Marine Population Connectivity and Dependency along the California Coast

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A long-standing question in marine ecology remains: From where does the next generation of fish and shellfish originate? Answering this question is challenging because nearly all the marine fish and invertebrate species living along coastlines – rockfish, kelpbass, halibut, grouper, snapper, lobster, crab, urchin, abalone, clams and thousands of others – release microscopic larvae into the open ocean. Those larvae then disperse for weeks (abalone) to months (rockfish) to nearly a year (lobster) before settling back into coral reefs and kelp forests. They are too small and they travel too far to be tracked directly. The extent to which the next generation of fish in your local kelp forest is from elsewhere (that is, they were spawned by parents living in other kelp forests, and then dispersed here as larva) means that replenishment of your local reef is dependent on sustainable management of the other reefs. Overall, understanding these patterns of "connectivity" and "dependency" among reefs is critical for making smart decisions on how to best protect, fish and in general manage our coastlines.

My marine ecology laboratory at Cal Poly is trying to figure out these patterns of connectivity along the Pacific Coast of North America. We are focusing our research on a predatory marine snail called Kellet's whelk, which we chose for four main reasons. Kellet's whelk is an emerging fisheries species (~100,000 whelk are harvested in California annually, up from nearly zero in the 1990s; Figure 1). Thus, it is of increasing economic value. Kellet's

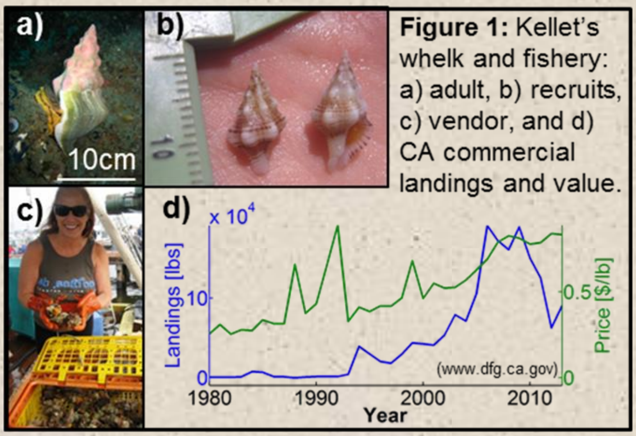


Figure 1: Kellet's whelk and fishery: a) adult, b) recruits, c) vendor, and d) CA commercial landings and value.

whelk's range spans the U.S.-Mexico border and a network of marine protected areas (no-fishing zones) in California, and the heart of its range lies in southern California, where pollution and fishing impacts can be intense (Figure 2).

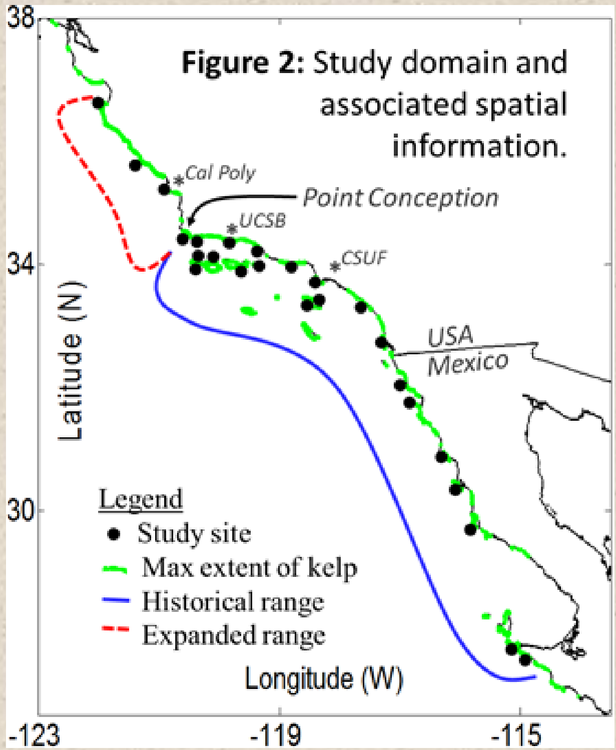
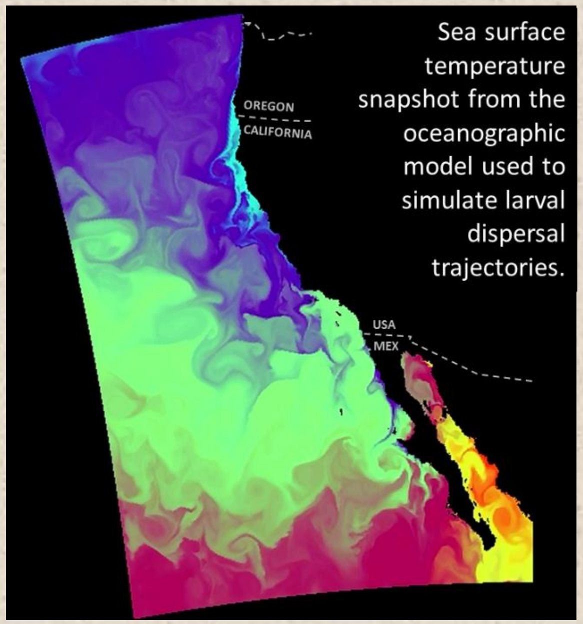


Figure 2: Study domain and associated spatial information.

Marine larvae

Understanding the patterns of connectivity and dependency within and among these areas can help guide international fisheries policy and sustainable marine management. For example, is California dependent on sources in Mexico? If yes, we'd better coordinate management between the two countries. Kellet's whelk also is expanding its range up the California coast. This range expansion is only a few decades old, and is hypothesized to be driven by a series of recent, strong El Niño years (e.g., in 1982 and 1997) that generated warm, north-flowing ocean currents along the central California coast able to support and deliver larvae from southern California to central California. Furthermore, climate models predict the frequency and intensity of El Niños along the California coast to increase in the future in response to climate change.

Because of the challenge in deciphering patterns of connectivity – in particular the impossibility of directly tracking the movement of marine larvae – we are tackling the problem using a variety of indirect tracking methods. We are assaying the genetic "signatures" of Kellet's whelk adult populations across the whelk's range as well as the individual genotypes of juvenile Kellet's whelk that have just recruited into the kelp forests. With this information we can then "assign" each recruit to the parental population that it matches genetically. Similarly, we also are assessing the chemical composition of the ocean at different locations along Kellet's whelk's range. Each area is slightly different in the concentration of lead, magnesium, barium and other elements in the seawater, and these differences get incorporated into the bones of the larvae before they disperse. We use this information to assign recruits to the source locations with sea water chemical properties matching those within the inner bone tissue of the recruit (that was developed when it was just a tiny larva prior to dispersing). Finally, we are using oceanographic models of the water currents along the coast to identify flows, eddies and upwelling patterns and use this information to predict where tiny larva released into the current will end up.



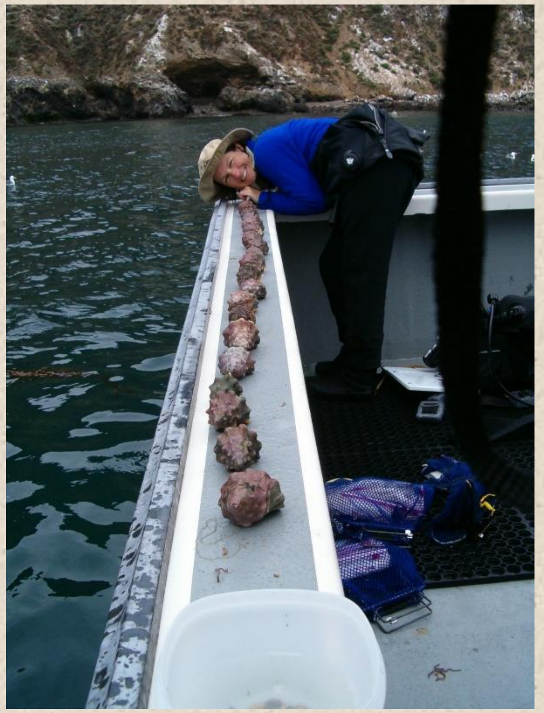
Sea surface temperature snapshot from the oceanographic model used to simulate larval dispersal trajectories.

Because this project requires expertise in not just marine biology, but also genetics, chemistry, oceanography and even statistics, our research team includes scientists from several universities: Cal Poly, CSU Fullerton, UC Santa Barbara and even distant labs at U Hawaii and S. Andrews University in Scotland.

Professors and undergraduate and graduate students at all of these schools are involved in the project, which is ongoing for several years (to determine how connectivity varies across years and in relation to El Niño conditions). The result is a project that is highly interdisciplinary and strongly student-centered. Our hope is that we will generate information useful for understanding and sustainably managing coastal marine ecosystems. Additionally, our ambition is that this multi-faceted project will also train the next generation of scientists with the knowledge and skills needed for tackling 21st century problems in marine ecology, conservation and management.

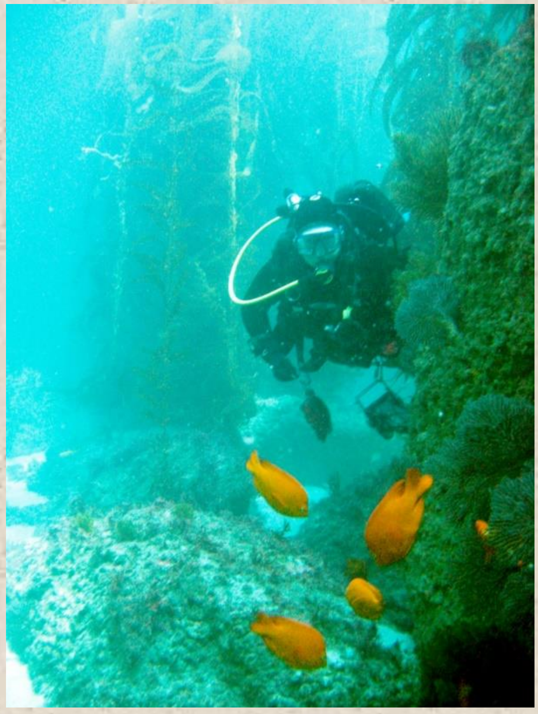
Kellet's whelk. The orange foot muscle can be quite tasty.

Professor Crow White (Cal Poly) diving a kelp forest in Baja, California, Mexico.



Professor Danielle Zacherl (CSU Fullerton) with a row of adult Kellet's whelk.

Point Conception. Historically, Kellet's whelk's northern range boundary ended here. But, recently, the species has expanded its range up to Monterey Bay.



Professor Alison Haupt (CSU Monterey Bay) diving a research site on Catalina Island, Garibaldi fish in the foreground.

Professor Alison Haupt (CSU Monterey Bay) getting ready to dive a kelp forest in Pt. Lobos State Park.

Kellety's whelk female laying egg capsules, each of which contains more than 1,000 larvae that will hatch and then disperse in the open-ocean for two months before settling back into kelp forest reefs.

Undergraduate and graduate student researchers Julie Hopper (UC Santa Barbara) and Sara Simmonds (CSU Fullerton) at a study site on Catalina Island.