THE SKIMMER ON MARINE ECOSYSTEMS AND MANAGEMENT

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The Links between Urban and Marine Ecosystems: Balancing the Sustainability of Coastal Cities and Their Adjacent Seas

For the first time in human history, more than half of the world's population now lives in cities, and each year tens of millions more people become city dwellers through births and migration. We have become an urban species.

What does this have to do with marine ecosystems? Most of the world's urban population is coastal. According to the Millennium Ecosystem Assessment (www.millenniumassessment.org), for example, two-thirds of the world's largest cities are on coasts. Coastal cities occur because that is where ecosystem services are often abundant. The adjacent seas supply food, allow for transportation and trade, carry away wastes, and so on.

Although the focus of marine ecosystem-based management is often on marine agencies and uses (e.g., how should we manage fisheries? where should we site offshore energy facilities?), the solutions to at least some of our oceans' ills start in our cities. Urban runoff and wastewater pollute coastal seas. Poorly planned urban development results in lost wetlands and other coastal ecosystems. Inefficient transportation and energy policies contribute to global warming and its associated ocean impacts, like acidification and coral bleaching.

Half a decade ago, former mayor Jeremy Harris of Honolulu posed a challenge to his fellow coastal mayors. Threatened oceans, he said, are an urban problem - the result of unsustainable urban development. The fate of the world's oceans therefore rests in the hands of city governments. Cities should be viewed and managed as urban ecosystems, he said, and should be modeled after natural ones. Integrating urban policies for land use, transportation, energy, and more - all of which are interrelated, after all - will lead to greater sustainability both for cities and their adjacent seas. (Harris's challenge, called *Saving Our Oceans*, is available at www.gdrc.org/oceans/Cities%20and%20Oceans%20PDF.doc.)

Sustainable oceans are good for coastal cities. In turn, sustainable cities can be good for oceans. Getting to that balancing point is the challenge. How do we ensure the ecosystem services provided by seas continue to be available to the urban systems that need them? Here, MEAM talks with experts who manage or study urban ecosystems about the challenges facing us today.

A. Restoring an inland sea next to a high-growth urban environment: Puget Sound

Puget Sound, an inlet of the Pacific Ocean in the northwestern US state of Washington, is not a healthy ecosystem. Swimming beaches and shellfish beds are contaminated and closed. Nearly 60% of Puget Sound's wetland habitat has been lost to development. Populations of salmon that once numbered in the millions now face extinction. The Sound's resident orca whales carry some of the world's highest levels of man-made chemicals in their bodies.

At the same time, the human population in coastal Seattle and other municipalities in the region is burgeoning. In just the past 20 years, the population in the Puget Sound watershed has grown by nearly 40%, from 2.7 million people to 4.4 million, and that is expected to jump to 5.1 million by 2020. Direct links can be drawn between the region's increase in population (in urban but also suburban and rural areas) and the decline of its marine ecosystem, particularly due to runoff, insufficient wastewater management, and unsustainable coastal development.

In an aggressive and ambitious effort to stop and reverse that decline, the state government created the Puget Sound Partnership: an inter-agency and multistakeholder initiative to address several stressors on Puget Sound (www.psp.wa.gov). The PSP released its latest two-year Action Agenda in August 2012, providing an updated blueprint for restoring the Sound's health by 2020 (www.psp.wa.gov/action_agenda_2011_update_home.php).

Anthony Wright is the PSP executive director.

In overseeing the PSP - one of the largest ecosystem restoration projects in the country - what are the main management challenges you face?

Anthony Wright: When it comes to managing the Puget Sound Partnership, there is the management and oversight of the agency itself and its defined tasks, such as coordinating advisory boards, developing plans, and creating reports that reflect a large and diverse stakeholder group. But it is not just about managing an agency or managing a project. It's about understanding and facilitating the actions of many people to move in a common direction. It's about creating a mass movement by removing obstacles and getting down to the business of Puget Sound recovery.

That recovery can incorporate behavior change, policy change, efforts by individuals and organizations, actual cleanup, or other activities. We are working with a lot of different partners: not just state and federal agencies, but also tribes, NGOs, businesses, and individuals. We find people and organizations and help them fill roles in that common direction.

The Action Agenda makes a point of saying that the PSP does not aspire to restore Puget Sound to its condition prior to European settlers (i.e., prior to 1850). In that light, and in light of the continued population growth that the region is expected to have, would you consider it a success simply to not allow the ecosystem condition to worsen beyond the current state?

Wright: We would not consider it a success merely to stop the decline of the ecosystem. The Partnership has developed statements of our interests for the future of the

Puget Sound ecosystem. These 19 targets for ecosystem recovery describe achievable, results-oriented conditions for the year 2020. Most of our targets specify conditions that are substantially improved from the current situation:

- Species such as Chinook salmon and orcas need to be on a path to recovery.
- Key contributors to the food web, like herring, should be recovered to levels seen in previous decades (but not back to 1850) to provide greater assurance that top predators (such as Chinook, orcas, marine birds) will be viable into the future.
- Habitats need to be stabilized to reflect a balance between ecological interests and services for people: such as to maintain forest cover into the future, increase functioning habitats in floodplains and estuaries, increase the extent of eelgrass, and improve the habitat condition of streams as measured by their insect communities.
- Water quality needs to improve to support aquatic life and human uses: our targets specify improvements needed for toxics in fish, marine sediment quality, freshwater quality, dissolved oxygen in marine waters, shellfish beds, and swimming beaches. The targets for shellfish beds and swimming beaches are focused on ensuring a future where people's health is better served by a recovered Puget Sound.

An older and perhaps more widely known inland sea restoration project is the Chesapeake Bay Program, on the East Coast of the US (www.chesapeakebay.net). Despite significant efforts and funding, the Chesapeake program is struggling to meet its cleanup goals. In what ways is the PSP different from the Chesapeake Bay Program?

Wright: Compared to Puget Sound, Chesapeake Bay has a more concentrated focus on a single type of ecosystem stress - that posed by nutrients [primarily from upstream farms]. Their cleanup goals are largely focused on reducing nutrient inputs and, yes, they have had trouble meeting their goals. This is worrisome for us here in Puget Sound because we have identified a complex suite of stressors that we believe are impacting the system, but haven't singled out a focal area as has been done in Chesapeake Bay. So we have to make progress on several fronts.

As far as how we make sure to be "more successful", well, nobody has done this with great success in a large complex ecosystem with many stresses. But we think we have some advantages. One is governance: we are a single state, not several states like Chesapeake Bay, although we do share an international boundary with Canada and have a number of treaty tribes [autonomous indigenous populations]. Having a single state government that is consistently focused on the environment, and aware that a healthy environment helps support a strong economy, is a big plus. We should note that the tribes and Canada are similarly focused on having a healthy environment. Also, while it is a complex problem set for us, we are attacking it earlier in the decline than the Chesapeake. We think we have gotten to work on our system comparatively sooner, given the size of the systems involved in proportion to the surrounding human population and associated degradation of the system. The farther gone an ecosystem is, the more difficult it is to bring it back to a desirable state.

Probably the biggest keys to our success moving forward are: 1) to honestly describe the level of effort that will be needed to do the work, and to sustainably provide the resources to undertake those efforts, and 2) to monitor and understand how the system is responding to management and policy decisions, and to similarly resource that effort. The first requires that we tackle the problem with the scope of effort needed, and the second will allow us to provide a better scientific basis for the work as we go along. Overall, we have a scientific understanding right now that allows us to develop a plan, but we are fully aware that our understanding is weak in several areas. By actually assessing the system (in addition to the modeling and laboratory experimentation that we currently conduct), we think we will learn enough to address those weaknesses.

For more information:

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The Puget Sound Partnership's biannual *State of the Sound* report, recently updated, is available at www.psp.wa.gov/sos.php

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B. Sea level rise and the future of an iconic city: Venice

Of all the coastal cities in the world, perhaps the one most indelibly linked to its marine environment is Venice. Located in the Venice Lagoon along the northwestern Adriatic Sea, Venice comprises more than 100 islands separated by the city's famous canals. It has been a trade center for nearly 1000 years, and the city and its lagoon are a UNESCO World Heritage site.

The link between sustainable cities and sustainable seas does not only involve reducing urban impacts on adjacent waters. Seas may also impact their adjacent cities. Venice, for example, is now in severe danger of inundation, owing to expected sea level rise (up to 2 mm per year in the region) and the increasing frequency of flooding events in the city, both consequences of climate change. The city has an average elevation of less than one meter above mean sea level. (To make matters worse, land in the lagoon is also gradually subsiding at rates varying from <1 mm/year to 5 mm/year, depending on local differences in subsoil characteristics and human activities. The city's historic center, though, is presently stable in terms of subsidence.)

Federica Rizzetto is a geomorphologist at the Institute of Marine Sciences for Italy's National Research Council. She studies the Venice Lagoon.

Venice is primarily addressing the threat of flooding by installing a floodgate system: the multi-billion-euro Modulo Sperimentale Elettromeccanico (MOSE) system, which is set for completion in 2016. The floodgates will isolate the Venice Lagoon from the Adriatic during high tide events. Would you say that floodgates provide an ideal, long-term management solution to the problem of sea level rise for Venice?

Federica Rizzetto: MOSE is a floodgate system projected to protect the Venice Lagoon from becoming inundated with water from the sea during tides higher than 110 cm above mean sea level. In the last century, a general increase of frequency and magnitude of high tides has occurred, more evident since the mid-1950s. The impact of high tides on the lagoon environment and the city has been magnified by the increasing relative sea level rise.

MOSE was proposed in the 1980s and projected taking into account rates of relative sea level rise lower than those calculated in the last years by the Intergovernmental Panel on Climate Change (IPCC). Consequently, if the new IPCC scenario is correct, this solution would not be sufficient to preserve Venice and its lagoon from high waters and sea level rise in the long term.

What do you think Venice will look like 100 years from now?

Rizzetto: A global relative sea level rise of 18-59 cm is expected from 1990 to the 2090s, in addition to the effects deriving from melting of the ice sheets that cover Greenland and Antarctica (IPCC, 2007), but even higher rates of relative sea level rise have been predicted by other researchers. Consequently, 100 years from now Venice could be partially submerged unless a proper set of solutions is envisaged and applied. Moreover, the periods of lagoon "closure" [by the floodgates] may become more frequent and/or longer owing both to relative sea level rise and to the increased number of high tide events. As a result, the exchange of water, sediments, and marine organisms between the sea and the lagoon will be variably, perhaps irreversibly, modified, causing drastic changes in the lagoon ecosystem and morphology through time.

If you were to design a long-term, sustainable solution to help Venice address the threat of sea level rise, what would that program look like?

Rizzetto: The Venice Lagoon is a very vulnerable and sensitive environment. For this reason all the interventions aimed to preserve and protect it must be planned carefully by using a multidisciplinary approach. Furthermore, the possible effects and interactions of those interventions must be evaluated in the short and long term in order not to cause irreversible major damage. The solutions must also take into account the magnificent artistic and architectural heritage, which makes Venice a unique city in the world, and the presence of other important urban areas and economic activities in the littoral and the lagoon surroundings.

Consequently, it is difficult to identify only a single solution to save Venice and its territory. I think the best way to safeguard the lagoon is the application of multiple and complementary interventions, compatible with the environment and the related human activities and able to preserve, as much as possible, the morphological,

sedimentological, and ecological characteristics of the lagoon. In my opinion, restoration projects aimed to slow down the degradation of the lagoon morphology and to contrast erosion represent the most important condition to preserve the territory, as well as the raising of the quaysides and the lower margins of the urban areas.

For more information:

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C. Managing urban growth next to the Great Barrier Reef

The Cairns region of northeastern Australia has grown rapidly in recent decades. Located adjacent to two World Heritage sites - the Great Barrier Reef to the sea, and the Wet Tropics rainforest on land - Cairns has become a major tourism destination. Spurred by that industry, urban development has converted significant portions of Cairns' coastal ecosystems. Although a master plan for Cairns does provide some protection for biodiversity within the urban footprint, loss of ecologically significant habitats is expected to continue. Maintenance of reef water quality from runoff has also posed consistent challenges.

Iris Bohnet is a social ecologist with CSIRO, Australia's national science agency. She has studied the management of urban growth for Cairns, as well as management of reef water quality in the adjacent catchment.

If you designed an urban growth plan for Cairns that aimed purely to maximize sustainability for the Great Barrier Reef seascape, what would be the main elements of such a plan?

Iris Bohnet: To maximize environmental sustainability for the Great Barrier Reef, I would suggest that a growth plan for Cairns would need to include the protection of all remaining coastal habitats such as mangroves, coastal wetlands, and other low-lying habitats. Not only do these areas provide filter functions for potential non-point sources of pollution that may enter the Reef from the land (mainly agricultural land), but they also provide a buffer zone when considering climate change and the risk of sea level rise and tropical cyclones.

Could Cairns, or any coastal city, be managed in such a way to have a neutral or even net-positive impact on its adjacent marine ecosystem, theoretically?

Bohnet: In general, it is easier to manage pollution from urban areas (point sources) via treatment plants than it is to manage pollution from agricultural land (non-point sources). In terms of whether a coastal city can have a net-positive impact on the health of the adjacent marine ecosystem, I would say that in theory a city could have a minimal impact on its adjacent marine ecosystem if managed properly. However, I think we also need to consider the activities that the city's human population carries out on the Reef: how well those activities (like fishing, for example) are regulated.

If you were to design an urban growth plan for Cairns that aimed to *balance* sustainability for the Reef ecosystem with sustainable economic growth for the city, what would be the main elements of that plan?

Bohnet: I think as above, protection of coastal habitats is important not only for better protection of the Great Barrier Reef but also to be prepared for the risk of sea level rise. Therefore, one key element of a growth plan for coastal cities might be guidance for sea level rise planning. In other cities that do not have up-to-date wastewater treatment plants, it would also be a requirement to establish those.

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