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Oceanic Island Ecosystems

by Jan Hodder

Oceanic islands are important for a wide variety of organisms and they are crucial places for seabirds, which use them as sites to breed and raise their young. Seabirds nest on islands that are normally free from mammals that could eat them, their eggs, and their chicks. The presence of nesting seabirds has an effect on the island as seabird excrement, or guano, fertilizes the terrestrial, intertidal, and subtidal zones of the island.

In the mid 1800s, guano came to be prized as an agricultural fertilizer and as a source of saltpeter for gunpowder. In 1855, the U.S. learned of rich guano deposits on islands in the Pacific Ocean and Congress passed the Guano Islands Act to take advantage of these deposits. The Act gave U.S. citizens who discovered a source of guano the right to take possession of unclaimed land, and the entitlement to exclusive rights to the guano deposits. One hundred islands located throughout the world were claimed. We still see the legacy of the Guano Island Act today as some of the claimed islands, such as Midway, Jarvis and Howland Islands, have become part of the U.S. Fish and Wildlife Service National Wildlife Refuge System because they have large numbers of seabirds nesting on them.

Guano produced by the birds coats the trees and the vegetation. It does two things: adds nutrients to the island soils, the intertidal and the surrounding ocean water, and it kills the trees by reducing their ability to photosynthesize.
Photo by Jan Hodder

On a smaller scale we can see the impact of nesting seabirds by looking along the Pacific coast. In a few places on islands and coastal headlands double-crested cormorants build their nests in trees and the guano produced by the birds coats

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the vegetation. This coating kills the trees by reducing their ability to photosynthesize.

In the North Pacific the Aleutian Island chain is an important seabird nesting area with 29 species breeding there, together numbering 910 million individuals. These islands provide an interesting case study for how they can be impacted by the introduction of non-native mammals. Arctic foxes were introduced to four hundred of the Aleutian Islands as early as the mid-1700s for the purpose of fur farming. Seabirds formed an important prey resource for the foxes and this severely reduced the number of nesting birds on many islands. In 1949 the U.S. Fish and Wildlife Service initiated a fox removal program, and by 2004 foxes had been removed from almost all islands. Don Croll, a UC Santa Cruz scientist, and his colleagues published an article in *Science* in 2005 that studied how islands with foxes and few seabirds differed from islands without foxes. They found that fox-free islands were grass dominated whereas a mix of shrubs, forbs and grasses dominated islands with foxes. The difference in vegetation was a reflection of the lack of the nutrient rich guano input from seabirds nesting on the island. Islands with foxes had much lower soil fertility than those without foxes and high numbers of seabirds.

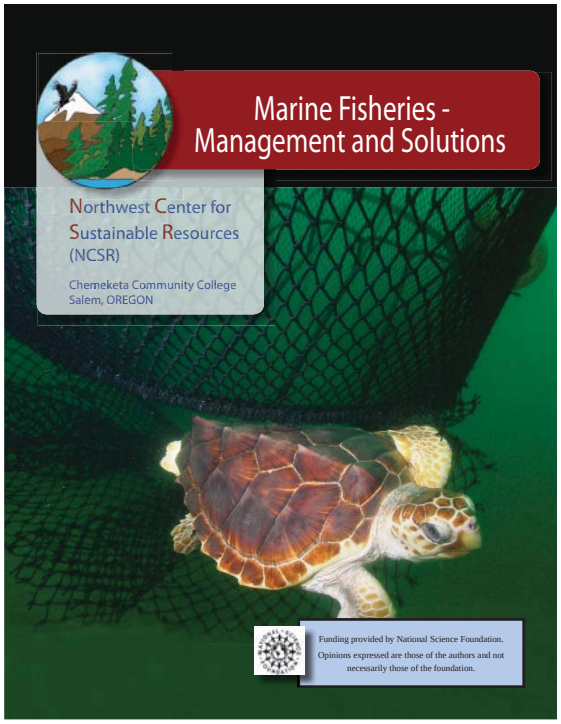
They also sampled stable isotope nitrogen ratios from a diverse group of terrestrial consumers, including a mollusk, an arachnid (spider), a dipteran (an insect), and two passerine birds - Lapland longspurs and song sparrows. Nitrogen ^{14}N and ^{15}N ratios (=delta ^{15}N) change with trophic level. All of the animals that they sampled from fox-free islands had a higher delta ^{15}N meaning that nitrogen is derived from higher trophic levels, in this case fish that birds feed on. These findings demonstrate that on fox-free islands the plants and animals that live there are strongly subsidized by marine derived nutrients brought to the island by sea birds.

Of the 328 seabird species currently recognized, the IUCN has determined that 102 are threatened or endangered and five are thought to be extinct. Invasive species, especially mammals, are the largest terrestrial threats to seabird breeding colonies. Rats that are commensal with humans have the largest impacts on seabird populations and are successful island invaders because of their generalist foraging strategy and high adaptability to novel environments. Because of human activities such as shipping, rats occur on over 90% of all island archipelagos. Rats prey on seabird eggs, chicks, and adults. Rats have also been responsible for the extinction and reduction of numbers of other island inhabitants such as small native mammals, land birds, and reptiles such as lizards, either because they directly eat the animals or they eat the eggs or young produced by the animals.

Carolyn Kurle and her colleagues at UC Santa Cruz showed in a paper published in the 2008 *Proceedings of the National Academy of Sciences of the U.S.* that introduced rats have several indirect effects on the community composition of islands. Norway rats introduced to the Aleutian Islands eat the chicks of glaucous-winged gulls and black oystercatchers both of which forage in the intertidal, eating invertebrates such as snails, limpets, mussels and sea stars.

On islands with rats the number of gulls and oystercatchers is much lower than on islands without rats and the rocky intertidal community is different. Islands with rats have far more herbivorous invertebrates such as limpets and snails, and a lot less algae because of the herbivory. Islands with rats also have higher numbers of mussels, sea stars, sea anemones, barnacles, tunicates and sponges due to both the decreased predation by birds and more available space for invertebrates to settle because there are fewer algal plants. So, introduced rats, because they eat seabirds, are responsible for a change in the intertidal community from an

algal-dominated to an invertebrate-dominated system by releasing intertidal herbivores from predation pressure. Oceanic islands have provided us with a great deal of interesting information about ecological and evolutionary processes. The terrestrial realm of islands inspired great scientists – Darwin, Wilson and McArthur to name but three. The oceanic connection of islands, through the need for seabirds to nest on land, is continuing that tradition of giving us interesting insights into how our world works.



About the Author

Jan Hodder is an Associate Professor and the Academic Coordinator at the University of Oregon's Institute of Marine Biology. Her specialty is the study of the natural history of marine birds and mammals. Besides her expertise in marine mammals and birds, she has taught undergraduate and graduate students for over 20 years. She is the director of the Center for Ocean Sciences Education Excellence-Pacific Partnerships (www.coseepacificpartnerships.org). COSEE-Pacific Partnerships provides professional development opportunities in marine research and education for faculty and students at community colleges. It also provides scientists with opportunities to participate in programs that train staff and volunteers at informal science education institutions. Jan can be reached at: jhodder@uoregon.edu.

NEW CURRICULUM MATERIALS COMING SOON!

The NCSR Marine Fisheries Series of modules is in its final stages of development. The series includes: *Marine Fisheries Overview; Marine Fisheries - Introduction and Status; Marine Fisheries - Causes for Decline and Impacts; Marine Fisheries- Management and Proposed Solutions* (pictured above)*; The Role of Marine Reserves in Ecosystem-based Fishery Management; Declining Expectations - The Phenomenon of Shifting Baselines*; as well as extensive resources and some activity-based learning modules. We expect the fishery modules to be available on our website in November and December 2009.

A Pictorial presentation - *A Visit to Southern Africa*: A photo safari in the game reserves of Botswana and Zambia is now available on NCSR's website. It is a large file (64 MB) and can be requested in hard copy (CD) or downloaded from our website www.ncsr.org/materials/index.

Shifting Baselines in the Lummi Fishing Industry
By Alyssa A. Cudmore

Editor's note: NCSR's most recent curriculum development effort has emphasized human impacts on marine fisheries including the phenomenon that has been dubbed "shifting baselines." While studies of shifting baselines have been completed on Caribbean and Asian fisheries, the first documented study on a Northwest Native American fishery was recently completed by an undergraduate at Huxley College of the Environment at Western Washington University in Bellingham, Washington. For her senior honors thesis Alyssa Cudmore, a 2009 Environmental Policy graduate, worked in collaboration with her father, NCSR Principal Investigator Wynn W. Cudmore, studying shifting baselines in the Lummi Nation fishing community on Puget Sound. The following is an overview of her study.

An environmental baseline is an important reference point because it measures the health of an ecosystem, provides information against which to evaluate changes, and shows how things "used to be." Establishing a baseline for all natural resources is necessary to fully understand the extent various populations have been impacted through time and is essential to their management and recovery. When these baselines or reference points change through time and successive generations do not notice these changes, a crucial management tool is lost in the process. This phenomenon is called shifting baselines. Shifting environmental baselines are inter-generational changes in the perception of the state of the environment. As one generation replaces another, people's perceptions of what is natural change even to the extent that they no longer believe historical anecdotes of past abundance or size of a species.

I spent the better part of spring 2009 on a small coastal peninsula located in western Washington's Puget Sound researching this very phenomenon. This area has been home to the Lummi Nation for over 12,000 years, and since time immemorial fishing and shellfish harvesting have been a mainstay of both their culture and their survival. Most Lummi fishers were born on the reservation and have spent their entire lives in the fishing industry.

Lummi fisher with fishing gear
Photo by Alyssa Cudmore

Using first-hand interviews of three generations of Lummi fishers, I attempted to determine whether or not shifting baselines existed in their fishing community. Forty-eight fishers were interviewed representing 10% of the fishing population. I initially predicted that as a result of a culture of storytelling, a close-knit community, and a population closely integrated and dependent upon the fishing industry, younger generations would have similar recollections of the condition of historic fish stocks when compared to older generations. In other words, I hypothesized that shifting baselines would not exist in the Lummi Nation. This, however, was not the case.

Older Lummi fisher and family of three generations
Photo by Alyssa Cudmore

Despite this strong cultural tie to the fishing industry, I found that shifting baselines do exist within the Lummi tribe. First, older fishers were more likely to remember anecdotes of larger past abundances or sizes of fish catches. Second, the older fishers remembered fish and other species higher in the food chain, while younger fishers remembered species lower in the food chain and of less historical and cultural significance to the tribe. Older generations also remembered fishing zones closer to the shore, and in places younger generations failed to ever mention. Furthermore, younger generations are harvesting species lower in the food web and do not remember many of the larger, more culturally significant species caught at one point in time.

From these findings I reached a number of conclusions. First, as expected, many fish stocks relied upon by the Lummi for generations are severely depleted from historical levels. As some species became scarce, Lummi fishers shifted to different species and to new sites for harvesting. For example, I found all generations had shifted from high quality, desired, and culturally significant species to lower quality, less desirable, and less culturally significant ones. As species were depleted, fishers have had to expand to new species to compensate for declining harvest rates. This has resulted in harvesting marine species lower and lower in the food web. Large primary species such as salmon were once the staple for the Lummi, but now echinoderms and shellfish dominate the harvest.

The second conclusion, and where I identified shifting baselines, was the disparity between young and old fishers. Younger fishers did not remember or have knowledge of many of the species, fishing sites, or abundances the elder fishers were able to recall. For instance, while all

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Fisheries declines – some good news for a change?

By Wynn W. Cudmore, Ph.D.

Reports of fishery declines have been with us now for well over two decades, and the issue remains one of the most pressing global natural resource management dilemmas. Atlantic cod, for example, has made minimal recovery despite protections that were put in place in the early 1990s. Bluefin tuna population levels have dropped to the point that the species may soon be considered for endangered species status and concerns remain about fishing pressure on slow-growing species like orange roughy that may live as long as 150 years. However, the most recent analysis of worldwide fisheries data reported in *Science* suggests that there may be some reason for optimism. In 5 of 10 well-studied ecosystems, the average exploitation rate has recently declined. The haddock and scallop fisheries off New England, for example, are probably as healthy as they have been in the last several decades. Some fisheries around Iceland and off the California coast are also experiencing recovery.

Purse seiner gets rigged with nets for the next trip.
Photo: (c) Wolcott Henry 2005/Marine Photobank

There is still plenty of work to do, however, as 63% of assessed global fish stocks are below target population levels and still require rebuilding. Also, the researchers emphasize that even lower rates of fish harvest will be required to reverse the collapse of vulnerable species. Fish stocks and the ecosystems that support them can recover, but only with reduced disturbance and patience. Rebuilding efforts may take decades and will in most cases have short-term economic costs as fishing effort is reduced. The authors of the study claim that fisheries and conservation objectives can be met by using a variety of management actions, such as catch restrictions, gear modification and closures. When firm implementation of strong national laws such as the Magnuson-Stevens Act in the U.S. occurs, both fish stocks and habitats can recover.

Although it is the most comprehensive analysis of global fisheries to date, the authors caution that it has some limitations. The study examined data from only about 25% of world's marine ecosystems. Also, their conclusions are based primarily on managed fisheries in developed nations, where long-term data are available. Fisheries data from the developing world are less reliable and have not been collected for as long. One exception cited in the study is Kenya, where a combination of fisheries closures and restrictions on the use of some types of fishing

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generations indicated the transition from a fish-based to a shellfish-based economy, there is stark difference in how younger Lummi fishers perceive this change in contrast to older. A higher proportion of the younger fishers (43%), did not report the change from fish to shellfish, which is clearly reported by both the mid-aged (95%), and the older fishers (100%). In addition, mid-aged and older fishers indicated the primary stocks they have harvested in their lifetime as Chinook, pink, chum, sockeye salmon, and herring. On the other hand, younger fishers named mainly crabs, clams, halibut, and echinoderms.

Furthermore, younger fishers many times failed to mention many of the species the older fishers had caught at one point in time. Only 14% of younger fishers indicated knowledge of the decline in herring, compared to 45% of middle aged fishers, and 75% of the older fishers. Likewise, no younger fishers indicated herring as ever being an important stock in comparison to 67% of the older fishers. Older fishers also reported nearshore fishing grounds as the primary harvest sites when they began fishing and most of the younger fishers were not aware that fishing had taken place at these sites at any point in time. As older generations of fishers are replaced by younger generations, they take with them a crucial piece of traditional ecological and cultural knowledge of past stocks and how the environment once looked.

Consequently, as the phenomena of shifting baselines occurs, older generations' stories of past abundance and size are often disregarded as inflated recollections by younger generations and scientists who have never experienced these conditions in their lifetimes. If these "tall tales" are not supported by scientific data, management strategies that are implemented will not reflect true past abundance or environments.

To avoid the hazards of shifting baselines two things need to happen: (1) historic conditions must be measured, estimated and documented and (2) this information must be conveyed through education or other cultural practices from one generation to the next in a way that is accepted and believed by each generation. Furthermore, integrating this knowledge into policies and laws in an effective and fair manner will be integral to the future sustainable management of these valuable resources.

As our society today is becoming increasingly mobile, no longer staying in one place long enough to notice incremental changes, and as inter-generational communication continues to degrade, shifting baselines, for all natural resources will become an ever pressing issue.

About the Author

Alyssa Cudmore recently graduated from Huxley College of the Environment at Western Washington University in Bellingham, Washington. Alyssa has a special interest in environmental issues related to the Native American tribes in the Northwest. She has been involved in natural resource issues with the Confederate Tribes of Grand Ronde and the Lummi Nation. Alyssa can be reached at aacudmore@gmail.com.

NCSR Summer Institute:
Connecting Classrooms to the Community

NCSR is offering a professional development institute for sixteen middle school and high school instructors on August 8-13, 2010 in Salem, Oregon. Jon Yoder, a nationally recognized expert in community-based education, will be the primary instructor for the institute. The institute's goal is to assist teachers in learning how to get students involved in meaningful community projects and still fulfill the educational curriculum outcomes that teachers are required to meet. Specifically, activities will provide experiences that will enable teachers to connect their students to their communities through community exploration lessons, to conduct community needs and opportunities assessments, and design and conduct community projects that focus on the environment and the use and management of natural resources. Participants will be provided lodging, meals, institute materials and a $500 stipend. A printable brochure and applications are available on our website www.ncsr.org (see "announcements" on the right side of the page) or you may e-mail us at ncsradm@chemeketa.edu or CALL 503-399-5270 to request an application. Applications must be submitted by June 15, 2010.

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gear have resulted in an increase in both size and abundance of some fish species. Local economies have benefited as a result.

The study follows an earlier study published in 2006 by one of the lead authors, which claimed that if current trends in fisheries declines persist, all seafood would disappear from the world's oceans by 2048. That prediction was challenged by other fisheries scientists, some of whom contributed to the current study. This new study took into account a broader range of data including scientific stock assessments, research trawl surveys, small-scale fishery data and estimates of illegal and unreported fishery catches.

Original article: Worm, B., et al. 2009. Rebuilding global fisheries. *Science* 325:578-585.

More details on the historic and current status of global fisheries can be found in the new NCSR Marine Fisheries Series. The series is expected to be available this winter.

CONTACT INFO
Chemeketa Community College
NCSR - 5/256A
PO Box 14007
Salem, Oregon 97309-7070

Phone: (503) 399-5270
Fax: (503) 589-7622

www.ncsr.org
ncsradm@chemeketa.edu

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STAFF

Wynn W. Cudmore, Ph.D.
Principal Investigator

Lester W. Reed, Ph.D.
Program Director

Jon Yoder
Secondary Education Coordinator

Liz Traver
Administrative Assistant