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Publications

- Now in Print: pages 1-5
- In press and online: page 6
- In press: page 6
- All publications to-date: http://www.piscoweb.org/outreach/pubs/publications

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Now In Print: Recently Published PISCO Scientific Contributions *(January-April 2007)*

- Barth, J. A., B. A. Menge, J. Lubchenco, F. Chan, J. M. Bane, A. R. Kirincich, M. A. McManus, K. J. Nielsen, S. D. Pierce, and L. Washburn. 2007. **Delayed upwelling alters nearshore coastal ocean ecosystems in the northern California current.** *Proceedings of the National Academy of Sciences* 104:3719-3724.

http://dx.doi.org/10.1073/pnas.0700462104

Abstract: Wind-driven coastal ocean upwelling supplies nutrients to the euphotic zone near the coast. Nutrients fuel the growth of phytoplankton, the base of a very productive coastal marine ecosystem [Pauly D, Christensen V (1995) *Nature* 374:255–257]. Because nutrient supply and phytoplankton biomass in shelf waters are highly sensitive to variation in upwelling-driven circulation, shifts in the timing and strength of upwelling may alter basic nutrient and carbon fluxes through marine food webs. We show how a 1-month delay in the 2005 spring transition to upwelling-favorable wind stress in the northern California Current Large Marine Ecosystem resulted in numerous anomalies: warm water, low nutrient levels, low primary productivity, and an unprecedented low recruitment of rocky intertidal organisms. The delay was associated with 20- to 40-day wind oscillations accompanying a southward shift of the jet stream. Early in the upwelling season (May–July) off Oregon, the cumulative upwelling-favorable wind stress was the lowest in 20 years, nearshore surface waters averaged 2°C warmer than normal, surf-zone chlorophyll-*a* and nutrients were 50% and 30% less than normal, respectively, and densities of recruits of mussels and barnacles were reduced by 83% and 66%, respectively. Delayed early-season upwelling and stronger late-season upwelling are consistent with predictions of the influence of global warming on coastal upwelling regions.

- Blanchette, C. A., and S. D. Gaines. 2007. **Distribution, Abundance, Size and Recruitment of the mussel, *Mytilus californianus*, across a major oceanographic and biogeographic boundary at Point Conception, California, USA.** *Journal Experimental Marine Biology and Ecology* 340:268-279.

http://dx.doi.org/10.1016/j.jembe.2006.09.014

Abstract: The Point Conception, California, USA region (hereafter PC) is one of the most important biogeographic and oceanographic discontinuities on the US west coast. Here we address how mesoscale oceanographic and environmental variability in the region around PC, CA may influence the distribution, abundance and size of the mussel *Mytilus californianus,* a competitively dominant species in rocky intertidal assemblages along the northeast Pacific. Strong upwelling and high wave exposure dominate the California coast north of PC, and weak, seasonal upwelling and warmer water temperatures are characteristic of the region south/east of PC. We hypothesized that the gradient in temperature, upwelling, and wave exposure around PC would greatly influence patterns of recruitment and abundance of mussels, potentially underlying large-scale differences in community structure. We evaluated these predictions by surveying intertidal community structure, mussel distribution, size, abundance and recruitment at a range of intertidal sites around PC. We found that intertidal communities north of PC were

dominated mainly by macrophytes, while mussels and barnacles were relatively scarce. Intertidal communities south of PC were dominated by mussels and barnacles, with a low abundance of macrophytes. Mussels were larger and mussel beds were more expansive and extended lower in elevation at sites ranging from north to south around PC. At northern sites, high abundances of sea star predators and elevated wave exposure effectively displaced the entire mussel zone upwards. We found no differences in the numbers of mussel recruits to sites around PC, suggesting that spatial patterns of mussel abundance were not driven by differential recruitment. These results suggest that unlike other well-studied systems, supply of benthic larvae does not underly the large-scale gradient in community structure around PC. We suggest that environmental conditions favorable to macroalgal growth north of PC, and conditions favorable to filter-feeder growth south of PC may underly mesoscale patterns of intertidal community structure in this region.

- Blanchette, C. A., B. Helmuth, and S. D. Gaines. 2007. **Spatial patterns of growth in the mussel, *Mytilus californianus*, across a major oceanographic and biogeographic boundary at Point Conception, California, USA.** *Journal Experimental Marine Biology and Ecology* **340**:126-148.

http://dx.doi.org/10.1016/j.jembe.2006.09.022

The Point Conception, California, USA region (hereafter PC) is one of the most important biogeographic and oceanographic discontinuities on the US west coast. Here we address how mesoscale oceanographic variability in the region around PC affects the growth of the competitively dominant species in the rocky intertidal assemblage: the mussel *Mytilus californianus*. Strong upwelling and high wave exposure dominate the California coast north of PC, and weak, seasonal upwelling and warmer water temperatures are characteristic of the region south/east of PC. We hypothesized that the oceanographic gradients in temperature, upwelling, wave exposure and productivity around PC would exert strong bottom–up influences on growth rates of mussels, potentially underlying large-scale differences in community structure around the PC region. We evaluated these predictions by measuring mussel growth rates across the PC region both in the intertidal and offshore on moorings. Intertidal mussels grew at much higher rates at sites south relative to north of PC and growth rates decreased in a gradient from south to north. The gradient in intertidal mussel growth around PC was uncorrelated with inshore concentrations of chlorophyll-a, and was most strongly correlated with the alongshore gradient in wave exposure and intertidal temperature. Mussels on moorings offshore from the intertidal sites grew at much higher rates than those in the corresponding intertidal areas, and mussel growth rates did not differ significantly among moored locations around PC. The gradient of increasing temperature from north to south among mooring sites was correlated with a decreasing gradient in productivity in the same direction, potentially contributing to equal and opposite effects on mussel growth at offshore moorings. This study suggests that environmental factors such as cold temperatures and high wave exposure contribute to the spatial pattern of decreasing mussel growth rates from south to north around PC, underlying large-scale patterns of community structure in this region.

- Cole, R. G., C. Syms, N. K. Davey, N. Gust, P. Notman, R. Stewart, C. Radford, G. Carbines, M. H. Carr, and A. G. Jeffs. 2007. **Does breathing apparatus affect fish counts and observations? A comparison at three New Zealand fished and protected areas.** *Marine Biology* **150**:1379-1395.

http://dx.doi.org/10.1007/s00227-006-0420-3

Abstract: Across three areas, open-circuit scuba (OC) and rebreather (RB) surveys produced similar results for the density and size distribution of fish species inside and outside marine reserves. At Tonga Island, more *Notolabrus celidotus* were counted with OC than with RB, independently of reserve status [log-scale response ratio of OC/RB (RR) = 0.7]. At Long Island, differences in abundance of *Parapercis colias* between sampling methods were small at reserve sites (RR = −0.1), but more were counted with scuba than with RBs at fished sites (RR = 0.5). RRs for *Pagrus auratus* were −1.0 in fished areas and 0.3 in the reserve at Leigh. We also sampled each site using a baited video system (BUV) to establish whether diver-transects sampled the full size range of target species. Most fish in BUV views were *Parapercis colias* at Long Island (97%), and Pagrus auratus at Leigh (77%). Size structures of *Parapercis colias* were similar among all three sampling methods within reserve and fished areas at Long Island (max. chi-squared distance = 0.11). BUV samples for *Pagrus auratus* at Leigh did not detect a prominent juvenile size class observed by divers, but size-frequency distributions of OC, RB, and BUV corresponded at sizes beyond 15 cm TL (max. chi-squared distance = 0.08). To investigate the effects of diver sound on fish behaviour at Long Island, we also compared fish activity when divers with RBs or scuba were present, when the sound of each breathing apparatus was replayed underwater, when no divers were present and no sound was replayed, and when bait was provided, within the reserve only. The lowest number of fish visits to the focal area (mean of 3.0 per 10 min) for *Parapercis colias* occurred with RB divers present. Maximum abundances of *Parapercis colias* in all speaker treatments averaged 4.1 per 10 min, whereas with scuba divers present maximum abundances were 5.7,

and with baits the average was 38.0 per 10 min.

- Hays, C. 2007. **Adaptive phenotypic differentiation across the intertidal gradient in the alga *Silvetia compressa*.** *Ecology* **88**:149-157.

Abstract: Populations of intertidal species span a steep environmental gradient driven by differences in emersion time. In spite of strong differential selection on traits related to this gradient, the small spatial scale over which differences occur may prevent local adaptation, and instead may favor a single intermediate phenotype, or nongenetic mechanisms of differentiation. Here I examine whether a common macroalga, *Silvetia compressa*, exhibits phenotypic differentiation across the intertidal gradient and evaluate how local adaptation, developmental plasticity, and maternal effects may interact to shape individual phenotypes. Reciprocal transplants of both adults and embryos showed a "home-height advantage" in two of the three populations tested. In laboratory trials, the progeny of upper-limit individuals survived exposure to air significantly better than lower-limit progeny from the same population. I compared the emersion tolerance of full-sib families generated from gametes produced in the field to those produced under common garden conditions. The relative advantage of upper-limit lineages was robust to maternal environment during gametogenesis; this pattern is consistent with genetic differentiation. The possible role of local adaptation has historically been ignored in studies of intertidal zonation. In *S. compressa*, phenotypic differentiation may have important consequences for vertical range, both within and among sites.

- Hofmann, G.E. and S.P. Place. 2007. **Genomics-enabled research in marine ecology: Challenges, risks and pay-offs.** *Marine Ecology Progress Series* 332: 249-255.

http://www.int-res.com/abstracts/meps/v332/p249-255/

Abstract: Genomics-enabled applications are becoming increasingly common in conjunction with research in marine ecology. In this Theme Section, we review the success of cases where techniques used to profile gene expression have been used to gain new insight into 3 areas of research: symbioses in marine invertebrates, physiological responses to environmental conditions, and examining the determinants of species-range boundaries in marine ecosystems. In addition, we briefly discuss the challenges facing new practitioners of these techniques, including an overview of essential equipment to conduct research in ecological genomics.

- Lester, S. E., E. D. Tobin, and M. D. Behrens. 2007. **Disease dynamics and the potential role of thermal stress in the sea urchin, *Strongylocentrotus purpuratus***. *Canadian Journal of Fisheries and Aquatic Sciences* 64 314-323.

http://pubs.nrc-cnrc.gc.ca/cgi-bin/rp/rp2_abst_e?cjfas_f07-010_64_ns_nf_cjfas2-07

Abstract: Evidence from field and laboratory data indicates that warmer ocean temperatures likely play a critical role in the disease dynamics of intertidal populations of the sea urchin, *Strongylocentrotus purpuratus*. Urchin populations along the west coast of North America have experienced numerous disease epidemics in the past several decades, and yet little is known about disease transmission, the geographic extent, or contributing factors to these outbreaks. In this study, we examine disease in Pacific *Strongylocentrotus* urchins over a broad geographic range with repeated sampling. We suggest that what has been assumed to be a single disease might be two distinct diseases presenting two disparate pathologies. Both potential pathologies were extremely rare or absent north of Point Conception, California, in a region associated with strong upwelling and cooler water temperatures but were common at warmer sites in southern California and northern Baja California, Mexico. Furthermore, during the survey period, disease prevalence at some of the study sites was positively correlated with sea surface temperatures as estimated from satellite data, leading us to hypothesize that heat stress may increase urchin susceptibility to disease. In experimentally elevated water temperatures, diseased individuals had significantly larger lesions and a significantly lower gonadal index, which could have important implications for urchin population dynamics.

- Miller, L. P., and B. Gaylord. 2007. **Barriers to flow: the effects of experimental cage structures on water velocities in high-energy subtidal and intertidal environments.** *Journal Experimental Marine Biology and Ecology* **344**:215-228.

http://dx.doi.org/10.1016/j.jembe.2007.01.005

For decades, marine ecologists have used cages as biological enclosure or exclosure devices to manipulate movement, growth, and survival of organisms. The ability to control the densities of focal organisms makes these

structures a powerful tool. However, cages can often produce artifacts that influence the outcome of experiments. Although a subset of these artifacts have been examined previously, the effects of cages on water motion have not been adequately addressed from a quantitative standpoint, especially in high-flow environments. We targeted this data gap by explicitly measuring the fractional degree of velocity reduction inside a variety of experimental cage structures across flow conditions spanning those typical of wave-swept shallow subtidal and intertidal zones. Cages decreased velocities inside by up to 47% and reduced high-energy impact forces by more than 40%. Associated cage controls, employed to mimic physical effects of cages without interfering with organism movement, often had effects on water flow similar to those of cages. However, the nearly half an order of magnitude change in velocities inside cages and their controls reveals the need to be vigilant in considering potential artifacts, especially those tied to secondary biological interactions. These artifacts may be reduced by maximizing mesh size, employing large plot sizes and low profile structures, using cage controls that best mimic effects of the full cage, and monitoring cage controls to avoid the establishment of high-density "consumer hotels" within them. Using such approaches, researchers can minimize experimental biases and simplify the explanation of experimental results.

- Philips, N. E. 2007. **High variability in egg size and energetic content among intertidal mussels.** *Biological Bulletin* **212**:12-19.

http://www.biolbull.org/cgi/content/abstract/212/1/12

Maternal investment is a fundamentally important parameter in life-history theory and models, yet the scales at which it varies (among individuals vs. among populations) is rarely reported. In this study, variability in attributes of eggs and early larvae of *Mytilus californianus* was examined from four sites spanning Point Conception, California, in June and September 2001. The effects of female, site, and month were examined for the following variables: egg volume (µl), egg energy content (µg carbon per egg), and initial larval size (µm). The only significant effect on both egg traits was that of female. Females differed by up to 57% in mean egg volume and 116% in mean egg energetic content. Although there were significant effects of rearing environment, female, site, and month on initial larval size, variability in larval length was small compared to the egg traits. Mean larval length was maximally 11% different among females. Neither female body weight nor length was correlated to mean offspring traits, and there were also no significant relationships between egg traits and initial larval size. The primary source of variation in maternal investment in this system appears to be among individual females rather than over space or time.

- Raimondi, P., R. Sagarin, R. F. Ambrose, C. Bell, M. George, S. F. Lee, D. Lohse, C. M. Miner, and S. N. Murray. 2007. Consistent **Frequency of Color Morphs in the Sea Star *Pisaster ochraceus* (Echinodermata: Asteriidae) across Open-Coast Habitats in the Northeastern Pacific.** *Pacific Science* **61**:201-210.

The sea star *Pisaster ochraceus* (Brandt, 1835) is among the most conspicuous members of northeastern Pacific rocky-shore fauna due to its dramatic color variation, ranging from bright yellowish orange to brown to deep purple. Despite a large body of ecological and developmental biology information on *P.ochraceus*, few studies have rigorously examined color patterns or their causes across its geographic range. We used thousands of observations of sea star color and size taken from southern California to northern Oregon to show that the frequency of orange sea stars is approximately 20% with little variation across a broad latitudinal band. However, the frequency of orange sea stars in a population increases with the size of the animals in most populations. We consider several alternative hypotheses for these color patterns but find that the most parsimonious explanation is that adult color is a selectively neutral genetic trait that expresses itself ontogenetically. These novel findings point to the need for renewed study of the basic biology of this key ecological species.

- White, J. W., and B. I. Ruttenberg. 2007**. Discriminant function analysis in marine ecology: some oversights and their solutions.** *Marine Ecology Progress Series* **329**:301-305.

http://www.int-res.com/abstracts/meps/v329/p301-305/

Abstract: Marine ecologists commonly use discriminant function analysis (DFA) to evaluate the similarity of distinct populations and to classify individuals of unknown origin to known populations. However, investigators using DFA must account for (1) the possibility of correct classification due to chance alone, and (2) the influence of prior probabilities of group membership on classification results. A search of the recent otolith chemistry literature showed that these two concerns are sometimes ignored, so we used simulated data sets to explore the potential pitfalls of such oversights. We found that when estimating reclassification success for a training data set, small sample sizes or unbalanced sampling designs can produce remarkably high reclassification success rates by chance alone, especially when prior probabilities are estimated from sample size. When using a training data set to

classify unknown individuals, maximum likelihood estimation of mixture proportions and group membership afforded up to 20% improvement over DFA with uninformative priors when groups contributed to the sample unequally. Given these results, we recommend the use of (1) randomization tests to estimate the probability that reclassification success is better than random, and (2) maximum likelihood estimation of mixture proportions in place of uninformative priors.

In Press and Available Online

- Osovitz, C. J. and G. E. Hofmann. In press. **Marine Macrophysiology: Studying physiological variation across large spatial scales in marine systems.** *Comparative Biochemistry and Physiology.*

http://dx.doi.org/10.1016/j.cbpa.2007.02.012

A new approach toward understanding marine ecosystems has emerged through the integration of ecological physiology and macroecology. This multidisciplinary approach, titled here marine macrophysiology, facilitates unique insight into the foundation of macro-scale ecological patterns, such as biogeographic distributions, via examination of functional attributes of marine organisms across large spatial scales. For example, these broad-scale physiological inquiries confer the ability to directly assess the abundant-center hypothesis (aka Brown's principle) which proposes that species have decreased performance toward their ranges edges. By extension, the marine macrophysiological perspective also stands to clarify our understanding of more complex macro-scale phenomena such as biological invasions, the design of marine protected areas, and species' responses to global climate change. In this article, we review recent marine macrophysiology research and offer insights into future directions for this emerging field.

In Press

Barnett-Johnson, R., C. B. Grimes, C. F. Royer, and C. J. Donohoe. **Identifying the contribution of wild and hatchery Chinook salmon to the ocean fishery using otolith microstructure as natural tags.** *Canadian Journal of Fisheries and Aquatic Sciences.*

Freidenburg, T. L., B. A. Menge, P. M. Halpin, M. Webster, and A. Sutton-Grier. **Cross-scale variation in top-down and bottom-up control of algal abundance.** *Journal of Experimental Marine Biology and Ecology*.

Johnson, D. W. **Habitat complexity modifies the recruitment dynamics of a temperate reef fish**. *Ecology*.

Kellner, J.B., I. Tetreault, S.D. Gaines, and R.M. Nisbet. **Fishing-the-line near marine reserves in single and multi-Species fisheries.** *Ecological Applications*.

Lester, S. E., S.D. Gaines, S.D, and B.P. Kinlan. **Reproduction on the edge: large-scale patterns of individual performance in a marine invertebrate.** *Ecology.*

Martone, P. T. **Kelp versus coralline: cellular basis for mechanical strength in the wave-swept seaweed *Calliarthron* (Corallinaceae, Rhodophyta).** *Journal of Phycology*.

Miller, L. P., M. J. O'Donnell, and K. J. Mach. **Dislodged but not dead: survivorship of a high intertidal snail following wave dislodgement.** *Journal of the Marine Biological Association of the United Kingdom*.

Pfeiffer-Hoyt, A., M. McManus, P. Raimondi, and Y. Chao. **Dispersal of barnacle larvae along the central California coast: A modeling study.** *Limnology and Oceanography.*

Philips, N. **A dramatic gradient in the reproductive output of *Mytilus californianus* from sites spanning Point Conception, California**. *Marine Biology.*

White, J. W., and R. R. Warner. **Safety-in-numbers and the spatial scaling of density dependence in a coral reef fish.** *Ecology.*