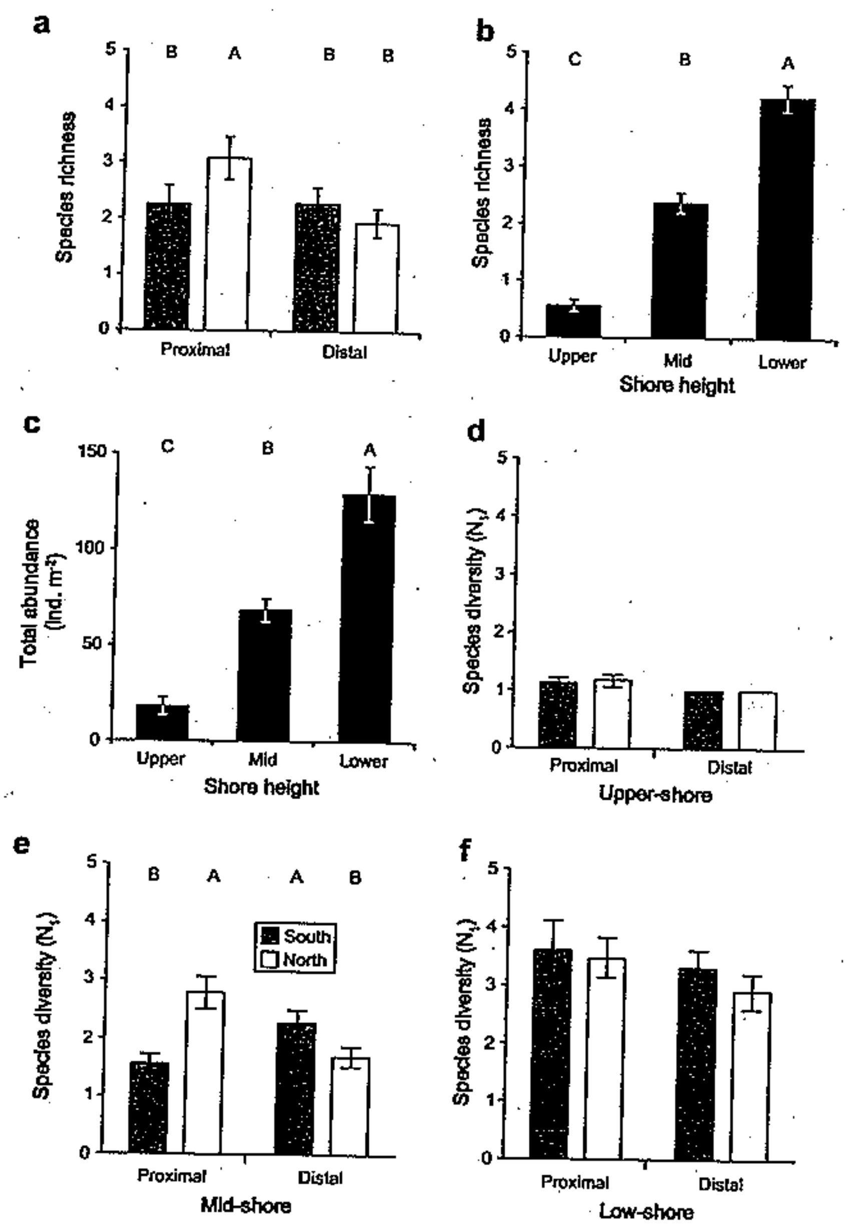


Fig. 5. Spatial variation in: (a) species richness (mean no. of species per sample ± SE) among proximal (<10 m) and distal (>15 m) transects on northern and southern sides o' the groyne wall; (b) species richness among the different shore zones pooled across all transects; (c) total abundance (mean number of individuals per m^{-2} ± SE) across the three zones pooled across all transects; and species diversity (Hills N_1 ± SE) between proximal and distal transects on either the northern or southern side of the wall, within each of the three shore zones: (d) upper shore zone, (e) mid-shore zone and (f) lower shore and swash zone. Light grey bars denote the southern part of the beach and white bars the northern b ach. Superscripts (A, B and C) refer to homogenous groups identified by SNK tests following significant main and interaction terms in ANOVA (A > B > C).

Table 4

Summary of a 3-factorial ANOVA testing the effects of location (north vs. south), distance from the groyne (proximal vs. distal; nested within location), and shore zone (upper, mid, and lower beach) on species richness, total macrobenthos abundance (m^{-2}), and Hill's diversity index (N_1). Data were log transformed to correct for heterogeneity of variance after Cochran's test. ($^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$)

Source of variation	d.f.	Species richness		Abundance		Species diversity (Hill's N_1)	
		MS	F	MS	F	MS	F
Location	1	0.21	1.72	4.11	2.87	0.02	0.29
Distance (location)	2	0.67	5.35**	2.93	2.04	0.31	6.05**
Zone	2	19.35	155.18***	130.50	90.99***	5.84	113.78***
Zone × location	2	0.07	0.53	0.08	0.06	0.07	1.28
Zone × distance (location)	4	0.16	1.26	0.94	0.65	0.14	2.65**
Error	132	0.12		1.43		0.05	

$R = -0.02, p > 0.05$). The assemblages close to either side of the wall (1–10 m) were most dissimilar (Fig. 7; ANOSIM proximal locations: $R = 0.51, p = 0.029$), becoming more similar further away from the wall (Fig. 7; 15–250 m; ANOSIM distal locations: $R = 0.17, p = 0.023$).

More than 80% of the total assemblage dissimilarity between locations (i.e. north vs. south) was accounted for by differences in the abundance of six species: the isopods, *Pseudolana concinna* and *Pseudolana elegans*; the amphipods *Urohaustorius halei* and *Exoediceros maculosus*; and the polychaetes, *Glycera* sp. 1 and *Scolelepis* sp. 1 (Table 5). *Pseudolana concinna* was the principal species driving differences in assemblages, contributing 31% of the dissimilarity between assemblages near the wall; its density was 5 times higher on the northern beach (Table 5). *Pseudolana elegans* and *Scolelepis* sp. 1 were more abundant (55 and 798%, respectively) on the northern beach near the wall. By comparison, *Glycera* sp. 1, *E. maculosus* and *U. halei* were less numerous on the northern beach, but only by a factor of 20–31% (Table 5).

Differences in the density of individual species between the northern and southern sections were less pronounced at greater distances from the rock wall. The two species *Glycera* sp. 1 and *Pseudolana concinna* contributed 49% of the dissimilarity in assemblages between the two locations, although mean densities were only marginally (7%) higher in the south. By comparison, *Pseudolana elgans*, *Urohaustorius halei*, *Exoediceros maculosus* and *Scolelepis* sp. 1 all increased in abundance by 33, 12, 9 and 70%, respectively, from the southern to the northern sections (Table 5).

4. Discussion

This study provides the first evidence to determine the effect of perpendicular coastal armouring on the distribution of macrofaunal communities on sandy beaches. On sandy beaches, the diversity and abundance of macrofauna generally changes with the morphodynamic state of the beach, decreasing from dissipative to reflective states, and with increased sand particle size and steepness of beach slope (Defeo and McLachlan, 2005). The species richness, abundance and biomass of macrofauna that inhabit wave-exposed sandy beaches are primarily controlled by the physical characteristics of the environment rather than biological interactions (McLachlan and Jaramillo, 1995; McLachlan et al., 1996; Defeo and McLachlan, 2005).

Coastal engineering structures substantially change the physical characteristics of soft sediment habitats (Fletcher et al., 1997; Dugan and Hubbard, 2006), which can alter the faunal assemblages living in these modified habitats (Meyer-Arendt and Dorvlo, 2001; Chapman and Bulleri, 2003; Dugan and Hubbard, 2006). The groyne modified the physical attributes of the beach, causing spatial variation in sediment grain size and sorting. Importantly, it changed the accretion–erosion dynamics with depositional conditions on the northern side and erosion on the southern side, within 15 m on either side of the wall. The main differences in morphodynamic characteristics were observed on the lower to mid shore within 10–15 m of the groyne, which may be due to interruption of longshore erosion and accretion processes, altering the morphodynamic properties on the beach in close proximity to the groyne (within 10–15 m). If the groyne extended further out into the water, the effects may have also extended beyond the 15 m because the groyne would have further disrupted the transport of sediment form the south to the north of the groyne.

The observed changes in the beach characteristics translated to changes in composition of the macrofaunal assemblages on either side of the groyne. Macrofaunal abundance was significantly greater in transects close to the northern side of the groyne, which were in a state of deposition, than those transect close to the southern side of the groyne, which were eroding. We also found that there were significant differences in the composition of the macrofaunal assemblages on either side of the groyne. Although the effect of the groyne was spatially limited, not extending beyond 10 m from the rock wall.

Erosion of fine sediment on the southern side of the groyne resulted in a substantial increase in the sediment grain size, which can decrease the moisture retention properties of the sand, allowing more water to filter through the sand matrix (McLachlan et al., 1985; McLachlan and Turner, 1994). Increasing the flow of water through the sand matrix, could flush nutrients and food particles out of the system, significantly altering nutrient pathways and affecting the diversity, species richness and abundance of soft sediment macrofaunal assemblages (McLachlan and Brown, 2006). In contrast, deposition of finer sediments on the northern side of the groyne decreased the overall sediment grain size, although the effect was only apparent close to the wall.

As beach morphodynamic characteristics have been shown to significantly control the abundance and distribution of macrobenthic communities (Defeo and McLachlan, 2005), we predict that the finer sand and increased moisture content on the northern side of the groyne would favour more abundant and diverse macrofauna community. In fact macrobenthic assemblages did respond as expected from empirical models (Defeo and McLachlan, 2005), being more diverse and abundant in finer-grained and depositional areas.

The isopod *Pseudolana concinna* contributed substantially to the difference between the two sections of the beach, being more abundant on the northern side of the groyne than the southern side. *Pseudolana concinna* is an abundant intertidal species found on sandy beaches throughout Queensland and New South Wales (Dexter, 1984), predominantly in the mid to upper shore areas (Dexter, 1985). Despite a significant difference in density of *P. concinna* between beach sections divided by the groyne, an unambiguous demonstration of a "groyne effect" would require additional manipulative experiments on sediment choice and the response of this isopod to altered flow regimens and accretion–erosion dynamics.

Abundant species such as *Pseudolana concinna* may be suitable to use as an indicator species for assessing beach health in response

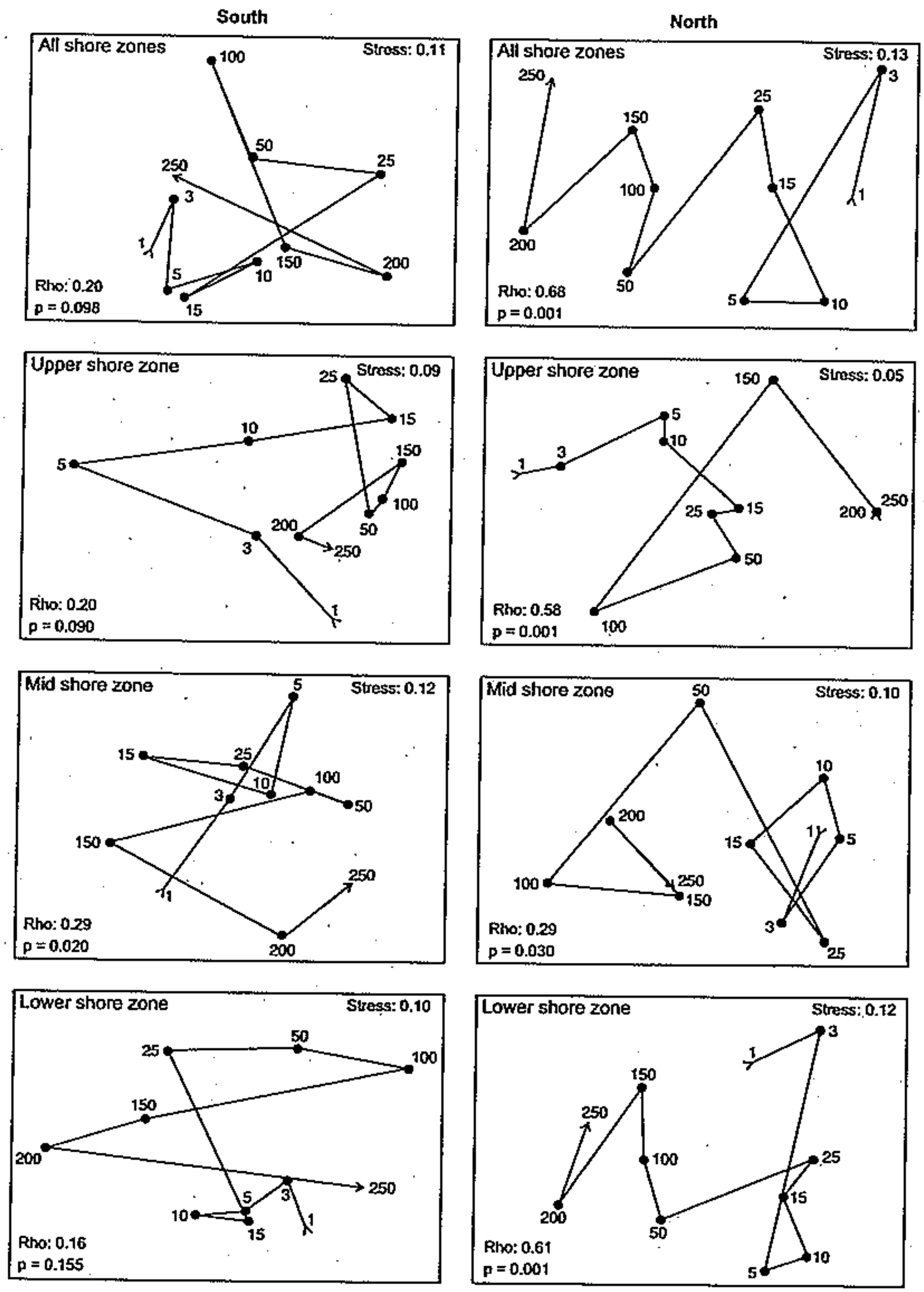


Fig. 6. NMDS ordinations showing serial patterns in the composition and abundance of macrofaunal assemblages with increasing distance from either the southern or northern sides of the groyne.

to coastal armouring. However, currently there are no data on the biology of this species – and most other beach invertebrates – in Australia. Therefore, an evaluation of the suitability of this species and others as indicators of beach health will require the collection of basic data on life histories and key ecological roles.

Our data demonstrate that groynes can cause spatial variation in community structure of the benthic macro-invertebrates. The limited information that is available for the effects of coastal armouring has shown that walls built parallel to the coastline have a significant effect on birds and macrofaunal communities due to narrowing of the upper beach and depletion of the amount of wrack being deposited on the upper beach (Dugan and Hubbard, 2006).

Perpendicular structures that extend out into the surf zone are popular locations for recreational angling. Thus, groynes are likely

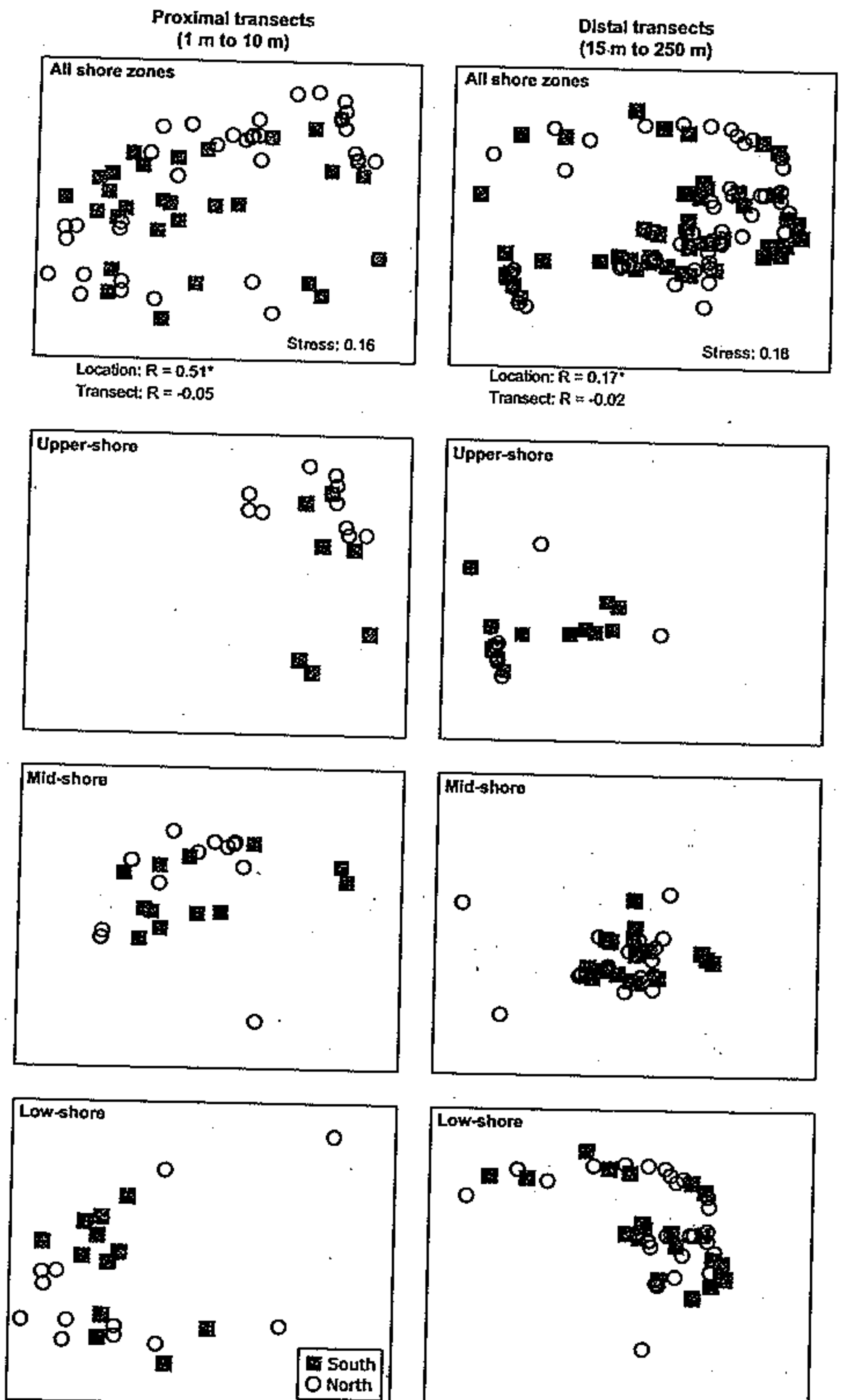


Fig. 7. NMDS ordinations showing the composition and abundance of macrofaunal assemblages on the southern or northern sides of the groyne, for both proximal (<10 m) and distal (>15 m) transects across all shore zones, and separately for each shore zone (upper, mid and low).

to lead to increased human harvesting pressure on surf-zone fishes, possibly modifying food-web dynamics on armoured beaches. However it remains unclear how fish populations are affected by these structures (Rice, 2006).

Hard engineered structured also promote the establishment of invasive epibenthic species and predators that may alter species interactions close to the structure (Chapman and Bulleri, 2003; Moreira et al., 2006). Clearly, more work is required to assess the

Table 5

Contribution of individual species to total community dissimilarity between assemblages south and north of the groyne, located (a) proximal (less than 10 m from the gr[illegible]ne) and (b) distal (greater than 15 m away from the groyne) from the rock wall. Bold values denote greater mean abundance between locations

Species	Mean abund. (ind. m^{-2})		Delta (south–north)	Average dissimilarity	Dissimilarity/SD	Contribution %	Cumulative %
	South	North					
(a) Proximal (<10 m from the groyne)							
Pseudolana concinna	5.08	31.36	−26.28	28.41	0.86	31.13	31.13
Glycera sp. 1	12.59	9.27	3.32	15.45	0.71	16.93	48.06
Pseudolana elegans	12.14	18.77	−6.63	13.21	0.61	14.48	62.54
Scolelepis sp. 1	1.77	15.9	−14.13	8.08	0.55	8.86	71.4
Exoediceros maculosus	8.61	5.96	2.65	6.59	0.44	7.22	78.62
Urohaustorius halei	4.42	3.53	0.89	5.24	0.45	5.74	84.36
Nephtys longipes	0.66	3.53	−2.87	2.87	0.39	3.14	87.5
Gastrosaccus sp. 1	1.55	1.55	0	2.45	0.28	2.69	90.19
Donax deltoides	1.32	1.99	−0.67	1.84	0.32	2.02	92.21
Owenia sp. 1	1.55	1.1	0.45	1.57	0.37	1.72	93.93
Insecta spp.	0.22	0.88	−0.66	1.5	0.26	1.64	95.58
(b) Distal (>15 m from the groyne)							
Glycera sp. 1	15.52	14.51	1.01	24.61	0.92	27.76	27.76
Pseudolana concinna	6.94	6.56	0.38	18.42	0.62	20.77	48.54
Pseudolana elegans	6.06	9.08	−3.02	9.3	0.52	10.5	59.03
Urohaustorius halei	4.79	5.43	−0.64	7.53	0.55	8.49	67.53
Exoediceros maculosus	3.91	4.29	−0.38	5.63	0.51	6.35	73.87
Scolelepis sp. 1	1.14	3.79	−2.65	3.94	0.42	4.44	78.31
Paphies elongata	3.41	0.63	2.78	3.85	0.39	4.35	82.66
Nephtys longipes	0.50	2.02	−1.52	2.62	0.32	2.95	85.61
Donax deltoides	1.01	1.89	−0.88	2.16	0.35	2.44	88.05
Gastrosaccus sp. 1	2.40	0.50	1.90	2.02	0.31	2.28	90.33
Tittikunara katoa	1.26	0.76	0.50	1.60	0.28	1.81	92.14
Owenia sp. 1	1.77	0	1.77	1.52	0.30	1.72	93.86
Capitellidae	0	1.39	−1.39	1.39	0.26	1.56	95.42

ecological impacts of groynes and seawalls at multiple levels of ecological organization on sandy beaches.

The coastal armouring structure we studied was a relatively small structure that has been established on the beach for 27 years. In other parts of the globe, armouring of coastal areas is far more extensive, with numerous structures placed in close proximity (Bush et al., 2001). In this study the impact on the distribution and abundance of the beach macrofauna was limited to within 10 m of the structure, but if the walls were placed in close succession, we predict that perpendicular hard-engineered structures would have a substantial impact on both sandy beach physical characteristics and macrofaunal communities that would effect large areas of a beach.

Furthermore, the groyne studied was built 27 years ago and we show that the impacts on macrofauna were limited to within 10 m of the wall. It is likely that more severe impacts on community structure would have occurred during and directly after the construction phase. There are currently no data on the immediate ecological impacts that construction and placement of hard engineered structures causes on sandy beaches. It is therefore important to measures the temporal trajectories of ecological effect sizes associated with coastal armouring activities to assess the time-scale of putative impacts and the recovery potential of the biota.

Within the coming decades, rising sea level and increased storms associated with climate change are predicted to cause dramatic inland retreat of shorelines (Slott et al., 2006). Society is likely to respond to accelerated beach erosion of this change by increasing coastal armouring to protect valuable property and infrastructure (Polome et al., 2005): more beaches in more coastal areas of the world will have groynes and seawalls. Given the likely dramatic future expansion of beach armouring, juxtaposed against cursory information on the ecological ramifications of these interventions, obtaining further evidence on the ecological impacts of coastal armouring will be critical in the context of environmentally sustainable beach management.

Acknowledgements

We thank Dave Wassmann, Serena Lucrezi and Stewart Lloyd for their valuable help with sample collection, and Lee Clark for assistance with sediment analysis. The comments of two anonymous improved this manuscript. This study was funded through a grant to TAS awarded by SEQ-Catchments from the Australian Governments NHT program.

References

Blott, S.J., Pye, K., 2001. GRADISTAT: a grain size distribution and statistics package for the analysis of unconsolidated sediments. Earth Surface Processes and Landforms 26, 1237–1248.

Brown, A.C., McLachlan, A., 2002. Sandy shore ecosystems and the threats facing them: some predictions for the year 2025. Environmental Conservation 29, 62–77.

Bush, D.M., Pilkey, O.H., Neal, W.J., 2001. Human impact on coastal topography. In: Steele, J.H., Thorpe, S.A., Turekian, K.K. (Eds.), Encyclopedia of Ocean Sciences. Academic Press, San Diego, pp. 480–489.

Chapman, M.G., Bulleri, F., 2003. Intertidal seawalls – new features of landscape in intertidal environments. Landscape and Urban Planning 62, 159–172.

Charlier, R.H., Chaineux, M.C.P., Morcos, S., 2005. Panorama of the history of coastal protection. Journal of Coastal Research 21, 79–111.

Clarke, K.R., 1993. Nonparametric multivariate analyses of changes in community structure. Australian Journal of Ecology 18, 117–143.

Clarke, K.R., Ainsworth, M., 1993. A method of linking multivariate community structure to environmental variables. Marine Ecology-Progress Series 92, 205–219.

Clarke, K.R., Warwick, R.M., 2001. Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. PRIMER-E, Plymouth, UK, 172 pp.

Cowell, P.J., Thom, B.G., Jones, R.A., Everts, C.H., Simanovic, D., 2006. Management of uncertainty in predicting climate-change impacts on beaches. Journal of Coastal Research 22, 232–245.

Defeo, O., McLachlan, A., 2005. Patterns, processes and regulatory mechanisms in sandy beach macrofauna: a multi-scale analysis. Marine Ecology-Progress Series 295, 1–20.

Dexter, D.M., 1984. Temporal and spatial variability in the community structure of the fauna of four sandy beaches in south-eastern New South Wales. Australian Journal of Marine and Freshwater Research 35, 663–672.

Dexter, D.M., 1985. Distribution and life histories of abundant crustaceans of four sandy beaches in south-eastern New South Wales. Australian Journal of Marine and Freshwater Research 35, 663–672.
Dugan, J.E., Hubbard, D.M., 2006. Ecological responses to coastal armouring on exposed sandy beaches. Shore & Beach 74, 10–16.
Fletcher, C.H., Mullane, R.A., Richmond, B.M., 1997. Beach loss along armored shorelines on Oahu, Hawaiian Islands. Journal of Coastal Research 13, 209–215.
James, R.J., 2000. From beaches to beach environments: linking the ecology, human-use and management of beaches in Australia. Ocean & Coastal Management 43, 495–514.
Jaramillo, E., Contreras, H., Bollinger, A., 2002. Beach and faunal response to the construction of a seawall in a sandy beach of south central Chile. Journal of Coastal Research 18, 523–529.
Martin, D., Bertasi, F., Colangelo, M.A., de Vries, M., Frost, M., Hawkins, S.J., Macpherson, E., Moschella, P.S., Satta, M.P., Thompson, R.C., Ceccherelli, V.U., 2005. Ecological impact of coastal defence structures on sediment and mobile fauna: evaluating and forecasting consequences of unavoidable modifications of native habitats. Coastal Engineering 52, 1027–1051.
McLachlan, A., Brown, A.C., 2006. The Ecology of Sandy Shores. Academic Press, Burlington, MA, USA, 373 pp.
McLachlan, A., Deruyck, A., Hacking, N., 1996. Community structure on sandy beaches – patterns of richness and zonation in relation to tide range and latitude. Revista Chilena de Historia Natural 69, 451–467.
McLachlan, A., Eliot, I.G., Clarke, D.J., 1985. Water filtration through reflective microtidal beaches and shallow sublittoral sands and its implications for an inshore ecosystem in Western Australia. Estuarine, Coastal and Shelf Science 21, 91–104.
McLachlan, A., Jaramillo, E., 1995. Zonation on sandy beaches. In: Ansell, A.D., Gibson, R.N., Barnes, M. (Eds.), Oceanography and Marine Biology: An Annual Review, vol. 33. UCL Press, pp. 305–335.
McLachlan, A., Jaramillo, E., Donn Jr., T.E., Wessels, F., 1993. Sandy beach macrofauna communities and their control by the physical environment: a geographical comparison. Journal of Coastal Research 15, 27–38.
McLachlan, A., Turner, I., 1994. The interstitial environment of sandy beaches. Marine Ecology-Pubblicazioni della Stazione Zoologica di Napoli I 15, 177–211.
Meyer-Arendt, K.J., Dorvio, A., 2001. Recreational development and shoreline modification along the north coast of Yucatan, Mexico. Tourism Geographies 3, 87–104.
Molser, A.E., Witherington, B.E., 2002. Documented effects of coastal armoring structures on sea turtle nesting behaviour. Proceedings of the 20th Annual Symposium on Sea Turtle Biology and Conservation, 304–306.
Moreira, J., Chapman, M.G., Underwood, A.J., 2006. Seawalls do not sustain viable populations of limpets. Marine Ecology-Progress Series 322, 179–188.
Pinn, E.H., Mitchell, K., Corkill, J., 2005. The assemblages of groynes in relation to substratum age, aspect and microhabitat. Estuarine, Coastal and Shelf Science 62, 271–282.
Polome, P., Marzetti, S., van der Veen, A., 2005. Economic and social demands for coastal protection. Coastal Engineering 52, 819–840.
Rice, C.A., 2006. Effects of shoreline modification on a northern Puget Sound beach: microclimate and embryo mortality in surf smelt (*Hypomesus pretiosus*). Estuaries and Coasts 29, 63–71.
Runyan, K., Griggs, G.B., 2003. The effects of armoring seacliffs on the natural sand supply to the beaches of California. Journal of Coastal Research 19, 336–347.
Scavia, D., Field, J.C., Boesch, D.F., Buddemeier, R.W., Burkett, V., Cayan, D.R., Fogarty, M., Harwell, M.A., Howarth, R.W., Mason, C., Reed, D.J., Royer, T.C., Sallenger, A.H., Titus, J.G., 2002. Climate change impacts on US coastal and marine ecosystems. Estuaries 25, 149–164.
Schlacher, T.A., Dugan, J., Schoeman, D.S., Lastra, M., Jones, A., Scapini, F., McLachlan, A., Defeo, O., 2007a. Sandy beaches at the brink. Diversity and Distributions 13, 556–560.
Schlacher, T.A., Schoeman, D.S., Lastra, M., Jones, A., Dugan, J., Scapini, F., McLachlan, A., 2006. Neglected ecosystems bear the brunt of change. Ethology Ecology & Evolution 18, 349–351.
Schlacher, T.A., Thompson, L., Price, S., 2007b. Vehicles versus conservation of invertebrates on sandy beaches: mortalities inflicted by off-road vehicles on ghost crabs. Marine Ecology-an Evolutionary Perspective 28, 354–367.
Slott, J.M., Murray, A.B., Ashton, A.D., Crowley, T.J., 2006. Coastline responses to changing storm patterns. Geophysical Research Letters 33, L18404.
Speybroeck, J., Bonte, D., Courtens, W., Gheskiere, T., Grootaert, P., Maelfait, J.P., Mathys, M., Provoost, S., Sabbe, K., Stienen, E.W.M., Van Lancker, V., Vincx, M., Degraer, S., 2006. Beach nourishment: an ecologically sound coastal defence alternative? A review. Aquatic Conservation – Marine and Freshwater Ecosystems 16, 419–435.
Stephenson, G., 1999. Vehicle impacts on the biota of sandy beaches and coastal dunes – a review from a New Zealand perspective. Department of Conservation, Wellington, New Zealand, 48 pp. ISBN 0-478-21847-8.
Underwood, A.J., 1997. Experiments in Ecology: Their Logical Design and Interpretation Using Analysis of Variance. Cambridge University Press, New York, 504 pp.

Attachment #17

Brian Trautwein

From: David Revell [D.Revell@pwa-ltd.com]
Sent: Monday, June 29, 2009 3:09 PM
To: Brian Trautwein
Subject: RE: when did the erosion wave stop affecting GB Park?

Erosion wave passed in January 2005. Even weathering two large storms in 2007 with only mild overtopping. Widths are nice and wide currently, and the reduction in grooming likely leading to increases in sediment accumulation…

=-)d.

DAVID REVELL, PHD.
SENIOR ASSOCIATE
PWA | Philip Williams & Associates, Ltd.
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, CA 94108
T 415 262.2300 | F 415 262.2303
D 415 262.2312 | C 503 577.4515
d.revell@pwa-ltd.com | www.pwa-ltd.com

From: Brian Trautwein [mailto:btraut@edcnet.org]
Sent: Monday, June 29, 2009 2:30 PM
To: David Revell
Subject: when did the erosion wave stop affecting GB Park?

Hi Dave,
Has it been 2 or more years since any of the park eroded?
It is not continuing to erode today, right?
thx

Brian Trautwein,
Environmental Analyst
Environmental Defense Center
906 Garden Street
Santa Barbara, CA 93101
btraut@edcnet.org
(805) 963-1622 X 108
(805) 962-3152 fax

RECEIVED
JUL 2 2009
CALIFORNIA
COASTAL COMMISSION
SOUTH CENTRAL COAST DISTRICT

Attachment #18

PWA
PHILIP WILLIAMS & ASSOCIATES, LTD.
ENVIRONMENTAL HYDROLOGY
550 Kearny Street, Suite 900
San Francisco, California 94108-2404
tel 415.262.2300 fax 415.262.2303
www.pwa-ltd.com

MEMORANDUM

Date:	July 1, 2009
To:	California Coastal Commission Attention: Steve Hudson 89 S. California Street, Suite 200 Ventura, CA 93001
From:	David Revell, PhD.
PWA Project #:	1940.01
PWA Project Name:	Goleta Beach Park Reconfiguration Alternative
Subject:	Goleta Beach Permeable Pile Groin Application No. 4-08-006
Copy(ies) To:	Brian Trautwein, Environmental Defense Center Scott Bull, Surfrider Foundation

---

The purpose of this memo is to provide a background summary on the Goleta Beach Pile Groin Project, summarize recent scientific research, identify impacts and primary deficiencies in the modeling and construction of the proposed groin alternative, and describe a Park Reconfiguration Alternative.

Background

- The County installed emergency revetments to protect Goleta Beach Park from erosion during winter storms in 2000 and 2002. The Coastal Commission extended the temporary permits in order to allow the County time to apply for CDPs for a longer-term solution. In January 2008 the County applied to the CCC for CDPs for a permeable pile groin collocated with Goleta Pier.

- Philip Williams and Associates was hired initially by the County in 2003-2005 during the stakeholder process to describe a range of alternatives including managed retreat; and then by EDC and Surfrider (2008-2009) to investigate options for protecting the beach and park.

- During the stakeholder process, several research questions were asked which led to subsequent research which answered several of these key questions.
  - What are the long term trends of shoreline change at Goleta Beach?
  - What caused the more erosion at Goleta Beach between 1999 and 2004?

- Research addressing these questions is in publication in scientific journals and technical reports. Most of this research, submitted to the County during the Draft EIR comment period, has apparently been ignored in the development of the proposed groin alternative and the GENESIS modeling supporting the proposed project.

Science:

- The beach at Goleta Beach County Park does not have a shoreline erosion trend – historically beach widths have fluctuated over time (Revell and Griggs 2006).

- Beach width fluctuations appear controlled by the Pacific Decadal Oscillation (PDO), a 20+ year climate cycle which regulates the intensity of El Niños and La Niñas. Calmer La Niña-like conditions result in wider beaches and El Niño energetic years result in narrower beaches (Revell and Griggs 2006; Adams *et al*. 2008, Adams and Inman 2009, Barnard *et al*.2009).

- Existing coastal armoring along Goleta Beach has significantly narrowed beach widths (Revell and Griggs 2006, Revell and Griggs 2007, Barnard *et al*. 2009).

- Erosion that occurred at Goleta Beach was caused by an erosion wave which formed at updrift Sands Beach following the 1997-98 El Niño, affecting Goleta by 1999 through 2004, and eventually propagated downcoast, eroding beaches way down to the Santa Barbara Harbor through 2009 (Revell, Dugan, and Hubbard in press, personal comm., Karl Treiberg, Santa Barbara Harbor District).

- A conceptual model of beach behavior along the Santa Barbara coastline suggests that more stable beaches such as Goleta Beach store various volumes of sand (hereafter referred to as sand boxes). These sand boxes are connected by the alongshore movement of sand between the sand boxes as driven by waves. As each sand box fills, it traps sand. Once full, sand cascades downdrift making it available to the next sand box. When this cascading transport of sand is interrupted, or reduced, then the downdrift box closest to the impoundment begins to erode. Conversely as sand is moved around the impoundment, the downdrift boxes fill up again in the order that sand is received (PWA 2008, report to BEACON for RSM plan).

Permeable Pile Groin Alternative Impacts:

- Increasing the size of the Goleta Beach sand box by construction of the groin (if it is effective in widening the beach) will increase the amount of time that Goleta serves as a sand sink (trap) following erosion events. **This will increase the magnitude of future erosion waves (length of time and severity) and thus magnify downcoast beach and bluff erosion impacts.**

- To mitigate downcoast impacts associated with the increase size of the erosion waves, it is likely that another nourishment similar to the initial pre-fill volume 500,000 cy will be required with a potential for an additional 175,000 cy possibly needed to mitigate natural storm erosion as well.

- This volume of future nourishment is not included in the pile groin environmental review or long term project costs estimating (+$10.5M), bringing the 20 year estimate of the project to $20.1M.

- Increasing the pier piling density is likely to create a rip current co-located with the pier, creating a safety hazard for ocean recreational users and increasing risk to the County.

Deficiencies of the Permeable Pile Groin Modeling:

The groin project is supported by GENESIS modeling which is a one line numerical model that calculates longshore sediment transport and shoreline change as a result of sediment input and output as well as differences in waves. As noted below, this modeling is flawed. The modeling and PWA's evaluation of the modeling were peer-reviewed by Coastal Tech, Inc. which concurred with PWA's criticisms. The modeling deficiencies include:

- GENESIS modeling of the proposed alternative did not consider the fluctuations in sediment supply historically observed along Goleta Beach.

- GENESIS modeling of the proposed alternative only used 4 years of recorded waves, which did not include the wave variability associated with the PDO or even a significant El Niño event.

- The GENESIS model used Coal Oil Point as the updrift boundary. This headland is downdrift of Ellwood (Sands) Beach where the erosion wave which affected Goleta Beach formed.

- The GENESIS model assumed steady erosion of the shoreline at Goleta Beach as opposed to the episodic sediment pulses observed and documented in the system.

- The GENESIS model does not test for the performance of a specific structure, rather it examines, what happens if you reduce the alongshore sediment transport by 65%. It is not clear that the proposed alternative can actually reduce sediment transport by 65%.

- The GENESIS model does not include or evaluate the effect of the existing rock armored (jetty-like) ocean outfall pipe extending offshore from the wastewater treatment plant.

- The GENESIS model does not explicitly account for the initial "losses" of sand just after sand placement due to the constructed beach profile differing from the natural beach profile, sorting of beach sand and increased longshore transport. This implies that a greater volume of sand (greater than the 500,000 cubic yards) needs to be placed initially to achieve the beach widths modeled.

Park Reconfiguration Alternative:

The Park Reconfiguration Alternative makes use of recent research findings to create an alternative that will function within the coastal system of episodic pulses of sand and varying wave conditions.

- This alternative uses the same constraints and assumptions as directed by the County during the Stakeholder process and used in drafting the "managed retreat" alternative in the EIR– e.g. 20 year planning horizon, no changes to restaurant, and same level of parking and park amenities.

- A "coastal processes zone" which is based on the historic extent of erosion and beach width fluctuations was identified to encompass the likely most landward limit of future erosion.

- This alternative would relocate park infrastructure including one of several parking lots, two restrooms and utility lines from the "coastal processes zone" to other areas within the park. The restaurant, pier and associated buildings remain protected by the existing revetment.

- This alternative reasonably minimizes potential future erosion damage, allows natural beach fluctuations, optimizes the natural beach width, and avoids downcoast impacts.

- The Park Reconfiguration Alternative reduces the long term operations and maintenance costs due to the upgrade of facilities and park improvements

- The Park Reconfiguration alternative enhances the recreational experience by maximizing the lawn-beach interface (1900 feet) over the existing conditions (1035 feet).

- **The Park Reconfiguration Alternative creates a 1.3 acre buffer area that can be either lawn or sand as desired by the County.**

- This alternative avoids the FEIR Class 1 Significant recreational impacts (Impacts BS-REC-1 and 3) associated with pier and beach closures during groin construction and tuning and substantially reduces the FEIR Class I recreational impacts associated with closures during beach nourishment (Impact BS-REC-2).

- This proposed alternative is estimated to initially cost approximately $4.7M to construct as opposed to the permeable groin alternative estimate to initially cost about $8.7M. Including future nourishment and maintenance the Park Reconfiguration Alternative's 20-year cost is estimated at $8.4 million, compared to a 20-year cost estimate of $20.1M for the proposed groin alternative.