Community-Based Coastal Observing in Alaska

Aleutian Life Forum 2006

August 10-13, 2006
Unalaska, Alaska

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Introduction to the Forum

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The coastal habitats of Alaska are among the most diverse and productive of any region in the world. Coastal areas serve as homes and refuges for 450 species of fish and invertebrates, 50 species of birds, and 20 species of marine mammals. Alaska's coastline provides the platform required for seabird and marine mammal reproduction, birthing, feeding grounds, and growth. Coastal Alaska waters are home to several environmentally sensitive ecosystems and species including the endangered Steller sea lions, coldwater coral and sponge gardens, and the endangered right whales. Coastal areas provide a critical link to the offshore environment in the early stage development of many benthic and pelagic fisheries. Alaska's people are intimately connected to its oceans and coastal areas. Alaska Natives continue a cultural dependence on the harvest of wild food that has lasted for thousands of years.

Within the last decade the need for coastal monitoring studies on a large spatial or even global range has become increasingly obvious for the intent of conservation and sustainability of diverse coastal ecosystems. Coastal productivity and biodiversity have become the focus of many university, government agency, nonprofit, and local community research.

In August 2006, Unalaska played host to 27 speakers from Alaska, Washington, and California for its second annual Aleutian Life Forum. The focus for the 2006 Aleutian Life Forum was to better understand how coastal communities and coastal monitoring programs can work together to determine changes in Alaska's coastlines.

The Aleutian Life Forum (ALF) was meant to be an annual celebration of the wonderful diversity of life in the Aleutian Islands. It was meant to be a place where information, between researchers and community members, could be shared and relationships established. Invited speakers included university, government, nonprofit, and contract researchers as well as several tribal and local representatives.

The Aleutian Life Forum 2006 served three distinct purposes. The first was to allow community representatives to voice their needs, concerns, and issues as they applied to coastal ecosystems on the verge of change. The second was to provide a venue for coastal monitoring programs to communicate their missions, objectives, and applicability to coastal community representatives. The third was to show and involve the visiting speakers in the living culture that exists in communities like Unalaska.

The 2006 forum began with a community reception and poster session. Moses Dirks, a respected teacher of Unangan culture and language, gave a welcome address, and Zoya Johnson, director of the Museum of the Aleutians, gave a brief history of the Aleutian Islands. The highlight of the evening, and perhaps the entire forum, was the Nawan Alaxsxan Ax̂anan dancers led by Laresa Syverson, who told stories of the Unangan people through movement and song.

Over the following two days, representatives from visiting communities and coastal monitoring groups gave lectures, attended cultural events, convened in small work group sessions, and toured the local landscape. These honored guests were also fortunate enough to attend the Qawalangin Tribe's annual culture camp, Camp Qungaayux̂, where they experienced Unangan culture first hand, by sitting in classes taught by Unalaska elders and mentors and by sampling local foods at a subsistence buffet.

The driving force behind the 2006 Aleutian Life Forum was the need for communities to sit on an even level with researchers and program representatives to communicate their opinions and needs. In this years' ALF, community representatives gained a bit more understanding of what kind of coastal monitoring programs are out there and how their efforts may apply to communities. The monitoring representatives and researchers gained an understanding of the needs and wants of coastal communities, while at the same time developing a respect for the culture of the Unangan people that was shared with them through forum events.

In the pages that follow, you will read articles from the presenters at the 2006 Aleutian Life Forum. It is the hope of the ALF organizers that the Aleutian Life Forum will continue to be an annual event. This year's forum was an excellent opportunity to learn and share experiences and information. The Aleutian Islands offer such a unique environment and the community of Unalaska is one of many whose livelihood depends almost completely on the oceans and the nearshore environment. We hope that these proceedings grant you some insight into information that was exchanged by ALF attendees on the importance of coastal monitoring.

Acknowledgments

I would like to thank the following for their time and effort, whose support was critical for the proceedings and the 2006 Aleutian Life Forum: Sharon Svarny-Livingston (Qawalangin Tribe of Unalaska) for her help in planning, organizing, and producing speaker sessions and cultural events; Tammy Peterson (Unalaska/Port of Dutch Harbor, Convention and Visitors Bureau) for dealing with all of the finances, tours, and promotions; and Susan Sommers (Grand Aleutian Hotel) for organizing hotel registration and arrangements.

I thank the sponsors of the 2005 and 2006 Aleutian Life Forums for their generous contributions. I would like to thank Alaska Sea Grant for publishing these proceedings, especially Sue Keller who aided in not only editing, but also putting this book together.

I would like to stress that the primary contributors to the success of this year's Aleutian Life Forum were the speakers and attendees of the forum. Thank you so much for all that you have done to make this year's ALF an incredible event. I would like to thank the following keynote speakers for going above and beyond the call of duty: Sherry Tamone (University of Alaska Southeast), Sharon Svarny-Livingston (Qawalangin Tribe of Unalaska), and Keith Criddle (University of Alaska Fairbanks).

I would like to thank the Qawalangin Tribe of Unalaska for allowing the speakers to take part in Camp Qungaayux̂ cultural events. Thanks also to Laresa Syverson and the Nawan Alaxsxan Ax̂anan dancers for what may have been the highlight of the forum. A special thank you goes to the Museum of the Aleutians for taking part in the cultural and historical education for visiting speakers. And thanks to Unisea for helping with accommodations and catering.

Most of all, I would like to thank the community of Unalaska for allowing us to host this forum and for getting involved.

Forum Agenda

Community-Based Coastal Observing in Alaska: Aleutian Life Forum 2006

August 10-13, 2006, Unalaska, Alaska
Workshop

Thursday, August 10

6-9 pm—Evening Icebreaker and Community Reception

- Posters/Booths/Handouts (Monitoring Groups)

8-8:30 pm—Welcome Address

- Opening Address (*Reid Brewer*)
- Unangan Welcome (*Moses Dirks*)
- History of the Aleutians (Zoya Johnson)

8:30 pm—Unalaska Dancers (*Laresa Syverson*)

Friday, August 11

7:30 am—Introductory Speakers

- *Sharon Svarny-Livingston*, Communities
- *Sherry Tamone*, Monitoring

9:30-12:00 pm—Attend Camp Qungaayux̂

2-3:40 pm—Session 1: Community Needs and Monitoring

- King Cove (*Desirae Roehl*)
- Atka (*Julie Dirks*)
- Akutan (*Antone Shelikoff*)
- Sitka (*Amee Howard*)
- St. Paul (*Katiana Bourdukofsky*)

4-5:40 pm—Session 2: Monitoring Programs

- *Bree Murphy*, Center for Alaskan Coastal Studies (Coastwalk Program)
- *Julia Parrish*, COASST (Coastal Observation and Seabird Survey Team)
- *Dawn Osborn*, LiMPETS (Long-Term Monitoring Program and Experiential Training for Students) (Invertebrates)
- *Carl Schoch*, NPRB (North Pacific Research Board) (SCALE Program)
- *Bob King*, Marine Conservation Alliance Foundation (Marine Debris)

Saturday, August 12

8-10:40 am—Session 3: Programs with Information for Communities

- *Poppy Benson*, AMNWR (Alaska Maritime National Wildlife Refuge)
- *Dave Aplin*, World Wildlife Fund
- *Doug Dashe*r, Alaska Department of Environmental Conservation (EMAP Program)
- *Karol Kolehmainen*, Alaska Department of Natural Resources, CSRA (Coastal Resource Service Areas)
- *Brenda Konar*, NaGISA (Natural Geography in Nearshore Areas) (Invertebrates)
- *Sue Saupe*, CIRCAC (Cook Inlet Regional Citizen's Advisory Council) (Shore-Zone Project)
- *Sue Mauger*, Cook Inletkeeper (Water Quality)
- *Bob Mikol*, Compass Rose Cartography (GIS)
- *Daniel Gilson*, Prince William Sound Regional Citizens' Advisory Council RCAC (Invasive Species)

3-5:30 pm—Work Session 1

8:30 pm—Movie: Journey of the Tiglaax̂, Hosted by *Poppy Benson*, AMNWR

Sunday, August 13

8-11 am—Work Session 2

An Introduction to Coastal Monitoring

Sherry Tamone
University of Alaska Southeast, Juneau, Alaska

> "The purpose of this year's conference is to develop and implement a community-based coastal observation system that can be used for rural Alaskan communities."

Introduction

Long-term data collection is important in evaluating environmental change, and in Alaska this concept is particularly important when considering coastlines. Alaska has over 45,000 miles of coastline, most of which is difficult to access. Coastal regions of Alaska are diverse and range from protected estuarine and marine habitats to exposed outer coastlines; some of these are seasonally submerged by ice. These regions support important algal, invertebrate, and macrovertebrate assemblages, which in turn support apex species that are important to coastal economies. Alaskans rely on healthy coastlines to support economic industries that include fishing and tourism.

Alaska is a tourist destination, marketed and sold for its "pristine" environment complete with abundant and diverse marine mammals and seabirds. Tour boats visit all regions of Alaska including Southeast Alaska and Glacier Bay, the Gulf of Alaska, and the Aleutian Islands, bringing visitors to local ports to experience recreational fishing, kayaking, and wildlife viewing. But what exactly defines pristine? To a visitor, the environment experienced in Alaska is closer to unspoiled than that experienced in an urban setting; therefore pristine is a relative term. We can appreciate a pristine and unspoiled environment if we are able to relate this to a contaminated and spoiled environment. We can therefore only recognize an environment as spoiled if we have some knowledge (baseline data) concerning the original and intact state. Baseline data are recognized as critical for reference as these data provide information against which to evaluate change.

Baseline data are historically incomplete and although we have anecdotal evidence and traditional knowledge to support environmental change, consistent long-term data are lacking. For example, the size of sport fish caught is decreasing, yet historical data are lacking to provide a more complete "picture" of changing fish sizes.

A recent satirical Web site (www.shiftingbaselines.org) highlights the importance of baseline information when inferring the health of the environment. Local fish abundance may be greater than a decade ago, but may be dismally depleted when compared to a century ago. Without published monitoring data, baselines are a function of generational memory and are therefore subject to change. Baselines are shifting (Tegner and Dayton 1998) and in order to document these changes, we need to initiate long-term monitoring of our environment.

Humans are impacting their environment in multiple ways and long-term monitoring studies are providing important information that could lead to rectifying these impacts. Three examples that I will discuss in this introduction are invasive species, pollution, and commercial fishing.

Invasive species

There is much concern these days about invasive species whether they are plants, invertebrates, or vertebrates. Invasive species are those organisms introduced into an environment that have the potential to disturb the native ecology of indigenous species. For example, the European green crab was introduced along the eastern Pacific through ballast water exchange in San Francisco Bay. Since its early introduction, the green crab has extended its range to Vancouver Island toward the north and threatens the extensive coastlines of Alaska. Will this species threaten native crab species such as the commercially important Dungeness crab? Without a clearer understanding of baseline populations of all life history stages of Dungeness crab, it will be difficult to correlate invasive crabs with changes in populations of native crab. To date the available data linking the invasive green crab to negative ecological impacts are scarce with only one long-term study showing marked changes in amphipod populations in regions of an estuary inhabited by green crabs (Grosholz 2000).

A more recent article demonstrates that the arctic fox, which was introduced on many but not all of the Aleutian Islands in the eighteenth century, has influenced plant communities (Croll et al. 2005) Islands with introduced foxes had noticeably fewer nesting birds and therefore less nutrients deposited by those birds. The vegetation varied from lush grasslands on islands without foxes to low growing shrubs (no higher than your ankle) on islands with introduced foxes. This inadvertent controlled animal introduction allowed for the comparison of one environment (invaded) to another (pristine). It should be noted that although the decrease in population of nesting birds was noticeable, there are no baseline data to define shorebird populations on those islands.

Pollution

Human-made chemicals are finding their way thousands of miles from their original source into the tissues of animals inhabiting "pristine" waters in the Arctic. Persistent organic pollutants are hydrophobic chemicals that do not readily degrade and can reside within tissues of all biota. Chemicals such as polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs) are flame retardants that bioaccumulate through the food chain are found at extremely high levels in apex species such as salmon, certain toothed whales, and humans. Sea otters from Adak Island in the Aleutians have DDT concentrations up to 36 times greater than sea otters in Southeast Alaska. In the example of pollutants, baseline data should be obtained in order to monitor changes over time.

The March 1989 *Exxon Valdez* oil spill provided a strong impetus for baseline monitoring of Alaska's coastlines. Current monitoring efforts demonstrate residual oil is still percolating up from the lower sediments and impacting restoration efforts. In the absence of baseline data, a restored intertidal community could look healthy (large diversity of algae, invertebrate communities, and vertebrates) but in fact be very different from the original intertidal community. Almost two decades have passed since the *Exxon Valdez* oil spill, and we still have very limited information concerning the long-term effects on coastal ecosystems.

Commercial crab fisheries

Coastal communities rely on healthy fish stocks to sustain commercial, recreational, and subsistence fisheries. Sustainable commercial fishing practices are important to maintaining long-term economic benefits that support local communities. Managing Alaska's fishery cannot occur successfully without long-term monitoring and continual surveying of specific populations.

Populations of snow crab harvested in the Bering Sea have been closely monitored since the late 1970s (Fig. 1). Harvest levels peaked in 1991 and have been declining ever since. In 1999, the National Marine Fisheries Service declared this species "overfished." From this figure it is not clear if the decline in snow crabs is a direct effect of the fishery or due to other factors such as disease, prey availability, or environmental change. The figure does not convey information about the snow crab population; only about male crabs that are harvested in the fishery.

Only male snow crabs having a carapace width greater than 95 mm are harvested. It turns out that male snow crabs stop growing after a terminal molt and the size at which they stop growing covers a broad range (Tamone et al. 2005). Those crabs that don't have the capacity to

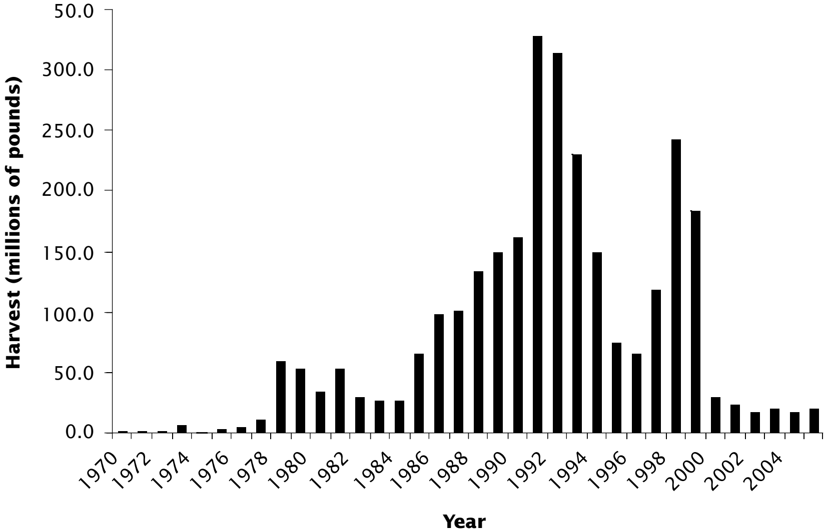

Figure 1. Snow crab harvest from the Bering Sea. From Alaska Department of Fish and Game, Commercial Fisheries Division.

grow can be characterized by having large chelae (Tamone 2007). What we do not know, because we do not have historical data on the proportion of sublegal crabs that have the large claw morphotype, is how the fishing practice of harvesting the "legal" large-claw males has impacted the snow crab population. Removing the largest of the males may be affecting the genetic structure of this population as has been shown for other fished species (Conover and Munch 2002).

Conclusions

In the case of each of these prior examples concerning invasive species, pollution, and fisheries, there was a tremendous amount of labor and financial expense involved in obtaining the data to document change. These studies were carried out by multiple governmental agencies and universities and required the input of collaborating scientists, graduate and undergraduate students, and staff. Long-term funding for monitoring projects is rare. Presently, the National Science Foundation (NSF) funds only two long-term ecological research (LTER) projects in Alaska. Neither of these involves monitoring Alaskan coastlines.

Contemporary discussions center on global climate change. How are we going to assess changes in the coming decades in the absence of documented data? One of the goals of this workshop is to discuss methods that will involve local communities in monitoring their environment and collecting long-term data that are meaningful in the future. Scientists, directors of nonprofit organizations, local community members, and others will contribute their ideas and expertise in generating feasible ideas for long-term coastal monitoring. Designing a sustainable monitoring program requires that we consider the cost for this investment and the biological inventory that is most relevant to the community. As much as we might desire a consistent protocol that evaluates all coastal biota over time, the ultimate limitation will be cost and manpower.

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Kachemak Bay CoastWalk: Twenty-One Years of Observing Changing Shores

Marilyn Sigman and Bree Murphy
Center for Alaskan Coastal Studies, Homer, Alaska

Changes in Kachemak Bay context for CoastWalk

The nonprofit Center for Alaskan Coastal Studies (CACS) was formed in 1981 by a group of concerned citizens to foster research in Kachemak Bay and to provide a repository for environmental information about this sensitive and productive area as a basis for its stewardship. During the life of the organization, many changes have come to Kachemak Bay. Through all these changes, the annual CoastWalk has remained a constant activity of our organization.

Several years after the formation of the organization, in the fall of 1984, several CACS members hatched the idea of the Kachemak Bay CoastWalk—an annual walk along stretches of the Kachemak Bay shoreline to observe how they changed from year to year. CACS was interested in the natural cycles of the bay and also concerned that as more and more people were attracted to live and work and recreate on the awe-inspiring beaches of this beautiful bay, human activities would become a large factor in the changes that would occur. Finally, and most important, our founding members all shared a deep and sheer enjoyment of a walk on a familiar beach whose cycles, patterns, and complexities were part of their extended sense of "home."

In fall 1984, only a few spruce bark beetle larvae were crunching away beneath the bark of trees in Kachemak Bay forests. The bay's single kayak tour company had stored their boats, and two wilderness lodges in China Poot and Tutka Bay had completed their seasons. Well-fed Alaskans had collectively spent 25,000 days harvesting king, Dungeness, and Tanner crab and almost 9,000 gallons of cockles, butter clams, and Pacific littleneck clams that year in Kachemak Bay and lower Cook Inlet. Oil flowed steadily and uneventfully through the Trans-

Alaska Pipeline system and into tankers that navigated successfully through the icebergs and rocks of the Gulf of Alaska.

Now we can look back at the changes that have occurred. A warmer climate has rippled through the forests in the form of the spruce bark beetles that have eaten their way through thousands of acres of trees in the bay's watersheds. Shrimp, then the base of the oceanic food web, have nearly vanished. The sport harvest of 62 king crabs in 1984 proved to be the last before the season was closed and the collective 25,000 days spent harvesting was never equaled, declining to only around 5,500 days in 2003 for virtually the same amount of clam stew and not a single crab or shrimp. Several wildlife species in the bay that were abundant in 1984 now have conservation concerns in part or all of their range: beluga whales, Steller sea lions, harbor seals, sea otters, sea ducks, and Kittlitz's murrelet. And, in a single event in 1989, eleven million gallons of crude oil were spilled into the marine ecosystem of which the bay is a part.

Since 1984, use of our shoreline and beaches has increased dramatically. The shoreline has gradually become lined in a number of areas with homes, businesses, and recreational cabins, and dotted in others with private and public docks and moorings, trailheads, kayak landing spots, and beach parks. A half-mile of seawall has been built in an attempt to protect coastal properties from the process of beach erosion and other long stretches have been armored. The Homer Spit has become a seasonal suburb of Homer, with many campsites and spaces for RVs with cable TV connections. Eighteen businesses offer kayak tours and rentals, 16 water taxi operators ply the bay, and 11 lodges provide overnight accommodations on the south side of the bay.

In the midst of these changes, however, appreciation and stewardship of our beaches have also increased dramatically. Kachemak Bay State Park and its shoreline has been expanded considerably and the entire bay has been designated a National Estuarine Research Reserve. An annual shorebird festival attracts thousands whose enjoyment depends on the integrity of coastal wetland habitats. The City of Homer has convened a Beach Policy Task Force and adopted ordinances regulating uses, including vehicle access, on the city-owned beaches. In addition to CACS, the Alaska Islands and Ocean Visitor Center and Pratt Museum orient thousands of community members and visitors to the natural and cultural history of the bay and opportunities to learn more, experience more, and sustain its diversity and productivity.

Kachemak Bay CoastWalk monitoring methods

The Kachemak Bay CoastWalk has been a means to document changes to the shoreline and intertidal areas. At the "local" scale of our bay communities, CoastWalk was developed as a program to increase awareness about the condition of specific areas on the shoreline and overall health of bay environments. Surveys of marine plants, animals, and human activities and impacts serve as an "early warning" system for major changes (erosion, invasive species) and for unusual events (e.g., large jellyfish blooms, mussel die-offs). The long-term survey has provided the basis to track areas near communities receiving heavy use and devise access and education efforts to minimize or avoid damage to biological communities.

When the program started the shoreline of Kachemak Bay was divided into 32 zones. These zones are now a map layer in the Kachemak Bay GIS with the associated data collected for each zone. Each fall volunteers are recruited to walk a stretch of beach once during a three-week window in September. Some zones are many miles long; therefore several sets of volunteers are assigned to one zone to cover the whole distance. Each CoastWalker is given a packet that includes data sheets, GPS unit, maps, garbage bags, a wildlife viewing etiquette handout, identification guides, and summaries of what has been seen in past years at the zone. Walkers are highly encouraged to bring their cameras to photo-document what they see. We currently have a loan program for our GPS units and identification guides, and are working on gaining cameras for loan.

Walkers pick up the packet at our CoastWalk kick-off event, or they schedule another time to pick up the survey materials. All new CoastWalkers go over the data sheets and survey technique with our coordinator, before participating. The data sheets include the CoastWalk data sheet, International Coastal Clean-up (ICC) data sheet, and the Marine Invertebrate Checklist. All CoastWalkers complete the CoastWalk and ICC data sheets, but only CoastWalkers with expertise and availability during a minus tide are asked to complete the Marine Invertebrate Biodiversity Checklist.

The CoastWalk data sheet asks for information on mammals and birds (focusing on marine mammals, sea ducks, and bald eagles), major groups of algae and the wrack composition, general geomorphology, archeological information, human activities, and impacts including basic information about trash. The ICC form involves tallying all of the trash collected from the beach, by type. The marine invertebrate checklist is for species observed, but does not involve a count or estimate of abundance.

Kachemak Bay CoastWalk trends

Fish and wildlife observations

Marine mammals

Due to the point-in-time nature of the surveys and the variability of observer skills, the surveys cannot provide counts or quantitative population trends. Of interest, however, are the single high counts of sea lions and beluga whales that occurred in specific zones—28 sea lions in 1988, 25 belugas in 1988, and 40 belugas in 1989—since these are species that experienced serious population declines in the 1990s. With a few later exceptions, sea lion sightings occurred regularly in some zones only before 1991. Past observations of dead sea otters have been compared with recent observations as part of a current study of sea otter mortality patterns. For example, in 1987 eleven dead sea otters were observed in one CoastWalk zone.

Terrestrial mammals

CoastWalk surveys also document terrestrial wildlife. Marmots were observed on the beach in a number of surveys until 1992. This is consistent with a long history that stretches thousands of years from the evidence in archaeological midden sites. They are now believed to be rare or absent from Kachemak Bay.

Birds

The number of juvenile bald eagles observed has increased. Crows are switching to the north side of bay.

Unusual occurrences of marine invertebrates

CoastWalk has documented an irruptive pattern of the flat-bottomed sea star (*Asterias amurensis*) in Kachemak Bay. Common in waters off Kodiak, only a few individuals had been observed anywhere in the bay until 2001, when hundreds were observed on several different beaches throughout the bay. Their abundance persisted for three years and then dropped off again to scattered individuals in a few locations. The occurrence of the species is of interest because it has been classified as of "suspicious origin" by the Smithsonian Institution, possibly introduced by ballast water dumping by log transport ships originating in Asian ports where the species is common. Large numbers of different jellyfish species have been documented during some CoastWalks, which are of interest because they may indicate annual shifts in the food web and changes in oceanic conditions.

Human use

Shoreline development

Shoreline development around communities has been documented in terms of the increasing number of structures on the beach and developed beach access points and stairs. Many areas on the north side of Kachemak Bay are prone to severe beach erosion and annual surveys have documented the location and relative severity on an annual basis as well as a variety of successful and unsuccessful erosion control measures attempted by landowners. A number of outfalls have been reported and addressed as point sources of pollution.

Archaeological sites

A CoastWalk volunteer has consistently observed and documented the erosion of several midden sites along the coast of Kachemak Bay. "Erosion over winter cut beach another two feet, taking with it some of the last traces of prehistoric middens in Neptune Bay. Two or three have vanished in the last 10 years." (Anne Wieland, Zone 23, 1989.)

Trashy trends

Some of our most obvious trends have been noticed in the changes in marine debris. In the late 1980s, the use of Kachemak Bay as dumping areas for cars, trucks, boats, and boat parts was common. Several garbage dumps were located on beaches. These practices are no longer acceptable and have virtually ceased.

An analysis of the types of marine debris found on the beaches also revealed a trend away from fishing-related trash and car parts and a dramatic increase in litter from shoreline recreational activities. During the 1984-2001 period, beverage cans, car parts, rope, buoys and floats, and plastic beverage bottles were the top five marine debris items. In contrast, during the 2002-2003 period, the top five items included fast food containers, caps and lids, and construction materials in addition to beverage cans and plastic beverage bottles (CACS 2004). The smaller amount of gear and marine-derived trash is in part due to a much-reduced fishing industry, but is likely also due to increased awareness about the laws prohibiting ocean dumping. CoastWalk data have been taken to the Homer City Council and Parks and Recreation Committee, which has resulted in more trash containers and regular pickups at the most heavily used beach access points. Younger kids who volunteer for the cleanup are often appalled at the habits of older kids who party and litter the beaches, which will hopefully influence their behavior in the future.

Successes of Kachemak Bay CoastWalk

Education

One of the great successes is the education program that has involved school and youth groups in the CoastWalk survey. We have had over 15 different schools and youth groups participate coming from six different communities around the bay. More than half of the classes have participated multiple years.

Ray Vining, a science teacher at Port Graham School in 2003, nicely summed up why he thought the program was beneficial to students and the larger community, "The students learned about stewardship of the intertidal zone and gained a deeper appreciation of the biodiversity of our beaches. Students felt that they were a part of an important scientific enterprise. The community expressed satisfaction with the students learning through hands-on activities using the outdoors as a classroom."

Building from our many years of successfully involving youth in the coastal monitoring process, we created a curriculum called *Gulf of Alaska CoastWatch Activity Guide*, which instructs teachers on how to involve their students in both entry level monitoring with CoastWalk and more rigorous marine invertebrate monitoring.

Stewardship

One of the most impressive products of this project has been the overwhelming sense of stewardship felt and expressed by the volunteers toward their stretch of shoreline. Volunteers who walk the same stretch of beach year after year have a sense of ownership and often follow-up on problems that they observe. In 2005, a CoastWalk volunteer spotted abandoned cars dumped over a cliff onto the beach and persisted in persuading the responsible agencies to locate the owners and enforce the removal of the vehicles.

Annual participation has ranged from 80 to 382 people with an average participation of 240. Over the course of the program, several hundred individuals and 20 organized groups have participated on foot and horseback, and by kayak, motorboat, and ATV. Partners have included schools, scouts, church and youth group, marine-oriented and water taxi businesses, the Kachemak Bay National Estuarine Research Reserve, the Alaska Maritime National Wildlife Refuge, the City of Homer, the Homer Chamber of Commerce, Cook Inletkeeper, and the SnoMads ATV Club.

As the Kachemak Bay CoastWalk has evolved into a model for a community-based monitoring program, it has also evolved as a model for marine debris removal. Based on the data recorded on ICC data sheets, the estimated weight of marine debris removed during the period 2001-2005 was 5,200 pounds, with average removal rates ranging from 15 to 162 pounds per year per mile of the shoreline. Major cleanups of large debris have been organized periodically to remove objects like junk cars.

Taking CoastWalk to the next step

The Kachemak Bay CoastWalk has been a successful community education program, drawing in students and community members at an "entry level" of caring about the local environment and taking stewardship actions, with beach cleanups being the major immediate and tangible action. One of the first CoastWalkers is still walking "his" beach, and a number of CoastWalk volunteers have sustained their involvement for more than five years. But, inevitably, sustained participation and community interest in the annual effort will lead to the "so what?" question about results. Have there been changes in the beaches? Has the information gained led to stopping or reducing harmful human activities? Has anybody else used the data? How do Kachemak Bay beaches compare to others in Alaska or the world?

To get to "so what?" we have tried for the last five years to connect and align CoastWalk with broader scientific monitoring efforts. We started at a global scale with the Global Observations to Benefit the Environment (GLOBE) program, then focused on the ecosystem-scale through the Gulf of Alaska Ecosystem Monitoring and Research (GEM) program. The difficulties that we encountered in the desired evolution of our program are instructive for other communities considering coastal monitoring programs.

The international GLOBE program was designed for school-based monitoring and offered a focus on global collection of data related to detecting climate change, protocols developed by teams of scientists and educators, and an online global database. The database was set up so users could enter data online. Users could also query the database and display comparisons of data with other locations in the world where it was collected in the forms of maps, graphs, and charts. The national program was supported by NASA and the National Science Foundation and had a base at the University of Alaska Fairbanks that provided trainings and support. We piloted the draft protocols, and even brought the scientist responsible for developing the protocols to Kachemak Bay to train us and assist in adapting them for Alaska, and included them in our CoastWatch manual. Unfortunately, the national GLOBE program decided the protocols would never be finalized or supported with training and online data archive and analysis tools.

We next turned to GEM, an ambitious vision for transforming the scientific understandings gained during the restoration efforts following the 1989 *Exxon Valdez* oil spill into a long-term monitoring system to detect significant changes at the ecosystem scale and to apply the information for better management and environmental decision-making. Nearshore habitats were key focus areas for monitoring, and rocky beaches were the primary candidate habitat for detecting change. We have worked closely with the scientists designing the nearshore monitoring program over several years to identify a community-based monitoring component and data collection protocols and to involve Gulf of Alaska communities in the selection of sites that could be monitored by community members. Tom Dean, an intertidal ecologist, provided grant support by the Exxon Valdez Oil Spill Trustee Council to develop the final nearshore protocols, reviewed the CoastWalk program and made a number of recommendations that would expand and extend our data collection in a tiered fashion, with trained observers contributing data to the GEM program. Unfortunately, the implementation of a GEM nearshore monitoring program, and GEM itself, depends on shifting political winds that do not currently favor this visionary approach to stewardship of our irreplaceable coastal environments.

Where are we now? We are looking at the LiMPETS and COASST programs that will also be presented at the 2006 Aleutian Life Forum to supply the "so what?" piece for marine invertebrates and seabirds, respectively. But considerable work is ahead of us in adapting and applying the protocols in Kachemak Bay and supporting expanded efforts by our CoastWalkers.

Future directions for CoastWalk

- Implementing recommendations provided by Tom Dean to develop a tiered approach to extend the annual beach survey effort .
- Piloting the COASST protocols and working to adapt them and support participation by CoastWalkers in COASST.
- Adapting the LiMPETS protocols to Kachemak Bay and incorporating them into the CoastWatch program.
- Development of an interactive Web site to share CoastWalk data among communities and to provide a portal to other scientific and citizen monitoring efforts.
- Expanded efforts in marine debris cleanup and prevention in partnership with Cook Inletkeeper and in transferring the CoastWalk program model to other Alaska communities.
  - » Organizing an Alaska Coastal Stewardship Conference in Homer in February 2007 (following the Alaska Forum for the Environment in Anchorage).

» Providing challenge grants for community-based marine debris cleanup and prevention.

Lessons learned about collecting and sharing community-based scientific data

Do:

1. Get people out on the beaches to collect information and trash, take photos, attach GPS locations to their observations, and celebrate and appreciate your local beaches!

2. Match the aspects of intertidal ecology and human impacts to be monitored to community concerns and to decision-makers (including other community members) who can be identified and provided with monitoring results. Select monitoring methods that are feasible that will detect the changes you wish to monitor.

3. Consider a tiered approach to coastal monitoring, recognizing that collecting certain types of information, such as the abundance and diversity of marine invertebrates, requires intensive sampling and extensive training of observers in order to be considered scientifically rigorous enough to be useful by scientists. The "entry level" may be primarily educational but a sustainable program should have levels that can contribute reliable scientific data.

4. Be prepared to adapt scientific monitoring protocols that have been developed somewhere else or for a broad geographic range to your local environment. You will need to select long-term monitoring sites and may need to identify the key or indicator species in your area for biological monitoring.

5. Figure out how you're going to archive and analyze monitoring observations and data before you start collecting them.

6. Develop regular and creative ways to get the information back to the volunteers and to the community, e.g., annual information summaries, news articles, "found treasure" art shows made from recycled beach trash.

Don't:

1. Adopt data collection efforts that cast citizen volunteers in a "data slave" role, where they collect and provide data to scientists, but receive nothing back in terms of the significance of the data collection effort or return of the results to the community.

2. Wait for the perfect Alaska coastal monitoring program.

   Happy CoastWalking!

For more information

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The Coastal Observation and Seabird Survey Team—Citizens Monitoring Coastal Environmental Health in Alaska

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Ecosystem health and long-term monitoring

National recognition of the need to address the intersection between human use of the marine environment and the ability to maintain healthy marine ecosystems has led to calls for better and more available science, and an ecosystem approach (U.S. Commission on Ocean Policy 2004, Pikitch et al. 2004). It is obvious that most coastal systems are subject to some amount of pressure from human activities and/or their consequences, including fishing, pollution, anthropogenic climate change, and disturbance (Wiese and Ryan 2003, Harley and Rogers-Bennett 2004, Williams et al. 2006). Marine ecosystems are also affected by natural forces such as climate variability and changes in biological interactions (e.g., predators, invasive species, disease; Ross 2002, Jones et al. 2005). However, it is not known which pressures are crucial to provoking change (Harley and Rogers-Bennett 2004). In fact, although some components of the marine ecosystem are monitored extensively due to the ease of monitoring (e.g., sea surface temperature), or high commercial or legal value (e.g., target species of fisheries, endangered species), the status and health of most species are only loosely known, and the complexities of ecosystem interactions are almost never known (Harley et al. 2006, De Jonge et al. 2006).

Two of the central difficulties of ecosystem-based management are the seeming necessity to monitor many aspects of the environment simultaneously, and the reality of limited effort capability of resource management agencies (Pikitch et al. 2004, U.S. Commission on Ocean Policy 2004). In Alaska, these issues are magnified by the spatial extent of the state, as well as myriad known forcing factors, including pollution (Piatt et al. 1990), changes in top predator dynamics (Estes et al. 1998, Springer et al. 2003), shifting climate and its impacts (Hare et al. 1999; Overland et al. 1999, 2001), and fisheries (Cornick et al. 2006, Dillingham et al. 2006).

One potential solution to the growing need for comprehensive monitoring is public involvement. The U.S. Commission on Ocean Policy pointed to the need to increase ocean education, public awareness, and a sense of stewardship for marine resources—in essence, getting the public more substantively involved in marine science and resource management. This realization, that citizens can—and should—play an essential role in ocean governance and natural resource management and conservation is relatively new, and diverges from traditional "top-down" management (Danielsen et al. 2005, Brossard et al. 2005). Citizen science is one realization of public involvement. At its heart, citizen science is about involving individuals from communities and constituencies with a vested interest in, and knowledge of, natural resources, in the science, management, and conservation of those systems. Within Alaska, marine citizen science can involve several interrelated communities each with unique as well as overlapping knowledge, including but not limited to native communities, fishing sectors, professional biologists, environmental organizations, local community groups, and coastal landowners.

Seabirds as indicators of marine environmental health

Marine birds have been suggested as environmental indicators because they are extremely abundant (e.g., nearly 100 million individuals of over 75 species occur regularly in Alaska; Byrd et al. 2005); collectively they feed across multiple trophic levels and are found across all coastal, nearshore, and offshore habitats; and individual species are especially sensitive to specific physical, biological, and/or anthropogenic forcing factors (Springer et al. 1996, Carney and Sydeman 1999, Oedekoven et al. 2001). When monitored as a group, the occurrence, abundance, species, and age-diversity of marine birds can reveal basic information about forcing factors affecting marine ecosystem health (Furness and Greenwood 1993, Furness and Camphuysen 1997). Because the expense and human effort required to comprehensively monitor Alaska seabirds is large, such an effort is not possible outside of already budgeted programs and more specific short-term research-driven efforts. However, unlike monitoring of other upper trophic species (i.e., marine mammals), marine birds can be monitoring via beach-cast carcasses.

In fact, beached bird surveys are most often cited as a mechanism to create baselines against which sudden increases in mortality—often anthropogenic in origin—can be assessed. For instance, many surveys throughout the world have been started in response to the threat, or actuality, of oiling events, both catastrophic and chronic (Burger 1993, Flint et al. 1999). Beached bird programs have been credited with showing declines in oiling rates as a function of changes in shipping practices and/or enforcement (Camphuysen 1998), or with providing evidence of high oiling rates that provoked legal action to alter unsustainable shipping practices (Wiese and Ryan 2003). For locally breeding species, the temporal patterns of beaching can indicate relative annual stress on post-breeding adults, relative reproductive success at local colonies, and intensity of response to annual climate events, such as El Niño (Bodkin and Jameson 1991). Longer-term beached bird programs have been able to document significant declines in locally breeding species prior to colony-based documentation and narrow the causal factors to specific climatological regime shifts and/or anthropogenic events (Scofield and Christie 2002). Beached bird surveys have also been used to document wrecks, or mass strandings, of a particular species, as a means to infer the status of local/regional ecosystem health (Camphuysen et al. 1999). Other than obvious anthropogenic causes (e.g., oil spills, Van Pelt and Piatt 1995; bycatch mortality, Robins 1991), wrecks have been associated with declines in forage fish food supply, where the exacerbating factor is poor weather (Camphuysen 1992) leading to starvation.

The Coastal Observation and Seabird Survey Team (COASST)

COASST is a citizen science program in coastal Alaska, Washington, Oregon, and California that trains people living in coastal communities to gather highly rigorous and independently verifiable data on beach-cast birds, human use of beaches, and beach oiling. Started in 1998, COASST now supports more than 400 volunteers monitoring over 250 coastal sites. In its last year of operation, COASST volunteers conducted more than 1,900 surveys, walked more than 9,500 kilometers, and found more than 2,800 carcasses of 76 different species. COASST volunteers range in age from 8 to 90 and represent a broad spectrum of the population. In part because of the high level of service, training, and outreach delivered to program participants, COASST benefits from a high retention rate of volunteers, averaging approximately 70% annually.

Volunteers are trained in a single day, and allowed to choose a beach location that suits their individual desires and restrictions. Armed with a protocol, field guide, and volunteer pack, pairs of volunteers collect data at least monthly, identifying carcasses to most specific taxa via a deductive process that includes standardized measurements, foot type identification, and photographs. All carcasses are individually marked and left in place. Data are entered directly onto the COASST

Web site (www.coasst.org), and hard copy data sheets are sent to the main COASST office at the University of Washington for entry by student volunteers and archiving. Seabird experts independently verify all volunteer identifications, using collected measurements and photographs. In this way, COASST is able to track volunteer accuracy (currently 90% to species), as well as identify individual volunteers who may be having problems with identification such that additional training can be applied in a proactive and positive way.

COASST data are assembled and analyzed on an ongoing basis, and used by a variety of stakeholders, including local, state, and federal agencies, academic scientists, environmental groups, news media, and museums and other outreach facilities. To date, more than 75 requests for data have been filled. In addition, COASST data are presented on the Web site, as well as in an annual report to volunteers (*COASST Reports*) which describes the patterns of bird deposition and connects them to likely forcing factors. In this way, individual volunteers are able to see the role their data play in describing a regional pattern of deposition.

In 2006, COASST data collection expanded into Alaska. Because of the vast geographic scope of Alaska, and it's rugged and remote landscape, the COASST approach has been modified to work extensively with both local and regional partners to secure participants including volunteers, professional biological staff, and recruits from partner organizations with similar missions. To date, partner organizations include the Alaska Maritime National Wildlife Refuge, the Center for Alaskan Coastal Studies, Alaska SeaLife Center, Kenai Fjords National Park, Sitka Tribe of Alaska, World Wildlife Fund Bering Sea EcoRegion Program, and St. Paul ECO. Collectively, we have recruited more than 55 participants surveying 42 beaches in Homer, Seward, Sitka, St. Paul, St. George, Kenai Fjords National Park, and the Alaska Maritime National Wildlife Refuge (Fig. 1). To date, participants have conducted more than 270 surveys, identifying 100 carcasses of 24 species. Beaches are surveyed year-round (23) as well as seasonally (19), to accommodate remote field camps and park sites only staffed, or accessible, during the summer and early fall months.

Applications of beached bird monitoring to Alaska issues

Although trends in the Alaska region data will not be apparent for several years, there are several key issues that Alaska data could address. In the remainder of this paper, we review how COASST data might be used in the context of environmental issues facing Alaska, using examples from lower 48 COASST data, for which there is a longer baseline.

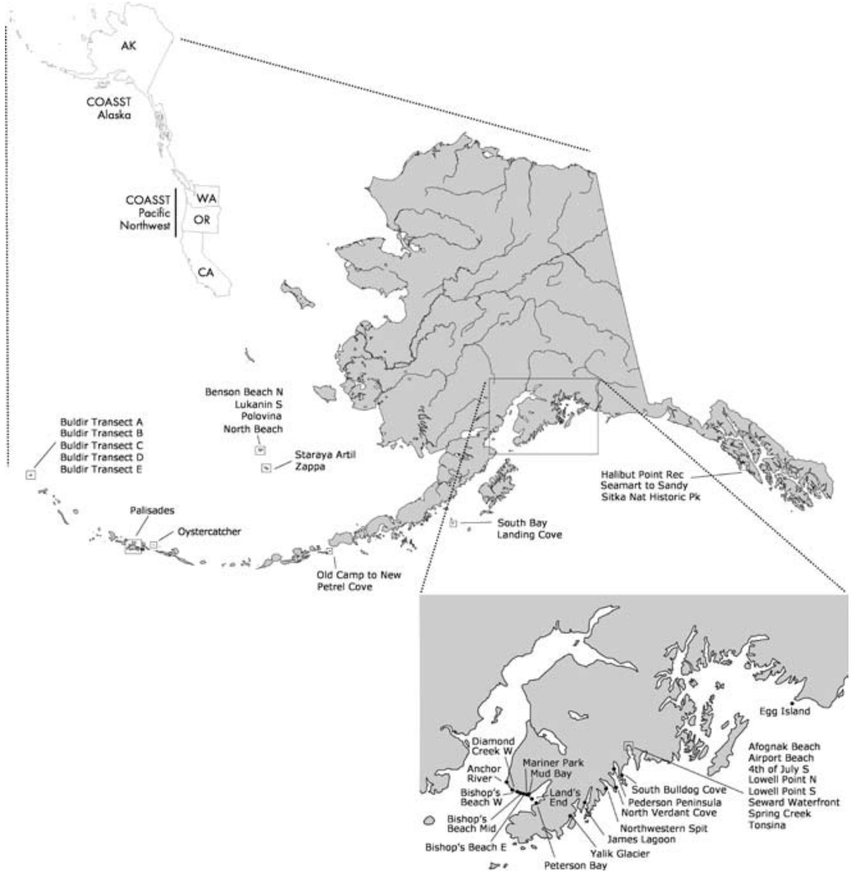

Figure 1. Geographic range of the COASST program, and survey sites in Alaska, 2006-2007.

Oiling

More than 3,000 large cargo ships travel the Great Circle Route through Alaska each year (Nuka Research & Planning Group and Cape International 2006). Since 1989, there have been 14 major (defined as more than 5,000 gallons) oil spills in Alaska waters (Alaska Department of Environmental Conservation 2007). Most notably, the *Exxon Valdez* in Prince William Sound spilled 11 million gallons of crude oil on March 24, 1989; over 30,000 seabird carcasses were recovered (Piatt and Lensink 1989). On February 17, 1996, the M/V *Citrus* collided with a crab processing vessel near St. Paul Island, spilling an unknown amount of bunker oil. Nearly 2,000 birds were impacted by this spill (Flint et al. 1999).

More recently, the grounding of the M/V *Selendang Ayu* on Unalaska Island on December 8, 2004 resulted in spillage of 321,000 gallons of intermediate fuel oil and nearly 15,000 gallons of diesel; just over 1,600 bird carcasses were recovered (Brewer 2006).

These incidents indicate that (1) spills will continue to happen in Alaska waters, (2) they are not restricted to a single geographic region, but may occur anywhere, (3) they are not restricted to a particular time of year, and (4) marine life and marine habitats will be negatively impacted, potentially with population-level results. In particular, marine birds will be affected. COASST surveys in Alaska set a baseline against which the impacts of an oil spill, or any catastrophic mortality event, can be assessed. Baselines can be used in at least two ways: (1) to assess the difference in carcass abundance, at overall and/or taxon-specific levels; and (2) to assess differences in the diversity of carcasses.

For example, the species diversity of carcasses collected during the *Nestucca* oil spill off of Grays Harbor, Washington, in December 1988 can be compared to the COASST beaching diversity (percent of total birds each species or species-group comprises) averaged annually from 2000 through 2006 from the spill area during December and January (Fig. 2). This comparative approach is useful, because it allows species sensitivity to be assessed after the spill event, by assuming that post-spill years returned to the same "normal" baseline as pre-spill years.

The gray box indicates an arbitrary 2% range around the one-to-one line, or noise. Species, or species groups falling within this box were found in approximately the same proportion during the oil spill as they generally appear on the beach during non-spills, whether they are rare, as in the cluster of points in the bottom left of the graphs, or relatively common, as in the case of grebes. Those species falling above the line were found in greater proportions during the spill, an indication of higher species sensitivity to oiling. Those falling below the line appeared less than "normal" during the spill, an indication of relative resilience with respect to nearshore spill events. During the *Nestucca* spill, common murres were highly sensitive to oiling, as they comprised 65% of the spill take, but represent only 6-7% of the birds normally found during COASST surveys in the same region and time of year. Scoters were also more sensitive to the spill, at more than 10% of the spill take and less than 3% of normal COASST finds. By contrast, northern fulmars make up almost 40% of all birds found on COASST surveys, but amounted to less than 1% of the spill take, and can therefore be considered much less sensitive to nearshore oiling events. Gulls, Cassin's auklets, and red phalaropes were also less sensitive to the spill, although in the case of the latter, the inflated "normal" percentage is a function of a single year in which phalaropes wrecked on the beach. With COASST Alaska data currently being collected in the spill areas of the *Exxon Valdez* and the M/V *Citrus*, similar post-spill

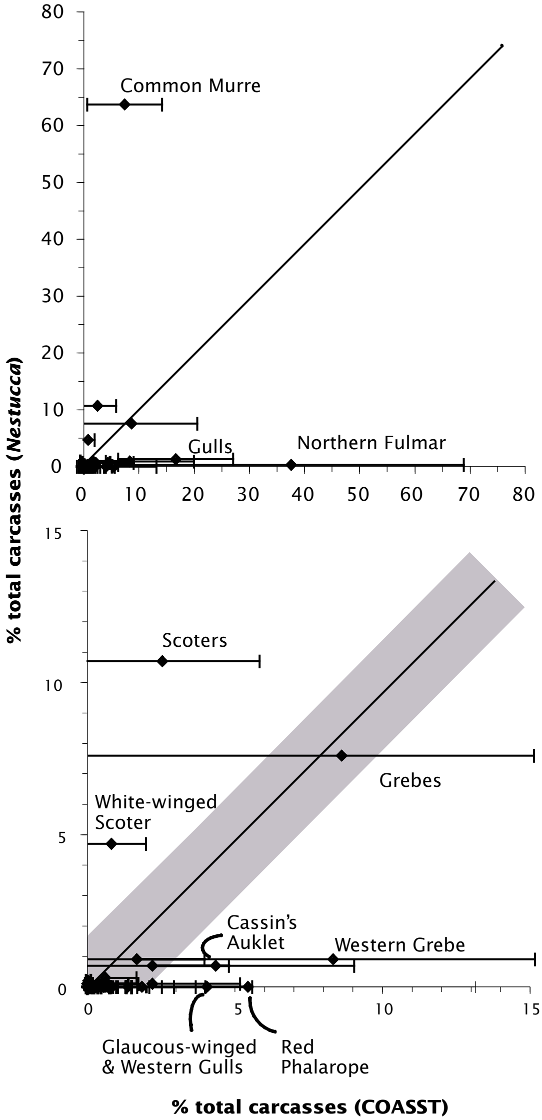

Figure 2. Percent of total carcasses recovered following the *Nestucca* oil spill on 23 December 1988 for each species or species group versus the annual average (±SD) percent of carcasses found on beaches along the Washington outer coast in December and January. The lower panel is an enlargement of the lower left quadrant of the upper panel. The diagonal line in both panels indicates equal percentages during the spill and COASST surveys. The gray bar in the lower panel encloses all points within 2% between spill and normal beaching. All species or groups exceeding this difference are identified.

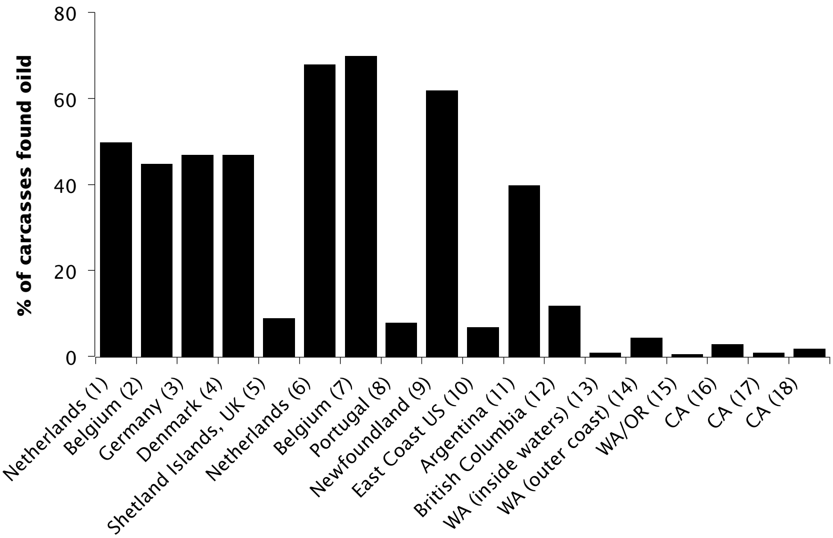

Figure 3. Chronic oiling rates reported from beached bird surveys around the world. Washington/Oregon data are from COASST. References for the other studies are indicated with the numbers in parentheses in the references section.

comparisons indicating species sensitivity will become possible within Alaska waters.

Beached bird surveys can also be used to monitor chronic oiling rates, or the percent of beached birds found oiled on an annual basis (Fig. 3). Chronic oiling rates vary widely from region to region and are thought to reflect shipping traffic, local surface currents and winds (Wiese and Ryan 2003). Rates have exceeded 50% in some parts of the North Atlantic, due, in part, to lax regulation of discharge at sea. COASST data from Washington and Oregon indicate that chronic oiling is relatively low in the Pacific Northwest, averaging less than 1% over the life of the program (7 years). Beached bird surveys in Alaska will add to this global picture, by quantifying chronic oiling rates along the Great Circle Route—the major shipping route from Asia to the West Coast.

Fisheries interactions

Seabird bycatch mortality in longline and trawl fisheries can be significant, both in number of birds caught, and potentially in the degree of population-level impacts (Tuck et al. 2003). In Alaska, active research on seabird bycatch and gear mitigation in both fisheries has resulted in

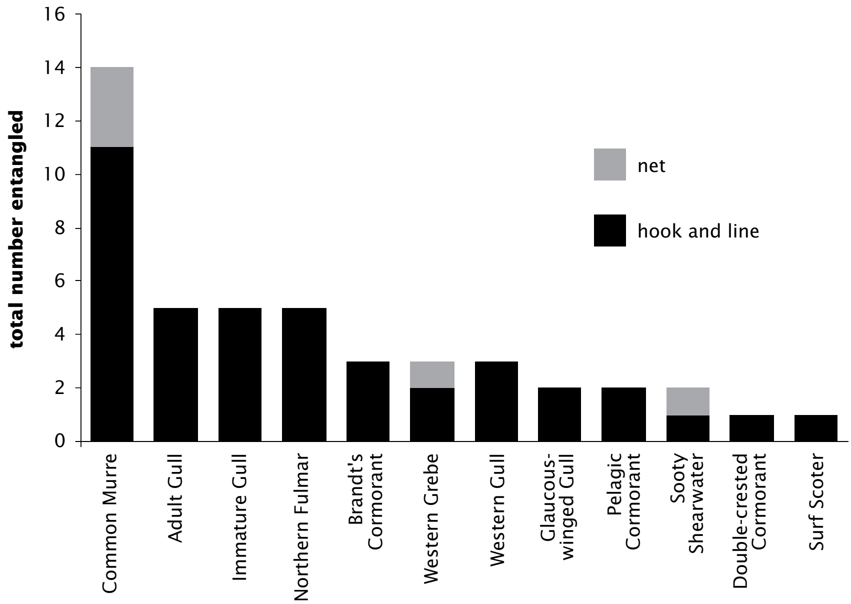

Figure 4. Species found entangled during COASST surveys, 2000-2006. The majority of entanglement occurred in hook and line (black bars) with only a few incidents of entanglement in net (gray bars).

dramatic declines in estimated annual bycatch of seabirds (Melvin et al. 2001, 2004). Nevertheless, it is estimated that nearly 5,000 birds were bycaught in Alaska in 2004 (Boldt 2006). In addition, seabirds are known to occasionally strike vessels, resulting in the death of up to thousands of birds, independent of gear interactions (Dick and Donaldson 1978). The impacts of recreational gear are much less well known.

COASST data from the Pacific Northwest show an overall low incidence of entanglement (less than 1% in all years), with the majority occurring in recreational hook and line gear (Fig. 4). In this data set, recreational gear was categorized as hook and/or monofilament line, whereas nets were categorized as commercial gear. Common murres are the single most vulnerable species. However, the gull complex (mostly glaucous-winged or western gulls) and all three cormorant species are also hooked.

It is important to note that interaction with commercial gear is underrepresented in beached bird surveys, because bycaught birds would be removed on board, washing up on the beaches as drowned birds, with no obvious evidence of entanglement. In addition, many of the commercial fisheries operating in Alaska occur well offshore, such that bycaught carcasses would likely sink well before reaching a shoreline. Thus, COASST entanglement data highlight the possibility of recreational gear impacts, rather than quantify commercial impacts.

Not surprisingly, no entanglement incidents have been recorded on COASST surveys in Alaska to date. However, in August 2006 more than 1,600 short-tailed shearwaters washed up over a 2.5 mile stretch of beach on Unalaska—possibly the result of ship strikes with incoming crabbers (R. Brewer, University of Alaska Fairbanks, pers. comm.).

Avian flu

Highly pathogenic H5N1 avian influenza has been detected in more than 60 countries worldwide (OIE 2007). The avian influenza virus persists in dead birds up to a few days, thus regular beached bird surveys are uniquely suited for the detection of avian flu in wild birds. COASST has already initiated an avian flu sampling program in Washington, as part of the Washington Department of Fish and Wildlife Avian Influenza Surveillance Program. Specially trained COASST volunteers collect fresh carcasses, which are then shipped to the Wildlife Health Center in Madison, Wisconsin, for testing.

There is increasing concern about the spread of H5N1 from Asia to North America through the overlap of birds in the Asian and North American flyways. Alaska has been identified as the area most likely to detect avian flu in North America, should it be passed from Asian migratory birds (Interagency Working Group 2005). Twenty-nine priority species have been identified for testing in Alaska (Alaska Interagency HPAI Bird Surveillance Working Group 2006), according to their occurrence in Asia, contact with known hotspot, habitat characteristics, and population size in Alaska—of these species, three have already been found on COASST surveys in Alaska (sandhill crane, Aleutian Canada goose, and glaucous-winged gull), although no testing of COASST birds in Alaska has occurred to date.

Climate change

Of particular concern to Alaska, global warming is expected to provoke significant changes in sea ice cover (Arzel et al. 2006, Sarmiento et al. 2004), nearshore habitat and coastal erosion rates (GAO 2003), range and relative abundance of commercially important species of fin and shellfish (Weller and Anderson 1999), distribution of new species able to invade due to temperature shifts, and shifts in trophic interactions as a secondary consequence of the above (Bertram et al. 2001, Boyd and Doney 2002). Detecting a biological response signal to warming within the inherent noise of the system is difficult, particularly without reference to a long-term and/or geographically comprehensive monitoring program. Beached bird surveys in Alaska can describe annual baselines within large marine ecosystems, as well as smaller geographic units. With enough coverage, even rare species can be detected; for instance, the introgression of rhinoceros auklets (*Cerorhinca monocerata*), expected to colonize from the south as temperatures continue to warm (V. Byrd, Alaska Maritime National Wildlife Refuge, pers. comm.).

Population health

Alaska is home to more than 30 species of marine birds, including significant populations of alcids (murres, puffins, auklets), procellariids (fulmars), larids (gulls, kittiwakes), phalacrocorids (cormorants), waterfowl (including endangered eiders and the Aleutian Canada goose), and shorebirds. In addition, Alaska waters are the endpoint for many migratory species, including shearwaters from the Southern Hemisphere, and albatross from Hawaii and Japan. Monitoring the health of both local and migratory populations is crucial not only for natural resource management, but also for local communities. For instance, subsistence harvests may be negatively impacted if seabird populations are in decline.

The Alaska Maritime National Wildlife Refuge is tasked with assessing and maintaining the health of local breeders, and in this capacity maintains research and monitoring programs on several islands throughout the Aleutian chain, in the Pribilofs, and in Southeast Alaska. AMNWR has adopted the COASST protocol at its seasonally monitored sites (five beaches on Buldir Island, two on Aiktak Island and Chowiet Island, and one on Adak Island and Kasatochi Island), and is working with COASST to explore beached bird indicators of breeding population health.

Long-term beached bird surveys provide the baseline, or "normal" pattern of deposition against which short-term and long-term, natural and human-caused changes can be measured. With six years of COASST data in the Pacific Northwest, this "normal" pattern reflects two persistent peaks in beaching rates: post-breeding mortality of exhausted breeders and wayward chicks (Jul-Oct) and winterkill, mostly of migrant species (Nov-Jan; Fig. 5). COASST data in Alaska thus far are too incomplete to establish the normal pattern, but early surveys do seem to indicate a peak in beaching rate closer to the beginning/middle of the breeding period, especially at sites adjacent to major breeding colonies (Fig. 5D). Fall and early winter mortality appears to be lower, although data are incomplete, and snow/ice have precluded surveys, and potentially comprised others. Despite these early logistical difficulties, it seems apparent that the large winterkill signal that typifies West Coast beached bird data from Washington through California is not present in the Alaska region, at least in the winter of 2006-07.

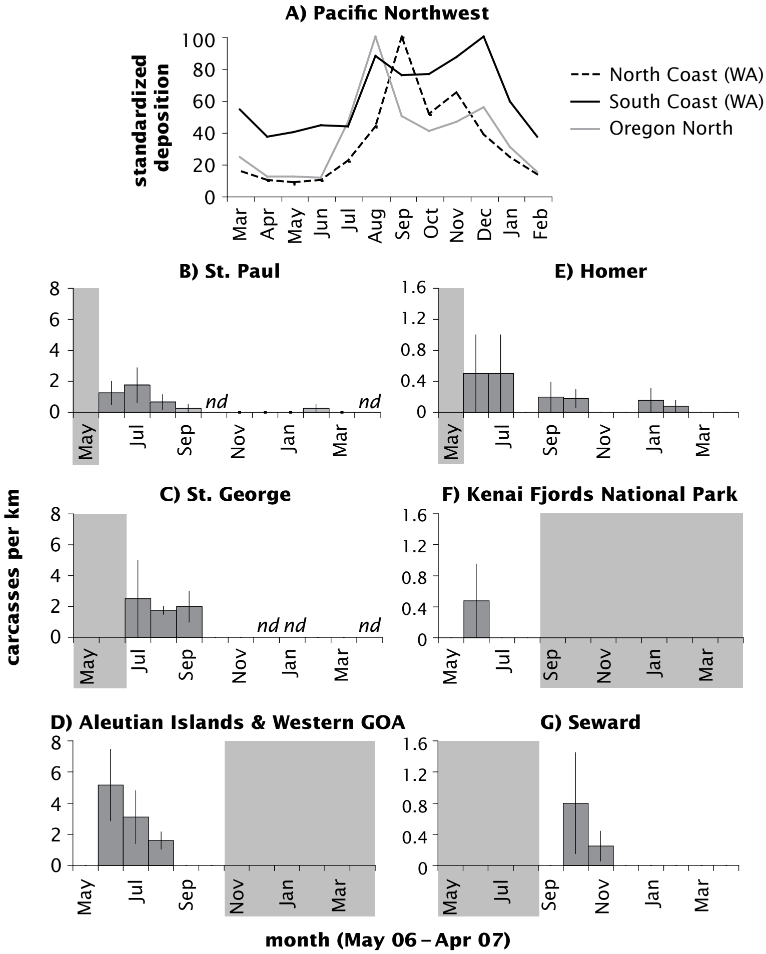

Figure 5. (A) The "normal" pattern of beached bird deposition in the Pacific Northwest. Encounter rates (carcasses per km averaged within month across all beach sites within a region) from 2001 to 2006 were rescaled to maximum month, within region, to facilitate comparison of annual patterns across regions. (B-G) Preliminary data from COASST surveys in Alaska, May 2006–April 2007. Average encounter rates within month across all beach sites within a location (+SD) are shown. Gray areas represent pre-COASST, as well as locations in which COASST surveys are seasonal (e.g., AMNWR colony monitoring sites, Kenai Fjords National Park sites). Sample sizes (number of beaches) ranged as follows for each Alaska region: St. Paul = 2-4, St. George = 2, Aleutian Islands and Western GOA = 1-11, Homer = 1-7, Kenai Fjords National Park = 3-5, Seward = 3-8.

Conclusions

COASST provides one example of how local citizens can collect rigorous scientific information that can be used to address issues of scientific and resource management concern. Through participation in data collection, volunteers increase their knowledge of the scientific process, as well as their stewardship of the local coastal environment. Many COASST participants already have a strong sense of place, regardless of which stakeholder group they belong to. Giving this cross-cutting community the ability to measure environmental change and biological response to human activities on a local, regional, and West Coast–wide scale puts the potential for resource management action back into the hands of citizens.

The long-term vision of COASST is to develop a comprehensive citizen science network throughout the coastal areas of the North Pacific, with thousands of citizens monitoring coastal environmental health. This comprehensive citizen science network would expand beyond beached birds to include a set of integrated indicator monitoring modules based on the principles of rigorously collected and independently verifiable data of immediate use in science and resource management. Data collected on beaches could easily expand to marine mammals, turtles, and fish; invasive species; and beach debris. The seasonal occurrence of beach wrack, mass moltings of local crustaceans, or wrecks of drifting organisms such as by-the-wind sailors (*Vellela vellela*) could be used to help quantify the effects of ocean warming. Episodic die-offs of benthic organisms could signal low oxygen events. Within local communities, different individuals would be responsible for different data sets, collectively painting a picture of local change. With a Web-based interface, adjacent communities could trace local signals regionally, and participants from all regions—Alaska to California—could discover the degree to which what is "normal" at home pertains elsewhere.

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Seabird Monitoring on Alaska Maritime National Wildlife Refuge

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Abstract

Alaska Maritime National Wildlife Refuge (Alaska Maritime NWR) has an ongoing long-term seabird monitoring program designed to detect significant changes in seabird populations that might signal conservation problems for the birds. At the same time the seabirds are used as indicators of change in the marine ecosystem, and the data from the monitoring program can be used along with data on climate change, oceanography, fish, marine mammals, and other physical and biological variables to better understand changes in the marine ecosystem. The monitoring program includes annual data gathering on populations of selected fish-eating and plankton-eating seabirds at ten locations scattered along the Alaska coastline and at additional locations visited less frequently. The data are summarized in an annual report and are in the process of being entered into the Pacific Seabird Monitoring Database so that interested parties will have access to the information.

Introduction

The Alaska Maritime National Wildlife Refuge was created primarily to conserve marine bird and marine mammal populations and habitats and the marine resources on which they rely (Alaska National Interest Lands Conservation Act of 1980). The refuge is far-flung. It includes islands, islets, and headlands from Southeast Alaska to the Chukchi Sea (alaskamaritime.fws.gov). Most of the Aleutian Islands are part of the refuge (formerly the Aleutian Islands NWR, created in 1913).

An important aspect of conservation of marine wildlife is to monitor populations to identify serious declines. In addition, it is important to understand patterns of change in the marine ecosystem to evaluate causes of observed changes in wildlife populations. Seabirds are particularly sensitive to changes in the marine environment, and therefore they can be used like "miner's canaries" to reflect fluctuations in marine food webs (e.g., Cairns 1987, ICES 2003). Because seabirds are long-lived, comprehending the dynamics of their populations requires long-term monitoring to understand their response to not only interannual variation but also to decadal or longer time scale patterns in the marine ecosystem (e.g., Hare and Mantua 2000). "Baseline" data provided by monitoring also facilitates determining impacts of acute perturbations like oil spills. This report describes the rationale, design, and implementation of the long-term seabird monitoring program on Alaska Maritime NWR.

Design of the monitoring program

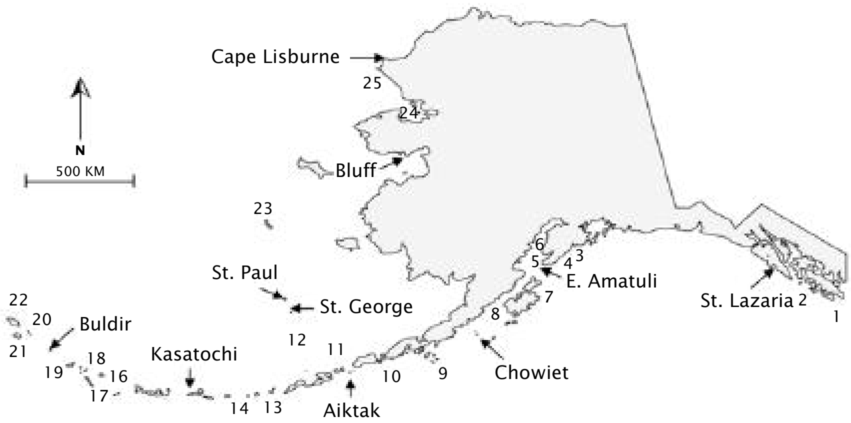
The objectives of the refuge monitoring program are to provide long-term, time-series data from which "biologically significant" changes can be detected and from which hypotheses about causes may be tested.

To accomplish the first part of the objective (i.e., detect population change) involves counting birds. The second part (i.e., understanding causes of change) involves measuring other parameters like timing of nesting, productivity, diets, and mortality events like die-offs along with environmental variables like ocean temperature.

As with any monitoring program basic questions include (1) where to monitor, (2) which species to include, (3) which parameters to measure, and (4) how often and when to conduct the surveys. Choosing the environmental variables to monitor also is important. On Alaska Maritime NWR, there are hundreds of seabird breeding sites scattered over thousands of miles of coastline (Sowls et al. 1978, USFWS 2002, Byrd et al. 2005). Furthermore, there are more than 30 breeding species of seabirds to choose from, and a number of different parameters such as breeding timing, reproductive success, chick growth rates, etc., are candidates for study.

Locations

Because the refuge spans most of the coastline of Alaska, the monitoring program needed to include at least one site in each major ecoregion, and that was the basis for selecting particular sites. The monitoring program includes sites in southeast Alaska, in the north Gulf of Alaska, off the Alaska Peninsula, in the eastern, central, and western Aleutians, in the southern and northern Bering Sea, and in the Chukchi Sea (Fig. 1). This ensures adequate geographic coverage.



1. Forrester*	6. Chisik	11. Krenitzins	16. Gareloi*	21. Agattu*
2. Hazy	7. Chiniak Bay*	12. Bogoslof*	17. Semisopochnoi	22. Attu
3. Chiswells*	8. Ugaiushak	13. Kagamil	18. Segula	23. St. Matthew*
4. Pyes	9. Outer Shumagins*	14. Chagulak	19. Kiska*	24. Chamisso
5. Nord	10. Midun	15. Adak	20. Nizki-Alaid	25. C. Thompson*

Figure 1. Map showing annual (named on map), periodic (asterisk by names), and examples of intermittent seabird monitoring sites on Alaska Maritime National Wildlife Refuge.

Species

At least 30 species of seabirds are known to breed on Alaska Maritime NWR. It is not feasible to monitor all of them, so we selected species that forage in different ways and eat different kinds of prey in order to be able to use the birds to tell when there are big changes in different parts of the marine food web. The two major subdivisions of breeding birds are fish feeders (piscivores) and plankton feeders (planktivores). For instance, we selected species like murres to represent piscivores and storm-petrels to represent planktivores (see Table 1). At any particular monitoring site 6-10 species of seabirds are monitored.

Parameters

From the standpoint of species conservation, population trend is probably the most important parameter to monitor. Nevertheless, understanding causes of change requires monitoring annual responses of seabirds to their environment and particularly to their prey. A number of aspects of breeding biology could reflect seabird response to environmental fluctuation (see Hatch et al. 1994), but our primary focus is on timing of nesting events like average hatch date and on overall reproductive success (e.g., chicks produced per nesting pair). Another important

Table 1. Foraging guilds of breeding seabirds on the Alaska Maritime National Wildlife Refuge.

Foraging guild	Primary domain	Seabird species
Diving fish-feeder	Offshore	**Common murre**
		Thick-billed murre
		Rhinoceros auklet
		Tufted puffin
		Horned puffin
	Inshore	**Pelagic cormorant**
		Red-faced cormorant
		Double-crested cormorant
		Brandt's cormorant
		Black guillemot
		Pigeon guillemot
		Marbled murrelet
		Kittlitz's murrelet
Surface fish-feeder	Offshore	**Northern fulmar**
		Black-legged kittiwake
		Red-legged kittiwake
	Inshore	Arctic tern
		Aleutian tern
Diving plankton-feeder	Offshore	Ancient murrelet
		Cassin's auklet
		Least auklet
		Crested auklet
	Inshore	**Parakeet auklet**
		Whiskered auklet
Surface plankton-feeder	Offshore	**Fork-tailed storm-petrel**
		Leach's storm-petrel
Opportunistic feeder		Parasitic jaeger
		Mew gull
		Glaucus-winged gull
		Glaucous gull

Bold indicates species is selected for use in one or more site.

measure is composition of diets, because shifts in prey signal changes in the food web and can affect reproductive success. Finally, surveying beaches for dead birds can provide an index to unusual mortality events. The refuge, and some of the neighboring communities, has recently been using an approach similar to The Coastal Observation and Seabird Survey Team (COASST) at the University of Washington (www.coasst.org). Sea temperature is the primary environmental measurement that we included. Data collection protocols for each of the parameters (e.g., Williams et al. 2002) ensure comparability of data.

Frequency of sampling

It is important to collect data for some of the parameters annually in order to understand ecosystem processes that affect the seabirds and their prey. Therefore, we selected one site in each of the ecoregions (Fig. 1), where crews collect data annually. Nevertheless, these annual sites are on average more than 500 km apart, so it is important to fill geographic gaps with measurements at other colonies in each region. The additional sites can only be surveyed periodically due to funding limitations. At least one site in each region was selected for data collection at 3-5 year intervals and other sites were selected for survey at least every 10 years. Typically visits to these periodic (3-5 year) and intermittent (10 year) sites are for shorter periods than the season-long work at annual sites, and particularly at intermittent sites, only population trend data are gathered. Nevertheless, data from these less-than-annual sites allow determination of the geographic extent of changes seen at annual sites.

Environmental variables

Hobo data loggers® are moored in nearshore marine waters at most annual monitoring sites to record sea temperatures throughout the breeding season for seabirds. These time series are used to distinguish between relatively cold and warm years.

Food web description

To facilitate comparison of patterns of change in seabirds among monitoring locations, the refuge ship M/V *Tiglax* enables us to describe the nearshore marine food web at each annual monitoring site. This aspect of the monitoring program is called "Seabird, Marine Mammal, Oceanography Coordinated Investigations" (SMMOCI, see Byrd et al. 1997). It involves having the ship run transect lines from the colony out to about 50 km. Observers record locations and numbers of all species of birds and marine mammals while simultaneously recording with a sounder the relative density of plankton and fish in the water column and the temperature and salinity of the water at the surface.

Additionally, profiles of temperature and salinity at various depths in the water column are measured at a series of sampling stations. Test fishing (small research bottom trawls and midwater trawls) and plankton tows are conducted to determine the relative abundance of different types of prey in the area. The refuge is currently conducting SMMOCI surveys in multiple years at some sites to evaluate interannual variability and evaluate the potential of this type of survey as a monitoring tool in addition to basic descriptions of the nearshore marine ecosystem.

Data summaries

Annually, data are compiled from seabird monitoring on Alaska Maritime NWR and from special studies and other seabird monitoring efforts in Alaska (e.g., Dragoo et al. 2006). Furthermore, a new database has recently been developed to be the repository for all seabird monitoring data for the North Pacific including Alaska. It is called the Pacific Seabird Monitoring Database, and it will be available online soon. This will make data from the refuge monitoring program widely available to interested parties.

Conclusions

The Alaska Maritime NWR seabird monitoring program is part of a broader effort to document and evaluate causes of change in Alaska's marine ecosystems. Integration of these data with data from other ongoing monitoring programs (such as marine mammals, fish, plankton, and other biological elements; and oceanographic and climate data) and with local knowledge, particularly about causes of changes, will strengthen the interpretation of results. The ultimate goal for all these efforts is to conserve in the long-term a healthy marine ecosystem.

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LiMPETS: Long-Term Monitoring Program and Experiential Training for Students

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Abstract

We have developed a program for middle schools, high schools, and other volunteer groups to monitor rocky intertidal, sandy beach, and offshore areas of the five West Coast National Marine Sanctuaries—Olympic Coast, Cordell Bank, Gulf of the Farallones, Monterey Bay, and Channel Islands.

The intertidal and offshore habitats of the West Coast sanctuaries are among the most diverse and productive of any region in the world. Despite their ecological significance and protected status, these habitats, along with sandy beaches, are being increasingly impacted by human activities (directly by harvesting and trampling, indirectly through pollution and litter). In addition, there are dramatic geological and climatic disruptions along sanctuary shores (earthquakes, severe storms, El Niño events, global warming) that could generate change in the biota. Awareness by the local communities of these phenomena and how they influence the habitats and their inhabitants is vital if these ecosystems are to continue receiving the protection they deserve. The sanctuaries and partners are establishing a rigorous program to monitor the abundance and distribution of major intertidal biota, sand crabs, and selected offshore species to increase awareness and stewardship of these ecosystems.

Protocols to monitor rocky intertidal, sandy beach, and offshore areas have been established and used by numerous school groups to date. There are various procedures used to collect data, including but not limited to transects, random quadrat counts, total organism counts,

sex determination and size measurements. Several sites are selected within each sanctuary for the rocky intertidal and sandy shore monitoring. Species were chosen to be monitored if they had the following characteristics.

1. Ecological importance.

2. Easily recognized, studied, and identified in the field.

3. Sensitivity to disturbance, pollution, or environmental changes.

Data are collected so that long-term changes can be followed by interested groups working with the sanctuaries' education staff. Protocols, species, site descriptions, directions and more are currently posted on the Web. All of the information in the LiMPETS Web site limpets.noaa.gov/welcome.html is public and free to be used in any way. However, please credit the National Marine Sanctuary Program when information or photographs are used by other Web sites or in publications.

Introduction

The rocky intertidal on the west coast of North America supports one of the richest and most diverse biota in the world (Stephenson and Stephenson 1972, Ricketts et al. 1985). Moderate climate, energetic waves, and productive nearshore waters all contribute to this wealth. This biota is subject to constant change, today largely from anthropogenic causes. At some sites, harvesting and trampling have lead to dramatic decreases in the abundance and diversity of the biota (Ghazanshahi et al. 1983, Brosnan and Crumrine 1994, Addessi 1995, Murray et al. 1999). The very accessibility of the intertidal has lead to more and more people visiting it. By its very nature, the intertidal zone is exposed to many of the pollutants produced by human society. Contaminants released into the air fall on the surface of the sea and are carried into the intertidal, as are chemical contaminants such as oil spills. Waste materials dumped on the land are washed into the sea across the intertidal, some of it remaining there. Indeed, the animals and plants of the intertidal may be affected more severely by human activities than those in most other parts of the sea. Fortunately, because of their accessibility, they also may be the easiest to monitor, and so can serve as our marine canaries.

Sandy beach monitoring in the west coast Marine sanctuaries focuses on the Pacific mole crab (*Emerita analoga*), or sand crab, a common inhabitant. Sand crabs are important organisms in the sandy beach ecosystem, filter feeding plankton from the water. They are eaten by coastal birds and sea otters. Sand crabs are used by humans as bait for fishing and have been used as indicators of the pesticide DDT and the neurotoxin domoic acid. The sand crab is also an intermediate host for a number of parasites, including acanthocephalans (thorny-headed worms) that affect threatened sea otters and surf scoters. Predators on sand crabs may become ill or die from the parasites after consuming numerous crabs.

Sand crabs would be severely affected by an oil spill along the coast. Data collected will provide baseline information about the distribution and density of sand crabs on beaches so if there is an oil spill, we can determine how long it takes for the population to recover. In this long-term monitoring program, we will be able to examine fluctuations in the population over a long time period which will greatly help us understand the sand crabs biology and the health of the sandy beaches. We hope to add more species to our sandy beach monitoring in the future, including arrival time and abundance of the jellyfish *Velella velella*, or by-the-wind-sailor, on the beaches.

Offshore monitoring focuses on Cordell Bank, a unique sanctuary. It is an underwater island offshore that sits on a peninsula surrounded by deep water on three sides. Cordell Bank is a granite peak that rises from the soft bottom of the continental shelf to within 37 m of the oceans' surface. The topography and oceanic conditions create a very productive marine environment. Because of the productive environment, Cordell Bank is also a feeding area for many migrant and seasonal pelagic birds from far away, including sooty shearwaters and Black-footed albatrosses. These albatrosses are able to fly long distances to Cordell Bank during food gathering trips between their nest sites on the northwest Hawaiian Islands. Offshore monitoring consists of examining video taken from a research submersible in different habitats of Cordell Bank and investigating migratory movements of Black-footed albatross during the breeding season, using telemetry tag data. In addition, the abundance of a sea cucumber, sponge, purple hydrocoral and rockfish is measured on the rocky reef video. In the soft bottom habitat, the abundance of box crabs, rockfish and ratfish is measured. We hope to add more species to our offshore monitoring in the future as well, and possibly even work with scientists who attach real-time data transmitters on some birds to track their movements across the Pacific during breeding season and have students analyze these data.

Until relatively recently, long-term monitoring programs were few (e.g., by the Channel Islands National Park (Davis et al. 1994), Diablo Canyon Nuclear Power Station (PG&E 1984), and the Minerals Management Services (Kinnetics 1992, Raimondi et al. 1999). In addition, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), supported by the David and Lucille Packard Foundation, is an ambitious effort to expand long-term monitoring along this coast www.piscoweb.org. These programs offer great promise in providing long-term data that can be used to detect changes in the future. However, they are large, expensive, and employ highly trained technicians to collect and analyze the data.

Another approach to monitoring environmental change is to utilize members of the public. The Audubon Society has taken this approach with their annual Christmas Bird Count www.audubon.org/bird/cbc for over a century. In the past decade the Great Annual Fish Count www.fishcount.org has taken that example into the sea. A variety of groups have made special efforts to involve school groups in monitoring programs, e.g., the federal interagency GLOBE program www.globe.gov/fsl/welcome.html.

Not only will LiMPETS provide another set of long-term data that can be used to follow changes, but it will also introduce people of all ages to the rich biota of the five west coast National Marine sanctuaries' ecosystems (Fig. 1), and build up a group of well-informed, concerned citizens who will watch over these habitats in the future. In addition, it is our hope that by being involved in this program, people will gain a better idea about how science is carried out, both in the field and when interpreting data.

Goals

Our overall program goals are to

1. Establish a long-term, quantitative intertidal, sandy beach and offshore monitoring program that can be used by the sanctuaries, other concerned organizations, and the public in general to assess the health of these habitats; and

2. Increase the understanding and appreciation of the intertidal, sandy beach and offshore habitats by the general public through the direct involvement of high school and middle school teachers, their students, and adult volunteer groups.

Our specific goal is for this monitoring program to be continued in perpetuity by high school students, middle school students and volunteers both to increase public awareness and to provide critical data that can be used to evaluate the health of sanctuary habitats and promote wise stewardship.

For the intertidal monitoring, we want to track changes in the abundance and distribution of selected organisms over time and allow students to analyze data looking for trends. Our hope is that is students will alert sanctuary staff to significant distribution and abundance shifts that could indicate stress to the intertidal habitat and species there. We developed protocols for three approaches to sample the rocky intertidal, depending on the sites and species involved: (1) Fixed quad-

Figure 1. Map showing the boundaries of the five West Coast National Marine Sanctuaries participating in LiMPETS—Olympic Coast, Cordell Bank, Gulf of the Farallones, Monterey Bay, and Channel Islands.

rats along a permanent vertical transect that crosses the intertidal from the top of the high zone through a mussel bed and into the low zone; (2) Random quadrats placed within large fixed plots covering more-or-less uniform areas, usually of mussel beds; (3) Total counts and measurements of selected larger animals within defined areas. Species had to be easily identifiable in the field to be included on our monitoring list. We tested numerous species in the field with students and excluded or combined those that were difficult for them to distinguish. Currently, we have 34 taxa of algae and invertebrates listed for monitoring (Osborn et al. 2005).

For sandy beach monitoring, the overall goal of the project is to assess changes in the sandy beach environment that might affect coastal birds and other species that depend on the environment. The following questions will be answered through monitoring:

- What is the community of sand crabs? Described in terms of the crabs' size, gender, and reproductive status.
- What is the abundance of sand crabs? Described in terms of density.
- What is the distribution of crabs along a transect?
- How does the community of sand crabs change throughout the year?
- What is the (Acanthocephalan spp.) parasite load in the sand crabs?

Students set up five transect lines perpendicular to the shore and collect ten samples one meter apart along each transect. The gender of the sand crabs is determined, and the carapace length measured to the nearest millimeter. Back in the classroom, the data are entered into the online database, www.sandcrabs.org. Students can graph and analyze their results on the Web site, looking at spatial and seasonal variation, and comparing their beach with other beaches being monitored. So far, sixteen schools are involved in the project, monitoring ten different beaches. Students have started collecting crabs to dissect in the lab to investigate the parasite load of sand crabs from their beach.

The offshore activities are done in a classroom setting. The purpose is to demonstrate other types of monitoring methods, such as investigating migratory movements of pelagic birds and subtidal monitoring with submersible video. The goals are to introduce students to a less familiar habitat offshore that is very different than those nearshore they are used to and show them organisms that exist in offshore systems.

Validation

Although getting high school students and volunteers into these habitats may be a great educational experience, there is always the question of whether students are able to collect reliable data, even with the taxa selected for ease in identification. To test the reliability of student counts with rocky intertidal data, we had teams of students and professionals do replicate counts both of large species within delineated areas and of species in the same quarter-meter-square quadrats on the vertical transects (Osborn et al. 2005). On two different days, student and professional teams counted nearly the same number of selected species. The variation among the teams of professionals was as great as those for the students. These differences among teams, whether by students or professionals, need to be taken into consideration when comparing counts (Pearse et al. 2002). It is probably best to always have several replicate counts that can be averaged to get a reasonable estimate of actual abundance. These results, however, provide reassurance that our monitoring program can provide reliable data suitable for use by resource managers and other interested people interested in tracking long-term changes along our shores.

Procedures

In order to familiarize students and volunteer groups with the species and monitoring protocols, teachers and group leaders need to check the LiMPETS Web site and then contact program coordinators in the sanctuaries to arrange classroom visits or, if appropriate, to pick up classroom kits to use themselves. The kit includes a slide show introducing the program: goals, what to wear into the field, the purpose of monitoring, photos of the sites, ecology of a few key species, and some data. We hope to have teacher training workshops each year as well to familiarize interested teachers with the sampling methods and species.

In most cases, there are activities for the monitored habitats that can be done in the classroom before sampling begins. For rocky intertidal classroom activities, there are life-sized photo-quadrats big enough to fit quarter-meter-square quadrats. Using data sheets identical to those used in the field, and aided by laminated photo-identification sheets, groups of students can do practice counts in the classroom. Then several species can be selected and the counts obtained by the different student groups can be put on the chalk board for discussion. Slight differences in the counts among the different student teams can be noted and the students can explore reasons for such differences, such as misidentifications or slight movement of the quadrats.

There are shell collections in the classroom kits as well. These allow the photo-quadrats to become 3-dimensional; students can feel barnacle or mussel shells to better familiarize themselves with the species. An activity on two selected species--owl limpets and turban snails--asks students to read a few paragraphs on each and then answer questions together, such as "describe an owl limpet farm?; why do you think we monitor owl limpets?; or why do you think we monitor turban snails?"

There are numerous ways to familiarize the students with the habitats and species. Please consult the LiMPETS Web site for these details. There are also detailed descriptions about preparing to visit each site. For example, for the first visit into the intertidal, the students should have clipboards, pencils, laminated photo-identification sheets with all the species to be monitored, and a specific assignment. A list of all the species to be monitored is given to each student; the assignment is to write descriptions, in their own words, of the algae or animals after they find them; students can also draw the algae or animals to help them remember. In this way, students can create their personalized identification sheets to laminate and bring into the field with them the next time for a practice count, and every time thereafter.

After the classroom activities and preliminary field trips, the students should be ready to monitor. They need the previous background and exposure to the species and the field to become familiar with the whole experience, however. We have found that reliable data are collected after these initial steps are executed. This is a "check-out" process as well, so teachers and the sanctuaries' coordinating staff can interact and answer questions.

After the classroom activities and preliminary field trip are completed, the teacher/leader will be given a passcode from the sanctuary coordinator for entering data into the program's Web site. The data can then be entered into the program's Web site for long-term storage and analysis, preferably by the students themselves. There are some checks in the data entry system on the Web site to make sure data are entered properly. After the data are entered, the students—and anyone else—will be able to download both their own and past data to create graphs for specified species, sites, or dates. These data also provide material for teaching about statistical analyses and critical reasoning.

Participant response

In order to gather comparable data among the different sites, habitats and over time, there needs to be consistency in how the different schools work in the program. Moreover, the program coordinators within the sanctuaries have limited time, and will find it difficult to follow disparate approaches by the different teachers. It is our hope that the program will continue to maintain flexibility in how people work in it, while at the same time the program coordinators refine the procedures to a manageable level. It would be best if data were collected at each site at least once every spring.

In addition to schools, volunteer groups could easily work in this program, adopting sites that their members could take over as their own, similar to "adopting a site." With the increase in volunteer programs today involved with hands-on environmental issues, we hope many groups become involved with LiMPETS and hope to foster new partnerships.

Partnering organizations

Staff from several organizations and West Coast Marine Sanctuaries has worked together since 2002 to create LiMPETS. Partnering organizations are the California Sea Grant Program, Farallones Marine Sanctuary Association, University of California, Santa Cruz, and NOAA's National Marine Sanctuary Program, including Olympic Coast, Cordell Bank, Gulf of the Farallones, Monterey Bay and Channel Islands National Marine Sanctuaries staff. This publication is a joint effort with staff at all participating organizations. Again, we are always interested in new partnerships and expanding the environmental monitoring. I would like to mention that Bree Murphy, Program Coordinator, Center for Alaskan Coastal Studies, Homer, Alaska, participated in a LiMPETS teacher workshop in California in 2005.

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Mapping and Monitoring Shorelines: Utilizing a Spatially Nested Geophysical Shoreline Partitioning Model to Increase the Statistical Power to Detect Change

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Introduction

Detecting change in biological communities is an inherent part of experimental ecological research and applied monitoring programs. Many organisms within marine ecosystems are sensitive to environmental changes over time or gradients in space and may serve as indicators of environmental health. Intertidal biological communities are made up of a diverse set of animals and plants that are known to respond to changes from a wide range of physical, chemical, and biological conditions. Therefore, it may be important to monitor intertidal biological communities for their intrinsic biodiversity value and also because these communities impact other organisms through the food web. The ecology of the nearshore benthos (from intertidal to water depths of 10 m) has been studied in detail in many locations in the United States, and our understanding of nearshore biological and physical processes has increased substantially. Many of the individual processes structuring nearshore communities, such as wave energy, substrate size, competition, and predation have been extensively examined and are reported in the literature (reviewed in Schoch et al. 2006), and it is clear that there are strong physical and biological linkages. These linkages force predictable patterns of biological communities and intertidal habitats (Schoch and Dethier 1996). However, we do not have a complete understanding of how the many processes that affect community structure interact over different scales of space and time. Determining why communities change over space and time is still a significant challenge, but the patterns observed in the data can be used to predict community structure so that changes can be quantified.

The purpose of most intertidal monitoring programs is to characterize the biological organisms that make up these communities and to track how they change over time. Many scientists and resource agencies have attempted to monitor localized intertidal and subtidal transects in hopes of finding a short-term experimental response or a long-term indicator of ecosystem health. Long-term monitoring presumably will provide a statistical baseline from which a change can be detected. The challenge inherent in this work is that minor differences in physical habitat characteristics such as the benthic substrate and wave energy are known to cause high spatial variation in the biotic community. Furthermore, the dynamic nature of the marine environment causes high temporal variation in organism abundances and community structure, and generally confounds our ability to detect non-catastrophic perturbations. Therefore, biological data from intertidal monitoring stations are plagued by two fundamental problems. The first is the large temporal variability of organism abundances in natural ecosystems that masks our ability to statistically separate an actual change caused by a perturbation (the signal) from natural cycles (the noise). The second issue is a scaling problem. Extrapolating or generalizing the results of localized studies to broad areas is statistically fraught with problems. As a result, it is difficult to select truly representative sites and to extrapolate data over large areas. Previous studies have often failed to develop quantitative links between specific intertidal assemblages and physical attributes of habitats, thus making it impossible to "scale up" in either time or space from limited in situ sampling.

Here we describe the application of a model (Shoreline Classification and Landscape Extrapolation: SCALE) that increases biological homogeneity by partitioning a shoreline into a spatially nested series of geophysically uniform segments. By then statistically aggregating similar but spatially separated units, we increase the power to detect an actual change in the biota and we can scale-up localized biological data to larger regions.

Methods

Our approach for increasing the statistical power of comparisons among communities and populations from intertidal beaches is to decrease the physical variability among sample sites by selecting a series of replicate beaches based on the physics and physical structure of the shoreline. We segment complex biogeochemical shoreline gradients using a combination of qualitative and quantitative partitioning criteria. This method relies on the quantification of physical features known to cause direct and indirect biological responses, and uses these as criteria for partitioning complex shorelines into a spatially nested series of physically homogeneous segments. For example, at the spatial scales of bays and inlets, geophysical parameters such as sediment grain size, wave energy, substrate dynamics, and pore water chemistry are quantified. At large spatial scales such as within ocean basins, water chemistry attributes such as temperature and salinity are used to identify major oceanic climates. These nested segments can be used to study within-segment and among-segment variability, which in turn will support studies of the biotic and abiotic processes that control variability.

Environmental characterization

The monthly upwelling index can be obtained from the Pacific Fisheries Environmental Laboratories (National Marine Fisheries Service, Pacific Grove, California, www.pfeg.noaa.gov). Monthly water temperatures, wind velocity, and direction can be obtained from buoys operated by the National Data Buoy Center, (National Oceanic and Atmospheric Administration, Silver Spring, Maryland, www.ndbc.noaa.gov). Since there is considerable variation in distance from these observation platforms to individual areas, data from closer platforms are potentially more relevant than from platforms farther away. Monthly air temperatures and precipitation can be obtained from coastal observation stations in or near each area (Western Regional Climate Center, Reno, Nevada, www.wrcc.dri.edu). The tidal range and times of low tides can be obtained from primary or secondary tide gauge stations (NOAA, Silver Spring, Maryland, co-ops.nos.noaa.gov).

Until recently, wave exposure comparisons among intertidal study sites were limited to categorical assessments, but recent studies have shown this to be inadequate. We calculated the offshore wave power for each area using

$$P = \left(\frac{1}{8}\rho g H_s^{\,2}\right)\frac{gT}{4\pi}$$

where ρ is water density (1,020 kg m^{-3}), g is the acceleration due to gravity (9.8 m s^{-2}), H_s is the significant wave height, and T is the wave period. Values for H_s and T were obtained for 2001-2003 from the nearest weather buoy to each area (NOAA, Silver Spring, Maryland, www.ndbc.noaa.gov).

The Iribarren number ξ_s can be used to compare the effect of wave dynamics as a function of local bathymetry:

$$\xi_s = \frac{S}{\sqrt{\left(\frac{H_s}{L_\infty}\right)}}$$

where S is the shore slope (e.g., tan α), and L_∞ is the deepwater wavelength in meters:

$$L_\infty = \frac{gT^2}{2\pi}$$

Dissipative or low angle shorelines correspond to Iribarren numbers less than 0.4, and reflective or high angle shorelines yield values greater than 2. Values in between generally represent shores subjected to the greatest wave forces.

Wave runup is a measure of the swash excursion across the intertidal zone. Runup directly affects intertidal organisms by providing water to elevations above the still-water level, thus continuing the supply of food or nutrients and preventing desiccation during low tides. This may affect the growth rates and abundance of many intertidal organisms (Menge et al. 1996). In areas of high runup many species can extend their vertical range, thus considerably raising the community above normal elevations. We used mean runup R_m as a first order approximation for swash height, and estimated it for impermeable substrates as:

$$R_m = H_s C \xi_s^{\,0.34}$$

where C is a constant. Holman (1986) found that for combinations of runup and the rise in sea level caused by radiation stress (the buildup of water along the coast from incoming waves), the C coefficient equals 0.90 over a smooth surface. Based on our estimates of shore segment roughness we used 0.60 for C to best account for turbulence over a rough impermeable surface. The theory behind these methods is explained in Komar (1998) and an application is fully described in Schoch and Dethier (1996).

Biological characterization

Three vertical zones in each selected shoreline segments are sampled. The zones are identified by surveyed elevations based on the local tidal datum to ensure that samples were collected at elevations with the same mean annual submersion times. This design potentially allows for detection of oceanic versus atmospheric effects over small and large scales, because the marine signal is presumably stronger at lower elevations than at higher intertidal levels which are subject to longer atmospheric exposure times (Helmuth et al. 2002). The low zone is sampled at mean lower low water (MLLW), which corresponds to an elevation of

0 m everywhere along the eastern North Pacific coast and where organisms are submerged approximately 90% of the time. The mid zone was sampled at mean sea level (MSL: 50% submergence time), and the high zone at mean higher high water (MHHW: 10% submergence time). These submersion times do not take into account the effect of wave runup. The elevation of MSL and MHHW changes relative to the distance and direction of the nearest amphidromic node. For each sampled segment, we determined the local MSL and MHHW elevations from tide tables and used a surveying level and stadia rod to locate the appropriate transect elevation for each zone relative to the predicted tide at the time of the measurement (NOAA, Silver Spring, Maryland, co-ops.nos.noaa.gov).

The low zone of any segment could only be sampled during extreme low tides which, along the eastern North Pacific, occur for approximately six days per fortnightly tidal cycle except in March and September when there are no extreme low tides. A six-person team could sample one site per day (three replicate segments), and thus, six sites (two areas) per fortnightly tide. The exposed rocky shores along the northern Pacific coast are generally not safe to sample until late spring due to extreme fall and winter wave conditions. This sampling schedule, driven entirely by logistical requirements, potentially introduces a temporal bias in the data since some biota might be expected to show significant variation due to seasonal variations in recruitment, light levels, nutrient delivery, and disturbance from storms.

Mean species abundance can be quantified using the transect-quadrat method (Lubchenco and Menge 1978), in which percent cover of sessile taxa, sand, and bare rock is estimated, and the density of mobile macrofauna is counted in a (0.5 × 0.5 m) quadrat placed at ten randomly spaced intervals along a horizontal 50 m transect tape. Species can be identified in the field using Morris et al. (1980), Smith and Carlson (1989), and Kozloff (1996) as references for invertebrates; and Abbott and Hollenberg (1976), Hansen (1997), and Gabrielson et al. (2000) as references for macroalgae. This method focuses on high spatial replication of samples within an area, and to some extent, this constrains the ability to identify every organism to the species level. However, taxonomic identification at the genus, and even family or "complex," level can be sufficient for distinguishing natural spatial patterns (Dethier and Schoch 2006).

Our samples (transects) consisted of the mean values from ten sample units (quadrats). Studies have shown that 10 sample units account for 95% of the diversity (measured as taxon richness) per sample with approximately 80% of the taxa accounted for by the first six sample units. Therefore, additional sample units would not appreciably increase the estimates of segment diversity. Similarly, studies have shown that the first site (of three sites per area) contributed a mean of 81% to the area taxon richness, the second site accounted for an additional 12%, while the third site contributed the remaining 7%. Provided that replicate segments are carefully matched for physically similarity, this method has shown that adding additional sites to an area would not appreciably increase area-scale taxon richness. Applications of this method for monitoring can be found in the listed references. A more detailed description of this and other monitoring methods for rocky shores can be found in Murray et al. (2006).

Conclusions

This model has application to oil spill damage assessments, inventory and monitoring programs, global change, and biodiversity studies. Our ability to evaluate the scale and consequences of changes in the ocean's biodiversity due to human activities is seriously compromised by critically inadequate knowledge of the patterns and the basic processes that control the diversity of life in the sea. Studies applied to the nearshore are helping to define the patterns and the processes influencing marine biodiversity. If the biogeochemical processes determining patterns in nearshore habitats are defined as proposed by this method, then predictions can be made about changes in community structure over many scales of space and time. Additional applications can be explored in hindcasting the ecological functions of disturbed habitats for mitigation and restoration projects, in forecasting impacts based on trends in human or natural perturbation patterns, and in site selection for experiments in community ecology.

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Marine Debris in Alaska

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There is an Aleut saying that goes, "One who walks usually finds something."

And sure enough, you don't have to walk very far in the Aleutians or Pribilof Islands before something turns up: tangles of nets and line, old fish totes and rusty 55 gallon drums, crab and trawl floats, strapping bands, plastic buckets, fish baskets, boots, gloves, hard hats, water bottles . . . the list goes on and on.

Fishing nets, buoys, fish baskets, tote covers, and more litter Malga Bay on Unalga Island in the Aleutians.

It is marine debris, and it is recognized as one of the most pervasive problems facing our oceans and coastlines around the world today.

I'm happy to be here at the Aleutian Life Forum to talk about marine debris and what's being done about it in Alaska.

I'm the Marine Debris program coordinator for the MCA Foundation based in Juneau. Our parent group, the Marine Conservation Alliance (MCA) is a fishing industry trade association whose members include most of the fishermen, processors, and vessel owners involved in the Bering Sea and Gulf of Alaska groundfish and crab fisheries, as well as fishing communities like Unalaska.

MCA was formed about six years ago to address issues facing the industry, with the goal of finding solutions that protect sustainable fisheries and improve the marine environment on which they depend.

The MCA Foundation was founded a few years later as the alliance's nonprofit arm to attract federal and private funding to tackle special issues. The foundation sponsors cooperative research work between industry and government scientists, such as testing devices to reduce trawl bycatch of salmon and halibut.

My job is to administer the marine debris program. MCA recognized marine debris as a problem several years ago because it is not just ugly, it's a killer.

Lost "ghost" nets kill fish; nets, line, and packing bands entangle marine mammals from fur seals to whales. Turtles and marine mam-

A juvenile fur seal on St. Paul Island faces strangulation from the strapping band or line apparent around its neck. Fish, seabirds, and whales can also become victims of marine debris entanglement.

mals clog their digestive tracts with plastic bags that look like jellyfish and seabirds starve to death with gullets full of brightly colored plastic scraps, bottle caps, even cigarette lighters, that they mistake for a meal.

So where does this stuff come from?

The Bering Sea is no stranger to shipping accidents, like those that drop an estimated 10,000 container vans into the sea every year, but most debris comes from closer to home.

The Ocean Conservancy has sponsored beach cleanups for years, and they estimate that about 60% of marine debris is things like food packaging and plastic bottles from shoreside recreation. Another 30% is related to smoking. Cigarette butts are the number-one item picked up off beaches worldwide.

But in remote parts of Alaska, marine debris has a very different character. In Prince William Sound you'll find recreational litter like pop bottles, styrofoam coolers, and gas cans but you'll also find trawl nets, crab buoys, and other fishing gear.

And in the Bering Sea, home to some of the world's largest fisheries, marine debris is almost all fishing related—but not necessarily from

A Korean apple juice bottle on St. Paul Island. Many, if not most, plastic bottles found along Alaska's shore are of Asian origin.

Alaska. Oceanic gyres in the North Pacific and Gulf of Alaska carry a huge amount of debris to Alaska from Asia.

The labels on plastic bottles that wash up along the shoreline here tell you they come from Japan, Korea, Taiwan, China, and Russia. A detergent bottle that turned up on Unalaska Island hailed from the United Arab Emirates.

Some of these may well have fallen off one of the many vessels that ply the great circle route that cuts through the Aleutians, but there's evidence that it also comes from afar.

The shoreline is littered with fishing floats not used in any fishery here. Korean hagfish trap cones litter the shoreline of the Aleutians, Prince William Sound, and Hawaii, as do scraps of foreign high-seas driftnets.

In fact, most of the nets you find on beaches here are a type not used by domestic fishermen. They either come from foreign fisheries or, since plastic doesn't go away, foreign vessels that operated in Alaska waters decades ago.

What is MCAF doing about it? Using funds from the National Oceanic and Atmospheric Administration (NOAA), we are supporting ongoing cleanup programs, jumpstarting new efforts, and accelerating other people's work.

One of many boatloads of debris from Knight Island. Gulf of Alaska Keeper removed 35 tons of trash from the remote island in Prince William Sound. (Photo courtesy of Gulf of Alaska Keeper)

A day on the beach on St. Paul Island. The Tribal ECO crew typically fills five trucks averaging two tons of debris per day.

The Gulf of Alaska Keeper has conducted volunteer cleanups in Prince William Sound for years. With MCAF support, they turned their weekend program into a monthlong effort this past summer that removed 2,200 bags of trash off Knight Island along with a similar volume of nets, lines, and other items too big for bags.

We contracted the St. George Tribal Ecosystem Conservation Office (ECO) to clean four fur seal rookeries on their island and they removed 18 truckloads of debris.

MCA began its work on marine debris four years ago, supporting the efforts of the St. Paul Island Tribal ECO office. That work continued this year and removed 10 tons of nets, lines, and other trash from just 2.5 miles of beach on St. Paul.

In Sitka Sound, we ferried volunteers out to clean up a World War II era causeway that is being converted into a hiking trail.

We're partnering with the fishing industry in Norton Sound where the regional CDQ corporation hauled 30 tons of trash from the beaches and floodplain near Unalakleet, including more than 200 lost gillnets and 15 abandoned skiffs.

In all, MCAF-sponsored programs removed more than 80 tons of debris from Alaska's shoreline in 2006. We're looking to continue those efforts next year and start cleanups in Atka, Bristol Bay, Kodiak, Yakutat, and anywhere we can find a partner.

But picking debris up is just the beginning. Once it's off the beach, what do you do with it? Landfill space is a precious commodity in many rural villages and some can't accept the huge volume of debris that washes up on their shore.

On St. Paul Island, debris from years of cleanups was stockpiled at a quarry. Earlier this year, we cleaned that stockpile out and shipped the debris to the nearest landfill, which on existing barge routes was in Roosevelt, Washington. The stockpile filled 15 container vans, weighed a total of 157,000 pounds, and cost $114,000 to remove.

Well, there has to be a better way to get rid of this stuff. We partnered with Pacific States Marine Fisheries Commission to examine options for the reuse or recycling of this polyethylene netting and the intriguing idea of converting waste to energy.

In Hawaii, they burn old nets and other garbage in a high-tech, clean-burning incinerator. They estimate every ton of netting can light a home for 5 months.

In fact, none of the alternatives are easy or cheap. There's enough netting in the Unalaska landfill to power the city for a few years but the economies of scale that work in Hawaii aren't present in Unalaska.

The cost of emission controls alone makes incineration prohibitively expensive and I'm not willing to trade off a debris problem for an air pollution problem.

Reuse of discarded gear seems like a good idea until you consider that much of it is discarded because it's reached the end of its life cycle. Better to retire old nets and lines before they break at sea and add to the debris problem.

And recycling the nylon and polyethylene in nets is labor intensive, requiring the webbing be cleaned, stripped of metal gear, and the different fibers separated.

We're investigating a successful net recycling program in the North Sea to see if it has potential here, but it's not an easy fit. High costs in rural Alaska make such an operation marginal at best but given the size of the problem, we're still looking for ways to make it pencil out.

In the meantime, what can people do? First, don't litter. Stow plastics properly and dispose of fishing gear in a landfill. Then start picking up. Getting this stuff out of the ecosystem is still a top priority.

Community beach-walk programs are the foundation of the response to marine debris and MCAF is looking to work with other communities, tribal groups, and others to address the debris problem, especially in outlying areas that have huge accumulations of debris but lack the population base to sustain volunteer efforts.

Resource agencies can help by reporting accumulation of marine debris that you see in the field. We're interested in the location (by common name and GPS coordinates if possible), debris composition, and photos if you have them. You can email me at marinedebris@ak.net.

The Unalaska landfill contains 8,000 tons of discarded nets, line, and other plastics related to the fishing industry and it grows by 1,000 tons per year.

From these reports we're compiling a statewide database of marine debris to better plan future cleanup efforts.

And most important: keep the faith. After a few years of cleaning and re-cleaning beaches, people can easily get daunted by a problem that seems impossibly huge and never seems to go away.

Out in the Pribilofs earlier this year I met a NOAA scientist who told me at first he was skeptical of marine debris cleanup programs.

Nice effort, he said, but totally impractical. There was just too much of it out there. Despite everybody's best intentions, they couldn't make a dent in it.

But after meeting some of those people and seeing the work they've done he now thinks their efforts have made a huge difference.

Not only are beaches cleaner and threats of wildlife entanglement being reduced but the effort, he said, has paid off in other intangible ways.

By empowering people to take on a Herculean task, the challenge of marine debris has inspired a newfound sense of community pride.

Take a walk on a beach anywhere and you'll find that marine debris is a serious problem. But it's also a man-made problem that's within our ability to solve and the MCA Foundation is committed to working with our fellow Alaskans to address it.

The Alaska Coastal Management Program

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Preface

The Aleutians West Coastal Resource Service Area (AWCRSA) program coordinator has compiled this summary of the state and local coastal management programs to be included as part of the proceedings from the Aleutian Life Forum held August 10-13 in Unalaska, Alaska. The background and history material regarding the state program is extracted from the state *Handbook of Statutes and Regulations*, May 2006. The AWCRSA material is included in the local coastal management plan and on their Web site: www.alaskacoast.state.ak.us/Explore/AWCRSA.

Background and history of the Alaska Coastal Management Program

The state of Alaska's coastline consists of approximately 44,500 miles which, measured either on the tideline or measured around an average perimeter that parallels the mainland limits of the territorial sea, exceeds that of the entire continental United States. The Alaska coastal area has national and international significance for its vast, healthy ecosystems and is a generous source of renewable and nonrenewable resources, especially proven and potential energy resources. Three-quarters of Alaska's people live on or near the coast. Many earn their living from direct use of coastal resources and many more from indirect uses, such as Alaska's growing tourist industry. The Native people of Alaska maintain a cultural and economic intimacy with the coast that dates back thousands of years.

Alaska began considering comprehensive coastal management in the mid-1970s, after passage of the federal Coastal Zone Management Act of 1972. At the time, state and local interest in participating in coastal zone management resulted in part from ambitious plans for federal oil and gas leasing off Alaska's coasts. Several federal agencies managed large portions of Alaska (over 60%) and Alaska's offshore areas, affecting the economies and lifestyles of local communities. Coastal communities also argued strongly for a voice in decisions that might affect their livelihood and way of life. Increasing demands for the use and enjoyment of Alaska's rich and diverse coastal resources (such as timber production, tourism, mining, fisheries, and oil and gas development) created a need for an effective forum for responsible development and resolving local issues. From its inception in 1972, the CZMA provided the various stakeholders and Alaska's coastal communities with that forum.

The Alaska Legislature enacted the Alaska Coastal Management Act (ACMA) on June 4, 1977, (ch. 84 SLA 1977), which established the Alaska Coastal Management Program (ACMP). In passing the ACMA, the Alaska Legislature noted several issues: waterfront space scarcity, energy resource development impacts, maintaining the fisheries, managing the forest resources, transportation needs and impacts, impacts of mining, impacts of Western culture on Native cultures, providing for the Alaska subsistence lifestyle, geological hazards, changing land ownership patterns, bottomfish, and governmental regulation. To address these issues, the legislature made the following findings about the state's coastal area, which apply as much today as they did in 1977.

1. The coastal area of the state is a distinct and valuable natural resource of concern to all the people of the state;
2. the demands upon the resources of the coastal area are significant and will increase in the future;
3. the protection of the natural and scenic resources and the fostering of wise development of the coastal area are of concern to present and future citizens of the state;
4. the capacity of the coastal area to withstand the demands upon it is limited;
5. the degree of planning and resource allocation that has occurred in the coastal area has often been motivated by short-term considerations, unrelated to sound planning principles; and
6. in order to promote the public health and welfare, there is a critical need to engage in comprehensive land and water use planning in coastal areas and to establish the means by which a planning process and management program involving the several governments and areas of the unorganized borough having an interest in the coastal area may be effectively implemented.

In 1978, Alaska adopted the Standards of the Alaska Coastal Management Program and the Guidelines for District Coastal Management Programs to implement the ACMP and to implement the finding of the Alaska Legislature. The Coastal Policy Council revised the original Standards and Guidelines in 1979, and ultimately guided the ACMP to final federal approval that same year.

Since ACMP approval in 1979, 33 coastal district plans and 33 areas meriting special attention and special area management plans have been approved. Another significant development occurred in the early 198's when the coordinated consistency review process was adopted by regulation. The original ACMP did not include a specific process to determine a project's consistency with the statewide standards and coastal district enforceable policies. The regulations adopted in 1984, created the process for coordinating the permitting and consistency review of a project.

Another set of significant developments occurred in 1994 when the legislature added a section addressing consistency reviews and included the first of a series of needed reforms in the consistency review process.

The ACMP has evolved significantly since 1979. Each district coastal management plan, statutory or regulatory revision, or other program amendment that gains state and federal approval is incorporated into the ACMP. Today, two chapters of statutes, three chapters of regulations, 33 coastal district plans, and 33 areas meriting special attention and special area management plans are part of the ACMP.

In February 2003, with the penning of Executive Order 106 by the Murkowski state administration the ACMP began a major program revision. Many felt the program was duplicative with current state and federal laws and that local policies overlapped or expanded state agency authorities. Others desired a more "streamlined" process. The years that have followed have required many changes to local coastal management plans.

Objectives, intent, and approach of the ACMP

The legislature set forth the following objectives for the ACMP, which remain unchanged over its nearly thirty-year life.

1. The use, management, restoration, and enhancement of the overall quality of the coastal environment;
2. The development of industrial or commercial enterprises that are consistent with the social, cultural, historic, economic, and environmental interests of the people of the state;

3. The orderly, balanced utilization and protection of the resources of the coastal area consistent with sound conservation and sustained yield principles;

4. The management of coastal land and water uses in such a manner that, generally, those uses that are economically or physically dependent on a coastal location are given higher priority when compared to uses that do not economically or physically require a coastal location;

5. The protection and management of significant historic, cultural, natural, and aesthetic values and natural systems or processes within the coastal area;

6. The prevention of damage to or degradation of land and water reserved for their natural values as a result of inconsistent land or water usages adjacent to that land;

7. The recognition of the need for a continuing supply of energy to meet the requirements of the state and the contribution of a share of the state's resources to meet national energy needs; and

8. The full and fair evaluation of all demands on the land and water in the coastal area.

When the legislature addressed the coastal issues it identified in 1978, it developed a comprehensive management program to satisfy the requirements of the CZMA and as the general solution to managing important coastal resources, and set forth basic program policy in Section 2 of the Alaska Coastal Management Act.

1. Preserve, protect, develop, use, and where necessary, restore or enhance the coastal resources of the state for this and succeeding generations;

2. Encourage coordinated planning and decision making in the coastal area among levels of government and citizens engaging in or affected by activities involving the coastal resources of the state;

3. Develop a management program which sets out policies, objectives, standards and procedures to guide and resolve conflicts among public and private activities involving the use of resources which have a direct and significant impact upon the coastal land and water of the state;

4. Assure the participation of the public, local governments, and agencies of the state and federal governments in the development and implementation of a coastal management program;

5. Utilize existing governmental structures and authorities, to the maximum extent feasible, to achieve the policies set out in this section; and

6. Authorize and require state agencies to carry out their planning duties, powers, and responsibilities and take actions authorized by law with respect to the programs affecting the use of the resources of the coastal area in accordance with the policies set out in this section and the guidelines and standards adopted by the Alaska Coastal Policy Council under AS 46.40.

The articulation of the program's objectives from 1978 carries through to today. So does the explanation that, while the ACMP is a program of government, the private sector is viewed as a partner in coastal management. This partnership applies to the business community, public interest groups, environmental organizations and, rural interests as well as the public at large. Certainly, the ACMP has environmental goals, but these goals are part of a spectrum of management goals set forth as policies for the program by the legislature.

Continued development of Alaska's coastal resources is vital to both the state and local economies and to national interests as well. Local governments, aside from being closest to coastal issues, are also most familiar with local conditions and have the traditional political right and responsibility to govern local land use on city owned land within their municipal boundaries. Alaska is little different from other states in this respect. Thus, the reader will note an emphasis on state management and use of coastal resources, with local input on matters of local knowledge and concern. Through this management philosophy, state, local, national, and private goals and aspirations which depend on the use of coastal resources can be met through an open planning and management process where interested parties can be brought together to resolve their differences and eliminate potential conflicts before more serious problems occur.

With this in mind, the legislature called on local governments to prepare plans to govern the use of coastal resources in their areas. At the same time, a state level element was established by the formation of the Alaska Coastal Policy Council or CPC. The CPC, made up of state agency and local government officials, provided overall leadership for the program and established the basic guidelines and standards to be used by the local governments in the development of their coastal plans and by state agencies in making coastal permitting and management decisions. While the CPC no longer exists, the ACMP was designed, and continues to operate, as a "networked" program. Rather than establishing its own comprehensive coastal permitting structure, Alaska instead coordinates existing agencies' authorization and permitting authorities and processes to determine whether a given use is consistent with the standards and objectives of the ACMP.

Alaska's program is voluntary at the local level. But the networking process encourages local land use planning that, coupled with statewide policies, provide coordinated, intergovernmental evaluation of a proposed coastal project. The process involves a partnership between the project review team, the applicant, the coastal districts, state/federal agencies, and the public. The ACMP thus places emphasis upon coordination between state, local, national, and private interests in the management and use of coastal resources. The networking approach satisfies Alaska's commitment to properly manage the competing demands upon, preservation of, and sustainable use of, its precious coastal resources.

The Aleutians West Coastal Resource Service Area (AWCRSA)

The mission of the AWCRSA is to facilitate sound economic development throughout the Aleutian chain while maintaining productive stocks of fish and wildlife, air and water quality, and other natural and historic resource values. The AWCRSA is vast and encompasses all the islands of the Aleutian chain from Unalaska Island west to Attu Island, a distance of approximately 1,000 miles. The chain of islands comprising the Aleutians is 20-60 miles in width. Bounded by the Pacific Ocean to the south and the Bering Sea on the north, the AWCRSA includes nearly 200 named islands.

The gentle arc of islands that comprises the Aleutian chain forms the largest archipelago in the world. It is an area rich in natural resources, its fishing grounds home to king and snow crab, pollock, Pacific cod, rock sole, black cod, and halibut. The area encompasses pristine shoreline as well as significant prehistoric Unangan coastal sites and contemporary villages, World War II bases and battlefields, and a state-of-the-art fishing port that delivers the bulk of America's seafood catch. The vast region is rich in resources and history. The largest city is Unalaska with a population of over 4,000 people. It is an international hub for the multimillion dollar fishing industry in the Bering Sea and a transportation and economic center for the Aleutians. Atka and Nikolski are small communities with populations of about 100 and 35 respectively with largely subsistence lifestyles.

AWCRSA participation in the Alaska Coastal Management Program

The AWCRSA is one of over 30 coastal districts in Alaska that participate in Alaska's Coastal Management Program (ACMP). In the late 1980s, the peoples of the AWCRSA elected to form a local coastal resource service area. The AWCRSA is governed by a seven-member elected citizen board of local representatives with five members from Unalaska and two members from either Atka or Nikolski.

The board is responsible for local implementation of the coastal management program and supports the early involvement of local residents toward the goal of promoting activities that are mutually agreeable to all affected parties in the region. There are three procedures that aid in this effort.

- Participation in pre-development conference reviews for proposed major projects.
- Provide an opportunity for affected communities and local landowners to participate in consistency recommendation, conferences, and program amendments.
- Review draft consistency recommendations for each project prior to forwarding to the coordinating agency.

The board is also a resource for the program director, who performs several key functions to ensure that communications, administrative functions, information transfers, and consistency determinations are handled expeditiously. The program director and the board work together to implement the AWCRSA Coastal Management Plan. In addition to its enforceable components, the plan includes a wealth of narrative information on area resources as well as maps and charts. It also includes census data and community profile information, all of which are available at no charge to the public for various uses. The plan is currently in the final stages of a multiyear amendment.

Through participation in the ACMP, the people of the Aleutians are entitled to a voice in the use of resources in their area, a voice that is heard at the local, state, and federal levels.

Alaska Department of Environmental Conservation's Environmental Monitoring and Assessment Program (EMAP): Relevance to Alaskans

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Introduction to EMAP

The Alaska Department of Environmental Conservation's Environmental Monitoring and Assessment Program (EMAP) incorporates EPA's probabilistic stratified random sampling design coupled with a common set of survey indicators to provide for a statistically unbiased, objective assessment of the overall environmental condition of Alaska's waters and streams (EPA 2001).

Unlike targeted studies, EMAP is focused on the "state of the region," providing the public, communities, elected officials, and resource managers with scientifically based data of known statistical confidence, with assessments of a region's ecological resources and the likely causes of observed effects. EMAP protocols are standardized, allowing for comparability of data among the EMAP participants and allowing for better regional assessment and prioritization of stressors and impacts. In addition, EMAP provides standard methods and procedures for sharing and managing comparable data sets held in a quality controlled data management system.

EMAP provides essentially two tools to the Alaska Department of Environmental Conservation (ADEC)—first, the bio-assessment framework (integrated physical, chemical, and biological measurements) and second, the statistically based design procedures. This statistical design is critical to being able to make inferences of the aquatic ecological condition and to assess trends over time to **all waters** in a region from a subset of waters actually sampled. Targeted non-probabilistic sampling, typically designed to answer specific localized questions, cannot answer

Principal Operational Objectives for ADEC Division of Water EMAP

1. Estimate current status, trends, and changes in selected indicators of Alaska's aquatic ecological resources on a regional and statewide basis with know statistical confidence;

2. Estimate geographic coverage and extent of Alaska's aquatic ecological resources within a know statistical confidence interval;

3. Seek to establish associations between selected indicators of natural and anthropogenic stresses and indications of the condition of aquatic ecological resources;

4. Provide for statistical summaries and periodic assessments of Alaska's aquatic ecological resources.

(Adapted from EPA 1997)

regional questions, such as "What are the conditions of all the wadeable streams in Alaska in the Tanana River drainage?" EMAP protocols are designed to provide general conclusions about the biotic and abiotic conditions within a study area, which can then be used for comparison with other regions of Alaska and the United States. This type of information cannot be obtained from targeted sampling programs, principally focused on specific "problem" areas.

Need for EMAP

Alaska contains over 40% of the U.S. freshwater resources, including glaciers, over 20,000 navigable rivers, and several million lakes. Alaska has approximately 45,000 miles of coastal marine shoreline, which constitutes more than 50% of the total U.S. coastline. The surface area of coastal bays and estuaries in Alaska is 33,211 square miles, almost three times the estuarine area of the contiguous 48 states. Alaska's surface waters include over 15,000 salmon streams--an important resource to Alaskans and the world. Under the Clean Water Act (CWA) Sections 303(d) and 305(b), Alaska has the responsibility to report and identify causes and sources of water quality impairment by "**characterizing all the waters in Alaska**." This could be accomplished by taking a census of all the waters in Alaska, but it is impracticable due to budgetary and logistical concerns. EMAP's probabilistic survey sampling provides a practical, cost effective method to characterize Alaska's coastal and surface waters. EMAP's survey design is an important tool to help resource managers, elected officials, and the public see the "big picture" for large regions, with known statistical confidence, and to report on the status of Alaska's ecological resources. No similar probabilistic sampling survey studies are under way within Alaska to provide regional ecological information on such a large scale.

EMAP statewide assessments

ADEC is the lead agency for EMAP in Alaska. In 2001, ADEC developed a cooperative agreement with EPA to join collaboratively in the Western States Coastal EMAP. The Western States Coastal EMAP was initiated as one component of a national program called the National Coastal Assessment (NCA), led by EPA to survey the condition of the nation's coastal resources (EPA 2001). This agreement has lead to completion of field surveys in two of the five Alaska coastal provinces for which reports are currently being done. Figure 1 shows the five biogeographical coastal provinces.

In 2004, U.S. EPA funded a demonstration wadeable stream EMAP survey in the interior of Alaska. This was the first freshwater EMAP project funded in Alaska. It is a demonstration project and does not include fish assemblages.

The main goals of EMAP from a national perspective include monitoring the condition of the nation's ecological resources, evaluating the cumulative success of current policies and programs, and identifying emerging problems before they become widespread or irreversible. These same goals are applicable at the state level. Data from EMAP sampling are envisioned as the beginning of ADEC's statewide ambient water monitoring program that will include Alaska's coastal as well as freshwaters.

Good scientific and statistical designs remain critical for any monitoring program attempting to assess spatial and temporal aquatic ecological resources and to reliably detect trends for making sound environmental and resource management decisions.

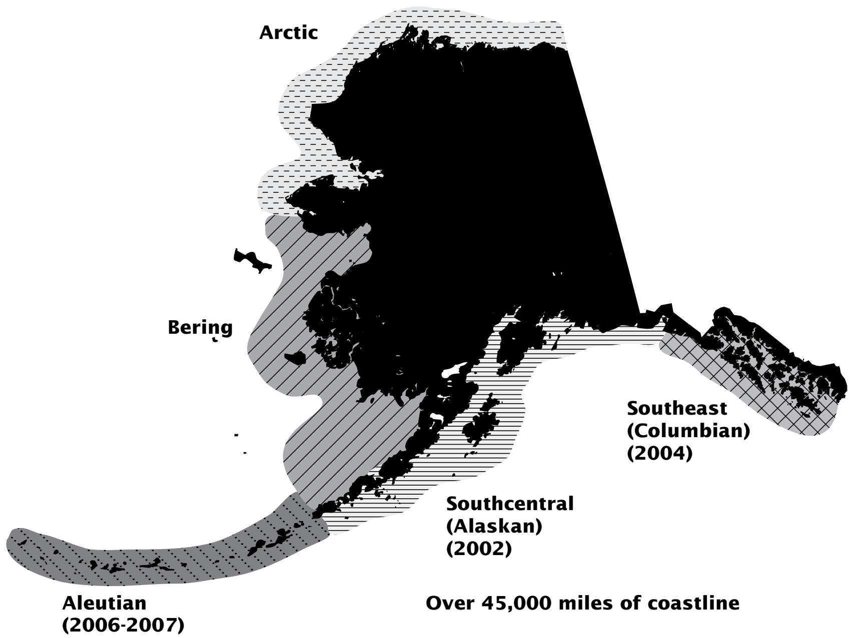

Figure 1. Alaska Coastal EMAP Provinces.

Core and supplemental indicators

EMAP protocols employ a **core** set of environmental indicators for each water resource type that include physical/habitat, chemical/toxicological, and biological/ecological endpoints as appropriate (EPA 2003). EPA recommends that this core set of indicators be monitored to provide statewide or watershed level information on the fundamental attributes of the aquatic environment and to assess water quality standards attainment and impairment status. Previously, chemical and physical indicators were emphasized; however, EPA now recommends that biological monitoring and assessment assume a more prominent role in state monitoring (EPA 2003).

EMAP also utilizes **supplemental** indicators when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core indicators indicate impairment, or to support a special study such as screening for potential pollutants of concern (EPA 2003). Supplemental indicators are often key to identifying causes and sources of impairments and targeting appropriate source controls. Supplemental indicators may include each water quality criterion in the state's water quality standards, any pollutants controlled by the National Pollutant

Discharge Elimination System (NPDES) permits, and any other constituents or indicators of concern (EPA 2003).

As ADEC tests and evaluates the EMAP core and supplemental indicators, changes will likely be made to reflect Alaska's ecosystems and specific environmental and resource management requirements. One example, reflecting specific ecosystem conditions, is the addition of hard-bottom benthic habitat surveys to the Aleutian EMAP, because of the large percentage of the coastal zone containing hard- rather than soft-bottom sediments. Similar adaptations were made in Hawaii and Guam. An example of changes necessary to the freshwater EMAP would be the addition of trace metals in stream sediments to assess water quality impacts from mining activities occurring in Alaska's watersheds.

Monitoring frequency

ADEC's current focus is to complete the initial EMAP surveys of the five coastal provinces, thereby providing the first ecological benchmarks for these regions. In the national EMAP program, five years has been considered the potential recurring sample interval, but alternative sampling schemes are being developed and assessed by EPA and individual states.

Once ADEC, EPA, and other partners have had the chance to assess the results of the Southcentral and Southeast Coastal EMAP sampling efforts, a long-term integrated probabilistic and targeted monitoring program will be implemented. Monitoring frequency cannot yet be determined, but should not be less than every five years. Monitoring frequency will also be dependent on establishing the infrastructure, stable financial resources, and partnerships required to implement a comprehensive statewide EMAP program. Without building these, it is not likely that EMAP will be carried out beyond the initial EPA funding period.

Program development, support, and infrastructure

The EMAP coastal and wadeable stream programs are demonstration projects to test the EMAP assessment strategy. For ADEC this represents a "proof of concept" or a chance to test, further develop, and tailor EMAP's methods to Alaska's environment, such as sampling design, indicators of condition, sampling procedures, and standardized assessment methods.

Once the initial benchmark EMAP surveys are completed, ADEC must assess the results and then, when and where appropriate, adapt the future EMAP sampling design. The results assessment is especially important in regard to having proper indicator conditions and sampling procedures for Alaska. For example, while it is useful to have a single test species for the west coast EMAP sediment toxicity test, the test organism may or may not reflect the toxicity of the sediments to Alaska organisms. After this is done, the repeated EMAP activities can be integrated as a component of the statewide monitoring and assessment network.

ADEC is planning to survey the three remaining coastal regions during the next six years, but this will require an EPA commitment of funding and development of many partnerships, neither of which are in place at the moment. ADEC is responsible for implementing Alaska's EMAP activities, but to enhance its technical and logistical capacity ADEC must seek out and form partnerships with other federal, state, and local agencies and organizations. Capacity building remains a crucial aspect of ADEC's initial EMAP implementation strategy for Alaska.

An ADEC/University of Alaska memorandum of understanding (MOU), incorporating a joint Alaska Monitoring and Assessment Program (AKMAP) effort, provides a vehicle to build this capacity. Objectives of the MOU are to facilitate cooperative research effectively utilizing the unique resources of each organization, to support environmental and resource management decision-making and problem solving, and educational activities in Alaska. Two goals expressed in the MOU are of practical importance in building EMAP capacity:

- Support and enhance ADEC's EMAP to assess the baseline water quality of Alaska's marine and freshwaters, during the period of the MOU agreement (November 17, 2004–June 30, 2007)
- AKMAP will focus on applied research on the status and trends of Alaska's air, land, and water resources to support environmental and resource management decision-making.

Other partnerships, using various memoranda of understanding, interagency agreements, and subcontracts with other agencies, not-for-profits, contractors, or vendors will be an important part of the implementation effort.

Relevance to communities

Many of Alaska's current and future resource development activities and growing population centers are located along or near the Alaska coast. Now it will be advantageous for ADEC to establish benchmark conditions for the marine and freshwater aquatic resources in these regions. These benchmarks will be an important tool for resource managers monitoring impacts from future resource development, and key to building an adaptive management strategy.

As the data are collected, compiled, and evaluated, ADEC will be able to describe Alaska's coastal and freshwater benchmark conditions for water chemistry, for toxic compounds in sediment and fish tissue, and for benthic infauna and demersal fish distribution and abundance. These data may be used in future focused studies targeting specific locations that exhibit elevated levels of toxic compounds in sediment of fish tissue, show anomalies in benthic infauna, or show anomalies in fish pathology, distribution, or abundance.

Data gathered by the EMAP may be used to

- Determine the extent Alaska's streams, lakes, and coastal waters meet some predetermined reference or water quality condition.
- Determine if an association exists between the status of aquatic resources and the most important natural or anthropogenic stresses.
- Help to determine the effectiveness of ADEC's pollution control measures.
- Revise, develop, or modify existing water quality standards.
- Help develop new water quality criteria, such as nutrients.
- Integrate repeated EMAP assessments to assess and forecast trends in monitored indicators into adaptive management practices.
- Evaluate if ADEC is making the correct regulatory decisions for protecting Alaska's aquatic resources.

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Community-Based Water Quality Monitoring: Keeping Alaskans Involved in Clean Water Protection

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Background

Throughout the United States, citizens have been collecting valuable information on the health of their local environment for over 30 years. At least 750 organizations, involving more than half a million people, are actively involved in watershed monitoring across the nation. As state and federal budgets for water quality monitoring continue to decline, more and more citizens are stepping forward to help gauge the health of our public resources. These programs serve two purposes: (1) to provide an opportunity for the community, youth, landowners, and planners to learn about local water resource characteristics and problems, thereby fostering a sense of stewardship for those resources, and (2) to provide data for federal, state, tribal, and local water quality agencies and private organizations for use in watershed planning, assessment, reporting, and water quality management.

The National Directory of Volunteer Monitoring Programs indicates there are several key users of the data collected by volunteer groups, including the groups themselves, state, local and federal governments, universities, and other community organizations. Eighty-five percent of the monitoring groups use the data for their own purposes, 56% report that state governments utilize the information, and 55% indicate that local governments are using the information. Data use by a government agency is often a function of the quality assurance/quality control (QA/QC) measures instituted by the volunteer monitoring program. Forty-five percent of the groups indicate that they have a quality assurance plan, with 27% indicating that it is state approved, and 18% report that their plan is EPA approved (EPA 1998).

Volunteer-collected data are used to determine baseline conditions, to screen for potential water quality problems, as a component in Clean Water Act reporting, and as a means to monitor restoration efforts. In Oregon, watershed councils are using volunteer-collected data as baseline measurements to detect changes in water quality that may result from land use changes. The Oregon Department of Environmental Quality uses volunteer-collected continuous temperature data to determine where sampling should be focused for total maximum daily load (TMDL) assessments (Williams 2000). The use of volunteer data for screening purposes can be an extremely important component to overall state monitoring programs because it allows for cost-effective preliminary assessment of water quality.

Citizens' Environmental Monitoring Program

In 1996, Cook Inletkeeper and the Homer Soil and Water Conservation District established the Citizens' Environmental Monitoring Program (CEMP) to actively involve citizens in collecting reliable water quality data in the Cook Inlet Basin. Educating people about their natural resources, discussing the impacts we have on our environment and what that means to water quality, and the benefit of having more eyes watching out for watershed and estuarine health are reasons enough to engage volunteers in monitoring their streams and bays. However, with dwindling resources for water quality monitoring at both state and federal levels, the need for volunteer-collected data is increasing in Alaska, especially when the monitoring program is well designed and institutes quality assurance/quality control measures.

With EPA funding passed through the Alaska Department of Environmental Conservation (ADEC) and guidance from a technical advisory committee, Inletkeeper developed a Kachemak Bay Pilot Project as a working template that could be adopted by other groups interested in conducting citizen-based monitoring programs. The objectives of CEMP are to (1) inventory baseline water quality in the Cook Inlet basin, (2) detect and track water quality trends and report significant changes, and (3) raise public awareness of the importance of water quality through hands on involvement. Water quality parameters, data quality objectives, and site selection criteria were developed with a technical advisory committee (TAC) made up of professionals representing various federal, state, and local agencies and diverse scientific backgrounds.

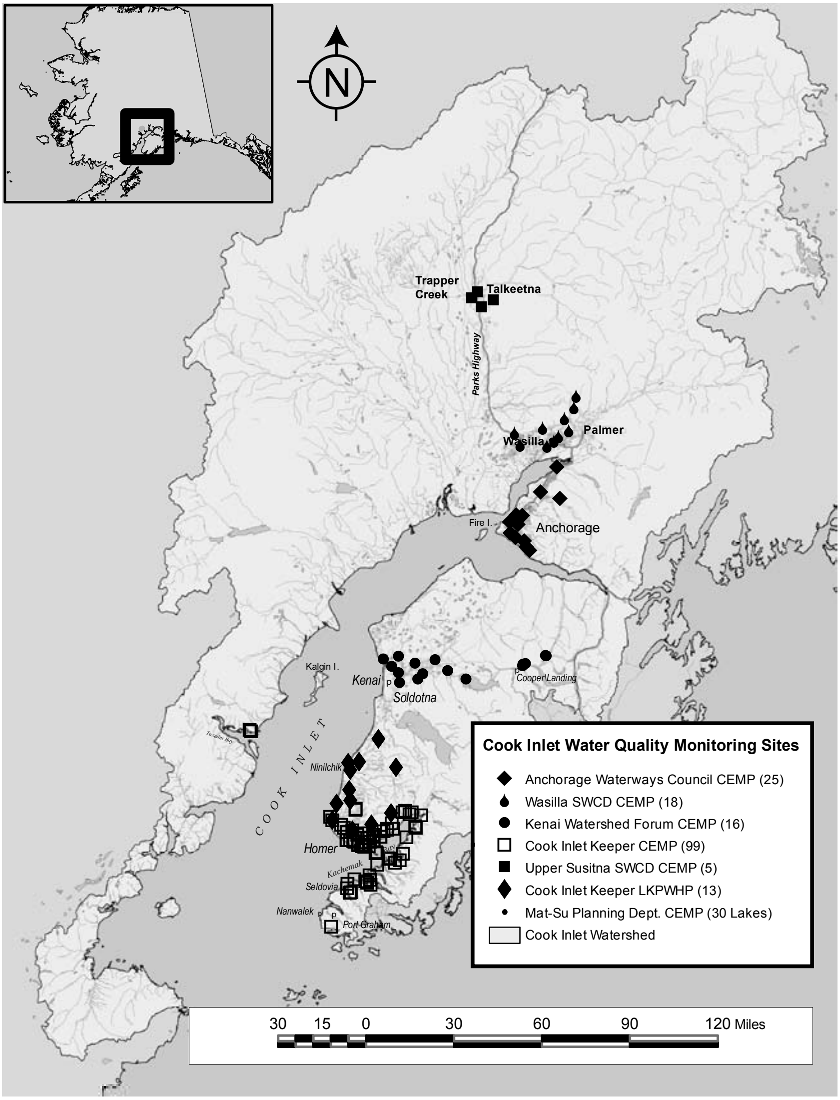
With assistance from the TAC, Inletkeeper selected water quality parameters that were relevant to the concerns citizens had about increasing urbanization and the impact on local streams. Testing methods were chosen that have proven successful in citizen-based programs throughout the United States. Primary parameters (water temperature, turbidity, dissolved oxygen, pH, and salinity) are measured using standard EPA-approved procedures and/or methods which are in use by established citizen volunteer monitoring programs (e.g., Friends of Casco Bay's Citizens Water Quality Monitoring Program, Texas Watch's Volunteer Environmental Monitoring Program). Methods for additional parameters (conductivity, nitrate-nitrogen, orthophosphate, apparent color, fecal and total coliform bacteria) are taken from the publication *Volunteer Estuary/Lake/River/Stream Monitoring: A Methods Manual* published by U.S. EPA.

To ensure adequate quality assurance oversight and consistency of CEMP data, Cook Inletkeeper produced a Quality Assurance Project Plan (QAPP) in 1998, which describes both how the program is managed (quality assurance) and how its technical activities are carried out (quality control). Quality assurance and quality control measures outlined in the QAPP include training requirements, recertification procedures, blind performance evaluation standards, duplicate sample analysis, and split sample analysis with a state-certified laboratory (Cook Inletkeeper 1998). CEMP data are compiled annually and submitted to the ADEC and distributed to concerned citizens, decision makers, resource managers, and others, as well as made available on Inletkeeper's Web page.

Cook Inletkeeper has trained 285 volunteers in the Kachemak Bay watershed since 1996. In addition to bringing water quality exceedances to the attention of the ADEC, CEMP gets citizens out into their watershed. The value of this is illustrated by an occurrence on the banks of McNeil Canyon Creek. A Department of Transportation (DOT) sand/salt pile had eroded into the creek, causing increased sediment loads and high conductivity readings in the stream. Thanks to a volunteer monitor who pointed this out to DOT, the pile was moved, filtration fabric fences were erected, and the bank was re-seeded to help prevent further erosion. An incident like this may have gone unnoticed without regular site visits by volunteers collecting water quality data.

CEMP Partnership of the Cook Inlet Watershed

Since Cook Inletkeeper established Alaska's first consistent and coordinated volunteer water quality monitoring program in 1996, other groups have requested Inletkeeper's assistance in establishing volunteer monitoring in their communities. Through these collaborations, the CEMP Partnership of the Cook Inlet Watershed has evolved and includes the Anchorage Waterways Council, Cook Inletkeeper, Environment and Natural Resources Institute, University of Alaska Anchorage, Kenai Watershed Forum, Matanuska-Susitna Borough, and Homer, Wasilla, and Upper Susitna Soil and Water Conservation Districts. The partnership has been working to integrate the interests and concerns of the


N
Trapper Creek
Talkeetna
Parks Highway
Wasilla
Palmer
Fire I.
Anchorage
Kalgin I.
Kenai
Soldotna
Cooper Landing
COOK INLET
Ninilchik
Homer
Kachemak
Seldovia
Nanwalek
Port Graham
Cook Inlet Water Quality Monitoring Sites
Anchorage Waterways Council CEMP (25)
Wasilla SWCD CEMP (18)
Kenai Watershed Forum CEMP (16)
Cook Inlet Keeper CEMP (99)
Upper Susitna SWCD CEMP (5)
Cook Inlet Keeper LKPWHP (13)
Mat-Su Planning Dept. CEMP (30 Lakes)
Cook Inlet Watershed
30 15 0 30 60 90 120 Miles

Native communities throughout Cook Inlet and, in addition, is working with the Native American Fish and Wildlife Society to share examples of methods, protocols, and quality assurance information. After ten years of data collection, Cook Inletkeeper and its partners have gained an understanding of monitoring techniques that work with volunteers, parameters that are most indicative of watershed/estuarine health, and how many volunteers can be maintained over time.

Salmon Stream Monitoring Program

In 1998, in partnership with the Homer Soil and Water Conservation District, Cook Inletkeeper began a new water quality monitoring program on four salmon-bearing streams: Ninilchik River, Deep Creek, Stariski Creek, and Anchor River. Using EPA-approved or standard methods, Inletkeeper's stream ecologist monitors twelve sites for discharge, temperature, dissolved oxygen, pH, conductivity, nitrate-nitrogen, ammonia-nitrogen, orthophosphate, total phosphorus, apparent color, turbidity, settleable solids, total suspended solids, and bacteria. Monitoring goals are to (1) inventory baseline water quality in lower Kenai Peninsula's salmon streams, (2) compare data with state water quality standards, and (3) inform citizens and natural resource managers about concerns related to salmon stream protection.

The Salmon Stream Monitoring Program was developed under the direction of a technical advisory committee (TAC) of scientists from federal and state agencies as well as industry. The TAC chose sampling sites, determined the sampling frequency, and reviewed the chosen methods to best address concerns related to salmon stream health. Sampling and analysis methods were chosen so that data could be compared with data from other professional-level studies both in Alaska and around the United States. All quality assurance methods are described in the Quality Assurance Project Plan (Cook Inletkeeper 2000).

In November 2004, the two partners published their sixth annual report that presents water quality data collected from August 1998 through June 2004 (Mauger 2004). This comprehensive report offers a preliminary water quality assessment of the four rivers. Based on the baseline assessment, water quality is generally high; however, monitoring on the lower Kenai Peninsula's salmon streams reveals that summer temperatures consistently exceed Alaska's standards and may pose risks to these culturally and economically valuable streams.

With assistance from the TAC, the Salmon Stream Monitoring Program was redesigned to address water temperature concerns. Water temperature is one of the most significant factors in the health of stream ecosystems. Temperature affects salmon egg and fry incubation, fish metabolism, organisms' resistance to disease, and availability of oxygen and nutrients to fish and wildlife. Temperature loggers (StowAway

TidbiTs by Onset Corp.) were deployed to collect data at 15-minute intervals to quantify how many hours per day and how many days per season salmon stream temperatures exceed state standards. In 2005, each stream surveyed exceeded temperature standard on more than 80 days. Significantly, temperatures have also been recorded above 20°C (68°F), which by state standards "shall not be exceeded." On the Anchor and Ninilchik rivers, the number of consecutive days with temperatures consistently above 15°C is increasing and may influence timing of migration to spawning grounds. Monitoring has been instrumental in identifying this temperature trend and illustrates the need to consider implications of both climate change and land use in our land and fish management decisions.

Cook Inlet Community-Based Water Quality Laboratory

In 2004, Cook Inletkeeper opened the Cook Inlet Community-Based Water Quality Laboratory, which has allowed Inletkeeper to expand its water quality monitoring capabilities. The lab, which employs professional chemists, provides analytical services to a variety of agencies and not-for-profits. In addition, volunteer monitors use the laboratory regularly to conduct water quality analysis, training, and annual recertification. The Cook Inlet Community-Based Water Quality Laboratory is an exciting development and will provide tremendous opportunities for expanding CEMP partners' and Cook Inletkeeper's capacity to monitor water quality.

Summary

Cook Inletkeeper was the first community-based organization in Alaska to start a federal and state-approved citizen-based water quality monitoring program, and has been praised by the Alaska Department of Environmental Conservation for "laying a credible foundation that establishes the role of citizen monitoring as part of a comprehensive watershed management program from which all Alaskans can share in its rewards, both now and into the future." Through observations and education, Cook Inletkeeper has encouraged watershed stewardship in Cook Inlet. As a result of its success, Cook Inletkeeper has become the support center for other community-based water quality monitoring programs in Southcentral Alaska.

The structure, methods, design, and quality assurance/control guidelines developed for the Citizens' Environmental Monitoring Program and Salmon Stream Monitoring Program are relevant to communities beyond Cook Inlet. Although some of the issues and concerns may be different in more remote locations, the citizen-based template is readily transferable to other motivated community organizations. With a thorough assessment of needs and objectives, development of a technical advisory group and careful attention to quality assurance/control measures, Alaskans across the state can play an integral role in clean water protection.

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Extending the Functionality of the Consumer-Grade GPS for More Efficient GIS and Mapping Applications

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Abstract

This paper presents a methodology for extending the geospatial data collection functionality of the consumer-grade GPS for circumstances that previously required very expensive equipment, software, and training. The approach presented here involves the use of a waypoint naming protocol based on a user-defined data dictionary. These two procedures, used with a relational database and a geographic information system, can assist communities, organizations, and agencies in the collection of high quality, accurate, and sophisticated geospatial data under circumstances where funds and expertise are limited or nonexistent. Furthermore, the applications of this system are limitless. This paper discusses the applications of these protocols in fields relating to disaster response and assessment, trail mapping, and coastal resource assessment. Other applications are also discussed.

Introduction

The GPS is a ubiquitous tool on the planet today. Its ability to pinpoint a person's position on the globe, and store information about that location has been a significant contribution to society in the latter twentieth century. In general, the GPS receiver is small, portable, and inexpensive. It is found in nearly every manner of technical, recreational, military, and civil geospatial data collection applications.

Currently, the systematic collection of geospatial attribute data is limited to very expensive GPS receivers and specially trained personnel. The general procedure for collecting geospatial attributes with the consumer-grade GPS has required the use of “add-ons,” such as handheld computers, laptops, and palm pilots. These add-ons are frequently outside of the financial and technical reach of many communities, organizations, and underfunded agencies. The protocols and procedures presented here are designed to modify and merge existing methods and technologies to overcome these financial and technical barriers.

Methodology

The GPS provides four major data collection functions: (1) precise location (waypoints); (2) precise time (a date/time stamp at waypoint collection); (3) a name for that location; and (4) tracks (routinely collected by the GPS, which in turn can display an area surveyed).

While items (1), (2), and (4) are self-descriptive, item (3) is the data collection engine for this naming convention protocol. It is in the waypoint name that the user is able to record specific data attributes about that location. For example, currently and commonly the waypoint name provides a location attribute such as “Home,” for a persons’ domicile or an abbreviation like “ST_J_LK,” for a place like St. John’s Lake. In the GPS receiver’s small database, the waypoint name is also the primary key field, in which no two names can be alike. A common number of character spaces provided on today’s GPSs is ten, and the number of available alphanumeric characters is 36 (10 numerals and 26 letters).

By using a data dictionary and a set of data structures for the waypoint name, even casual GPS users can provide organizations with high quality, accurate, and sophisticated geospatial data. These data, created with the waypoint name, are both a unique descriptor for that location and the primary key value for the relational database. Also, once the waypoint name is parsed, a set of data fields are created with very specific attribute information about the location surveyed. At a minimum, the waypoint name and subsequent parsed fields should describe the GPS (including the operator), data ID, and something about that location. In the event of an oil spill, additional data might include information on shoreline type, presence of oil, vegetation, birds, mammals, and fish. An entire list of possible items need not be included in the lists to describe the shoreline, vegetation, etc.--just those most common to the area. All of the fields created in and parsed out from the naming convention will be sorted out in the relational database management system (RDBMS).

Prior to any field use, a data dictionary should be established. The nature of the survey will determine the format and content of the naming protocol and structure. For example, a set of protocols for mapping out a trail system might only have five data entries in the name: GPS ID, Trail ID, Data ID, and Trail Attribute ID. The number of character spaces allotted for each data ID will depend on the number of items involved in the survey. If you do not expect to ever have more than 36 GPS receivers in your database, then one character space will be enough. The same is true for the number of trails to be surveyed. On the other hand, if the number of GPS units (or trails) can be expected to exceed the amount of 36 over the life of the project, then two character spaces should be allocated. Two character spaces will provide 1,296 alphanumeric ID combinations. So, a small trail mapping project might only have one character space allocated for the GPS ID, one space allocated for the Trail ID, two spaces assigned to the Data ID, and one space allocated to the Trail Attribute ID. The waypoint name might look like this: “270C4”. This waypoint name, parsed out in the database, provides the following information: GPS #2 (owner, make and model); Trail #7 (St. John’s Lake Trail, 23.8 km, moderate difficulty, average round trip speed 6-8 hours); Data ID #0C (the 12th data entry for that trail); Trail Attribute ID #4 (a bridge). Connect these data into a GIS and you have a trail made from tracks whose symbology indicates moderate difficulty and a waypoint on that trail that indicates a bridge. This same set of protocols and database design can now be modified for search and rescue (SAR): Trail ID becomes Sector ID; and the Trail Attribute ID becomes Hazard/Item of Interest Attribute ID. Everything else stays the same.

Now imagine, 15 SAR personnel going out looking for a lost hiker. Each has a GPS receiver turned on, recording their tracks. Each member of the team also has a waypoint naming convention key that explains how to enter the waypoint name. As each person returns to base, the data in the GPS are downloaded directly into a database and immediately displayed in the GIS for review and analysis. At the end of the day a map document is produced of their efforts, with minimal effort and within a few minutes.

Coastal oil spill model

Often when an environmental disaster strikes, the nearest local community is the first to know and the first to respond. Federal and state government resources, along with private contractors, though experts in their field, often take days to fully mobilize. During that time, precious information is lost through the absence of data. This is an opportunity where members of the community, with local knowledge of plants, wildlife, and terrain, can be mobilized to collect high quality, precision data with simple, consumer-grade GPS receivers.

A resourceful community will have a flexible response plan in place and will have practiced that plan. The elements of a response plan are likely to look like the following outline:

- Purchase GPS units (or find out who has them).
- Develop a data dictionary.

Selandang Ayu Data Model (Emergency Response)

Charater Space									
Id Type	GPS ID	Data ID	Beach Type	Oil Present	Veg Type	Animal	Bird	Marine Mammal	Fish
Possible Choices	36	1296	33 + 3	2	33 +3	33 +3	33 +3	33 +3	33 +3

Some fields will require 3 reserved characters:
0 NOT PRESENT
1 NOT KNOWN
Z OTHER

... Leaving you with 33 characters for specific assignment

Figure 1. GPS waypoint naming convention for the oil spill model.

- Develop a database (relational database management system or RDBMS).
- Store the data dictionary in the RDBMS (this can then be printed and distributed on a moment's notice).
- Simulate emergency situations and train with the GPS receivers and GIS resources.

In Fig. 1, it is important to note that several of the fields only allow for the specific choice of 33 values, where three input values are reserve characters for Not Present (0), Not Known (1), and Other (Z). This is particularly useful when a single character space is being used to identify an attribute. In many cases, 33 variables will be enough to identify the presence of a common feature of concern

Data collection

Once an emergency has been identified it will be important to contact community members with knowledge of all aspects of the local geography, including the weather, vegetation, and wildlife. Next, pass out GPS receivers, the naming convention keys and a map, along with a track line or area to cover.

In the field, the waypoint data are collected according to established protocols. This means that each waypoint is given a name, and each character in the waypoint name corresponds to a specific attribute value in the data dictionary and that attribute value is specific to the location in the waypoint name. A written record is made of the data point, and this includes the following.

- Time of data entry.
- Waypoint name.

- Attributes identified.

Additionally, tracks from the GPS are collected according to protocol. Most likely this will simply involve setting the "polling" rate or the position data collection rate at a specific interval. This may be a standardized rate of 10, 20, 30, or 60 seconds, or it may vary with each GPS in order to distinguish one GPS unit from another.

Data integration

Upon returning from the field, each member of the data collection team needs to download the data from their GPS and load them into the relational database management system (Fig. 2). This may be a direct download to the database, or it may involve more steps. For the purpose of this protocol set, we will use more steps to ensure data quality. This is more likely to be necessary if you are using members of a community who have not had much training in emergency procedures or GPS units.

To begin, download the raw waypoint and track data from GPS to a text file. Next, label this file with the date of data collection (in reverse format), the letter "r" (indicating raw data), underscore, and first waypoint name (i.e., "060416r_0101011). By including the first waypoint in the file name you will be identifying the GPS (possibly the user) and the area surveyed.

Next, import the file into a spreadsheet. This will allow for easy and efficient data checking and editing if necessary, essential for quality control. Each user should be responsible for checking their own data for accuracy. If necessary, this should be done with a member of the GIS team.

Next, import the "clean" data (waypoints and tracks) into the database. All of the waypoints can go into a single table. The waypoint naming convention ensures that each waypoint can effectively be used as a primary key value. Additionally, the naming convention allows for extracting information related to a single GPS or survey area. The database administrator may want to import track data into tables designed for each GPS. This would be the easiest and most effective way to distinguish one set of GPS tracks from another.

Data management

The RDBMS will need to have a set of reference tables and transaction tables. The example set listed below uses the Unalaska Trail Mapping Project (UTraMP) model. The UTraMP model is particularly useful in that it is the easiest to understand and modify for single attribute acquisition, like stream surveys or search and rescue operations.

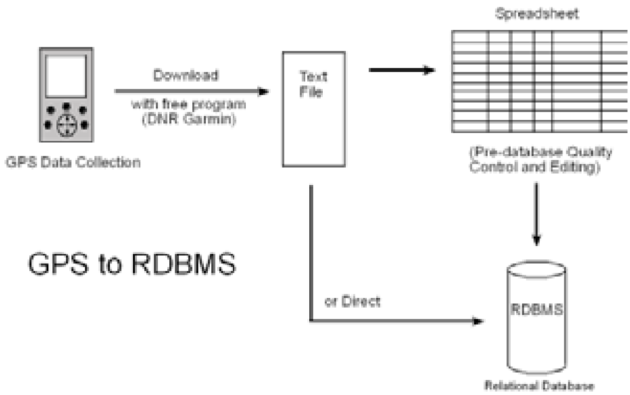

Figure 2. Data flowing from the GPS unit to the relational database management system (RDBMS).

UTraMP reference tables

GPS reference table (tbl_GPSId):

- cGPS_ID (GPS receiver ID number in the database).
- cGPS_Make (manufacturer).
- cGPS_Model (model of GPS).
- cGPS_SN (serial number).
- cGPS_Owner (owner or operator).
- cGPS_Name (written on the case of the GPS, i.e., "CRC-1"; in this case it meant the first GPS unit for that organization. Others were labeled CRC-2, CRC-3, etc.).

Trails reference table (tbl_TrailInfo):

- cTrail_ID (trail ID number in the database).
- cTrail_Name (name).
- nTrail_Length (the trail length in linear distance).
- nTrail_Time (the amount of time it takes to go out and come back).
- cTrail_Difficulty (on a scale of 1-3).
- Trail attribute table (tbl_WayPtsId):

- cTrail_AttributeID (this was the primary key value for the table and the waypoint key value for the naming protocol).
- cTrail_AtributeDescription (this was the description of the ID value, i.e., 1 = Start of trail; C = Cabin. Note that the Attribute ID was a mnemonic to the description).

UTraMP transaction tables

GPS waypoints table (tbl_WyPts):

- cType (this field is information generated by the GPS unit to indicate whether the datum is a waypoint or track point).
- cWypt_Name (a user-defined field, in this case, this is where the attribute information for the specific location is stored).
- nLat (latitude, generated by the GPS receiver).
- nLon (longitude, generated by the GPS receiver).
- dtTime (time and date, generated by the GPS receiver).

GPS tracks table (tbl_Trax):

- cType (this field is information generated by the GPS unit to indicate whether the datum is a waypoint or track point).
- nLat (latitude, generated by the GPS receiver).
- nLon (longitude, generated by the GPS receiver).
- nAlt (based on the GPS datum, generated by the GPS receiver).

Data manipulation

Data manipulation is done through the use of queries--either by combining tables or queries of related data and/or running calculations on them. In this database, the common data manipulation is parsing the waypoint name field (cWyPt_Id) and "joining" or linking the newly created parsed fields with the primary key fields of the associated attribute table.

Figure 3 is an illustration of the data flow for the *Selendang Ayu* data model for oil spills. The illustration is simplified from the actual RDBMS. In the actual RDBMS all data tables become queries before any relation is applied. This is done as a precaution to protect the integrity of the original data.

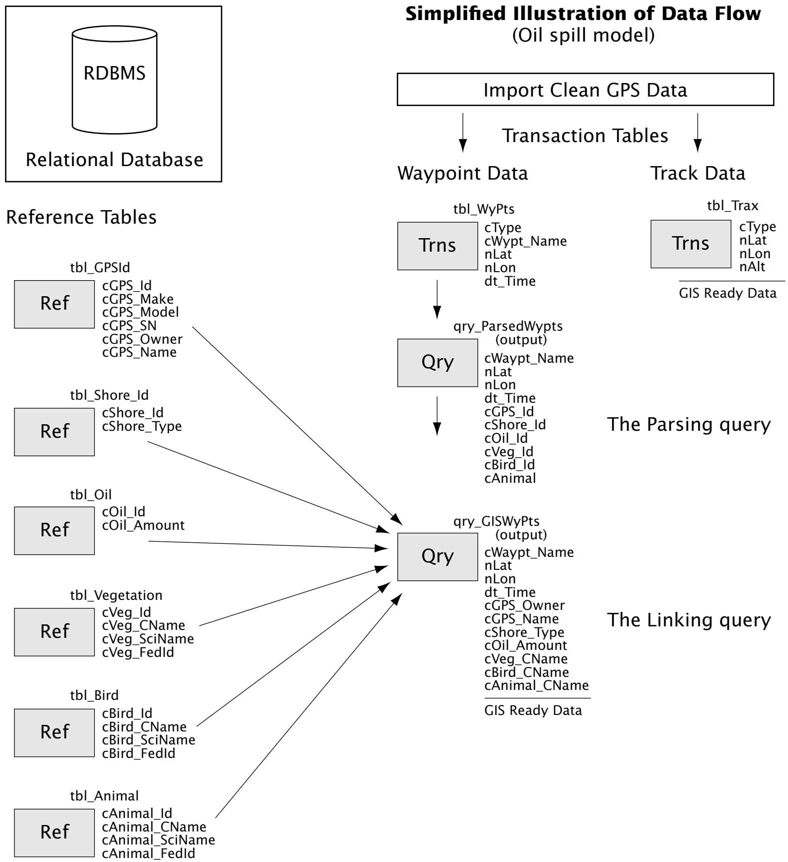

Figure 3. Minimum database structures for the oil spill collection model.

Data analysis

At this point, the geospatial data are ready for visualization in a GIS. Now the management team can see what areas have been surveyed, who surveyed them, and what was found. Most likely, you will have had to acquire or create our own base maps. You will have had to ensure that all of the maps and data are in the same projection with the same data, and you will have had to create symbology for the different attributes of your data.

At this point, you are also ready to perform advanced analysis on your data. From here you can buffer points and lines, and use other tools that will allow you to clip, merge, and intersect your GPS data with other map features. Also, if this were a disaster, you could use advanced statistical calculations on the collected data in order to evaluate the nature and spread of a given contaminate. If this were a SAR operation, a view shed analysis could be performed from the elevation of the hiker and a maximum area of observation could be obtained.

A coastal resource assessment protocol has been investigated using this protocol. At present it is still in development. It was originally a modified version of the oil spill model, but going through a list of items and plugging them into a GPS was overly tedious and time consuming. A possibly better model, soon to be tested, involves limiting the number of items of concern to subsistence species or indicator species or both. In this case the data field would identify either a Boolean value of either presence or no presence, or presence and quantity.

Summary

The elimination of Selective Availability and the incorporation of Wide Area Augmentation System (WAAS) and Differential Global Positioning System (DGPS) have greatly increased the accuracy and precision of the consumer-grade GPS. This new, high precision tool has the potential to greatly expand the resources of communities to respond to challenging situations that require immediate geospatial information. Additionally, having this information and the knowledge that comes with it, as an emergency unfolds, can empower a community to make better decisions with the hope of a better outcome.

Acknowledgments

The author would like to thank Wendy Svarny-Hawthorne and the shareholders of the Ounalashka Corporation for their support in the UTraMP project. Without them this protocol concept and method could not have been so rigorously field tested. Further thanks go to University of Alaska Fairbanks professors Anupma Prakash and Michael Sfraga, both of whom gave their time and support to write up this project. Anupma was kind enough to read and comment on several drafts. Finally, Tom Heinrich from the Geographic Information Network of Alaska encouraged this project and helped clean up several working drafts of this document. His kindness and talents are greatly appreciated.

2006 Alaska Green Crab Monitoring Program

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Background information

Certain species have established invasive populations in several locations around the world, and these "repeat invaders" provide opportunities to assess factors that promote invasions. Such repeat invaders are typically characterized by life-stages that interface with established transport systems, are ecologically adaptable, and have broad physiological tolerances. Once established, an invasive population often expands its range to the limits of its physiological tolerances set by climate and/or biogeographic barriers created by ocean current systems. Human-mediated transport may facilitate range expansion at a faster rate than natural dispersal and may surpass natural barriers (Hines et al. 2004).

Carcinus maenas, commonly known as the green crab, is a native inhabitant of Europe, from Norway to Mauritania, and has invaded several locations around the world. The species has had established populations on the east coast of North America since the early 1800s and has more recently arrived in San Francisco Bay where it was first seen in 1989. Since that time, the green crab has spread northward along the coast to Washington state. Adult crabs have most recently been found as far north as British Columbia, although juvenile populations have not been found there. As recently as 1999, the long established population on the east coast of North America suddenly expanded its range northward around Nova Scotia and into the Gulf of St. Lawrence. Thus, natural dispersal of green crabs along the west coast may allow this invasive population to spread to Alaska (Hines et al. 2004).

Habitat and physiological tolerances

On the West Coast, the green crab is found primarily in protected embayments with soft sediments (Grosholz and Ruiz 1996). On the East

Coast and in Europe, the green crab is also found on hard substrate in protected embayments and on the outer coast (Grosholz and Ruiz 1996). They can be found in a wide range of temperatures (22°C to –1°C) and salinities between 10 and 33 ppt. Green crabs feed on benthic invertebrates, mainly on mollusks and crustaceans (Hines et al. 2004).

Laboratory experiments indicate that self-sustaining, reproductive populations are probably more limited by temperatures needed for larval development. Larval survivorship dropped below 12.5°C in those experiments. NOAA field data indicate that many coastal locations in Alaska have a sufficient thermal dose (days above 10°C) to complete development to juvenile crab stage (Hines et al. 2004).

Threats

Green crabs have a significant impact as predators on many invertebrates, especially bivalves. They also survive prolonged periods of starvation, up to three months, by lowing their metabolic rate. The diverse food items in their diet include bacteria along with sediment, carrion, marsh vegetation, algae, worms, crustaceans (including crabs), insects, mollusks, urchins, and tunicates. Their diet differs throughout the life cycle and from site to site (Behrens Yamada 2001).

Human-mediated transport

The main vector for species transport is ballast water. Large cargo vessels use water inside special tanks for stability during voyages when they are carrying less than a full load. Typically, millions of gallons of water are pumped into these tanks in one port and discharged into another (Behrens Yamada 2001). Oil tankers uptake ballast water in west coast ports for their voyage to Valdez, Alaska, where they offload from 100,000 barrels to 400,000 barrels of ballast water directly into Port Valdez.

The green crab research program in Alaska

Objectives

There are two objectives for the green crab research program in Alaska.

1. To establish a network of sites to detect the arrival and spread of green crabs in Alaska waters, and

2. Provide outreach and educational opportunities to young Alaskans on the issue of nonindigenous species in their ecosystems.

Implementation of network

These objectives will be accomplished by trapping on a regular basis beginning in May 2006. A group of researchers from the Smithsonian Environmental Research Center (SERC) initiated the sampling for Valdez in 2000 and instructed a local group of researchers so they may continue the sampling in following years and expand the program to other coastal areas of Alaska. The local teams will collect crabs and data about the crabs such as size, species, and habitat.

Ten locations will be examined: Homer, Cordova, Seward, Kodiak, Tatitlek, Chenega Bay, Unalaska, Whittier, Ketchikan, and Valdez.

Methods

Permits are needed for scientific collection and must be carried during sampling activities. The Alaska Department of Fish and Game issues the appropriate permits for collection as specified in this protocol. Persons working under direct supervision of the researchers of this project are covered as well. To inquire about individual permits for your institution contact Jeri Museth at ADFG, at (907) 465-6149.

Schedule

According to Ted Grosholz (University of California at Davis, working in collaboration with SERC), trapping should be done in the spring and early summer. An optimum schedule for trapping is once per month from April to July. Traps should be placed in the field at low tide and remain in the field for a 24 hour period so that full tidal and day/night cycles are included.

At each location in Alaska, 24 traps will be deployed and will be distributed in the following manner. Three sites will be chosen within each embayment (location). At each of these sites, eight traps will be deployed. They will be set out in pairs every 25 meters at the low-mid tide level. When all traps are deployed at a site, there will be two pairs of traps every 25 meters for 100 meters.

Packet instructions

To deploy minnow traps or Fukui fish traps

Plastic (or wire) minnow traps that have an entrance opening of 1 inch should be modified to have an opening of 2.5 inches. The plastic (or wire) can be snipped with tin snips or a sharp knife. Each trap will have a tag that indicates who the trap belongs to and a “do not disturb” warning. The Fukui fish traps do not need to be modified. Rocks or fishing weights (about 4 ounces) could be added to the trap if the bait isn’t heavy enough to keep it on the bottom. Fish parts and herring make good bait. Snap the two halves of the trap together and attach several cable ties to insure the trap remains closed. Tie a rope to the trap using a bowline knot and tie the other end of the rope to a stake. Drive the stake into the ground so that it is securely anchored. The top of the stake should be marked with a bright color to identify it as a hazard. Stakes should be sturdy enough to remain in the field so that the same spot can be trapped again. Identification tags should be attached to the stakes.

To retrieve traps

After a 24 hour period return to the traps, untie them from the stake, open up the trap, and examine the catch. All crabs caught should be identified as well as possible, measured, and recorded. (Pictures of green crabs and other common native crabs are included in the packet.) If a green crab or another crab is caught that can't be identified, it should be kept. To preserve the animal for identification, place it in 10% buffered formalin or 95% alcohol in a labeled jar with a tight fitting lid. On the jar, indicate what chemical preservative was used, the date and place the specimen was found. You may wish to first place the animal in the freezer before placing it in a chemical preservative to humanely kill it. All other animals can be released once they have been recorded. Record information on the data sheet provided (measurements, description of habitat, time of day, date, tides, etc.). Send the data sheets and preserved animals of interest to Prince William Sound Regional Citizens' Advisory Council after each trapping.

Labeling procedure

All preserved material must be clearly labeled. It is best to use a black Sharpie pen on a white label and to print clearly. An adhesive label must be applied to the outside of the bottle and a label printed on high quality cotton bond paper must be placed inside the bottle. The same information must be displayed on both labels. This ensures identification if one of the labels gets lost. Information that must be included is location (city), site (one of the three sites in a location), core number or trap number, date the sample was taken, and the initials of the person who took the sample.

Equipment for trapping

The following equipment is needed for trapping:

24 plastic or wire minnow traps or Fukui fish traps	Hammer or rubber mallet
24 lengths of rope (each about 2 meters)	Bucket
12 stakes	Rulers
24 weights (about 4 ounces) or use rocks on site	Clipboard
Cable ties	Pencil
24 pieces of bait	Data sheet
Fishing line	Field guide

Cost

The cost for establishing and monitoring one location is minimal. The initial cost is approximately $270, so monitoring every year after that will cost approximately $80-$160 per year depending on how many times trapping is performed

Cost to buy the equipment and trap a minimum of four times:

24 modified minnow traps plus line	$250
12 pieces of steel rebar	$10
Herring for 4 trappings at $20 per time	$80
Total	$340

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