1ST BIENNIAL MARINE ECOSYSTEM HEALTH PROGRAM SCIENCE SYMPOSIUM

September 6, 2002

Rosario Resort

Orcas Island, Washington

Mission

Ensuring the health of marine wildlife and their ecosystems through science and education

A program of

Wildlife Health Center

(http://www.vetmed.ucdavis.edu/whc)

School of Veterinary Medicine

University of California, Davis

Contact us

Program Coordinator
Kirsten V.K. Gilardi, DVM, Dipl. ACZM
Wildlife Health Center
School of Veterinary Medicine
University of California
Davis, California 95616

(530) 752-4167
(530) 752-3318 fax
kvgilardi@ucdavis.edu

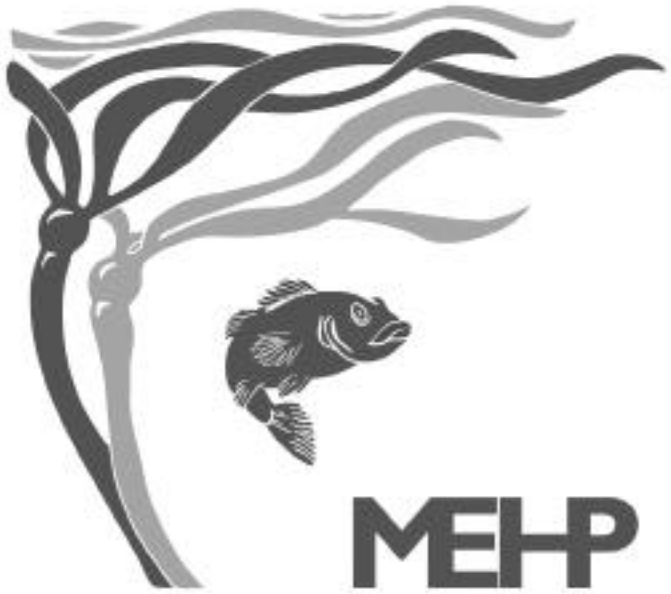
Staff Scientist
Joseph K. Gaydos, VMD, PhD
MEHP, Orcas Island Office
982 Deer Harbor Road
Eastsound, Washington 98245

(360) 376-3910
(360) 376-3909 fax
jkgaydos@ucdavis.edu

Visit the MEHP website
http://mehp.vetmed.ucdavis.edu

Support for the MEHP comes primarily from the private sector. If you wish to support the MEHP, contact Drs. Gilardi or Gaydos (contact information above) or Ms. Celeste Borelli, Office of the Dean, School of Veterinary Medicine, UC Davis, (530-754-5873) or clborelli@ucdavis.edu.

First Biennial
Marine Ecosystem Health Program
Science Symposium



Program and Abstracts

Rosario Resort
Orcas Island, Washington
September 6, 2002

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WILDLIFE HEALTH CENTER
SCHOOL OF VETERINARY MEDICINE
UNIVERSITY OF CALIFORNIA
ONE SHIELDS AVENUE
DAVIS, CALIFORNIA 95616-8734
(530) 752-4167
FAX (530) 752-3318

September 6, 2002

Dear Symposium Attendee:

Two and one-half years ago, the Marine Ecosystem Health Program (MEHP) convened a workshop here at Rosario. Many of you attended that workshop, in which we asked participants to identify priorities for scientific investigation to better understand and reverse wildlife and ecosystem health problems in the inland waters of the Pacific Northwest (Puget Sound, Northwest Straits, Georgia Basin). As a result of that workshop, the MEHP distributed calls for research proposals in May 2000 and 2001, specifically soliciting projects investigating the following priority areas:

- Collation and analysis of existing ecosystem health data; identification of information gaps
- New technologies and methods for marine ecosystem health assessment
- Multidisciplinary/multi-institutional strategic convening and partnerships
- Design, monitoring, and evaluation of marine protected areas
- Environmental contaminants in marine ecosystems
- Presence and impact of exotic species
- Effects of marine fisheries operations

It is with great pleasure that we now convene the First Biennial MEHP Science Symposium. The primary purpose of this symposium is to facilitate the sharing of information resulting from MEHP-supported projects among scientists and stakeholders. Whether you are a natural resource manager, a fisherman, a conservationist with a non-governmental organization, or a citizen who is concerned about the changes you've seen in the health of this unique ecosystem, you are part of the outstanding effort underway to conserve and restore the inland waters of the Pacific Northwest. We sincerely hope you find today's symposium educational and thought-provoking and that you obtain new information that helps you manage, conserve, protect, or sustainably utilize the inland waters ecosystem and its wildlife. Also, it is our hope that this symposium provides a forum through which researchers, managers and conservationists can establish or renew collaborative relationships. Thank you for attending.

Sincerely,

Kirsten V.K. Gilardi
Program Coordinator

Joseph K. Gaydos
Staff Scientist

Overview of the MEHP

The MEHP, a program of the UC Davis Wildlife Health Center

The MEHP was founded in January 2000, by the Wildlife Health Center (WHC) at the University of California, Davis School of Veterinary Medicine. Using scientific skills, animal health expertise, and strong stakeholder collaborations, the WHC works to ensure the health of wild animal populations and their environments. Although disease can impact wildlife at the population level, the health of wildlife populations is threatened by unfavorable environmental conditions, like poor habitat quality, lack of forage or prey, over-extraction of natural resources, unnatural species interactions, and contaminants. The Wildlife Health Center focuses its efforts on wild animals in the context of their ecosystems, recognizing that without a healthy place to live, wildlife populations and humans cannot coexist. Our guiding principle is that sound scientific data will catalyze and enhance stewardship of wildlife and their habitats.

Through targeted ecosystem health programs like the MEHP, the WHC addresses complex problems facing wildlife health and seeks balanced solutions through education, research, and service. Other WHC programs focus on oiled wildlife and the urban/wildlife interface. The WHC is a global leader in the paradigm shift occurring within the field of veterinary medicine — applying animal health expertise and diagnostic skills to wildlife conservation and ecosystem management.

The WHC: Catalyzing and enhancing sound scientific stewardship of wildlife and their habitats through research, service and education.

The MEHP in the Inland Waters of the Pacific Northwest

Funding to initiate the MEHP came from a private gift to the Wildlife Health Center from citizens who were concerned about the health of the Pacific Northwest inland waters ecosystem (Puget Sound, the Northwest Straits, and the Georgia Basin region). Nearly six million people surround these marine waters. In the last few decades, native populations of northern abalone and Olympia oysters have experienced unprecedented declines, and populations of salmon, herring, cod, and rockfish have nearly disappeared from some areas. Flocks of common murres and tufted puffins which once numbered in the thousands now number in the hundreds or less. Harbor porpoises are rarely seen. Orca (killer whales) inhabiting the inland waters regions are now considered to be among the most contaminated cetaceans in the world. Biologists, conservationists, and citizens agree that the Pacific Northwest inland waters marine ecosystem is experiencing an unprecedented health crisis.

This region represents a microcosm of the conservation and ecosystem health issues occurring worldwide at the interface between urban development and oceans. The mission of the MEHP is to ensure healthy marine wildlife and ecosystems through science and education. The strategy of the MEHP has broad applicability and ultimately, the MEHP approach and the lessons learned will be applicable to other regions.

The Pacific Northwest inland waters: a microcosm of the ecosystem health issues occurring at the interface of land and sea.

How the MEHP Achieves its Mission:

Since its inception, the MEHP has been working to restore health to the inland waters of Washington and British Columbia and its wildlife by pursuing science addressing the complex issues affecting this marine region. Key aspects of the program include funding and conducting innovative research that yields essential information, serving as a scientific resource for the community, and fostering public participation, outreach and collaboration. The MEHP fills gaps and complements existing scientific knowledge in ways that provide unifying approaches for ensuring the health of the region's marine resources. The MEHP:

- funds and conducts applied scientific research on topics essential to the health of the region and its wildlife.
- provides expertise and assistance in areas of marine science, conservation and animal health through a staff scientist/veterinarian.
- sponsors symposia and strategic planning sessions, and participates in educational forums, working groups and regional committees.
- translates and transmits scientific information to stakeholders to inform policy and decision-making.
- helps train current and future leaders in the science and conservation of marine wildlife and ecosystem health.

The MEHP provides objective science on issues concerning wildlife and ecosystem health in an effort to inform and guide effective policy and management. The MEHP does not serve in an advocacy role.

The MEHP Vision:
By supporting and conducting targeted science and training tomorrow's leaders, the MEHP will profoundly and positively influence the health of marine wildlife and their ecosystems through science and education.

The Marine Ecosystem Health Program benefits from the experience and expertise of the following individuals who volunteer their time as Advisory Board and Scientific Advisory Committee members. These individuals help ensure that the MEHP maintains the highest scientific standards and remains responsive to issues facing the health of the Pacific Northwest inland waters marine ecosystem and its wildlife. The MEHP thanks these individuals for their time and effort.

Advisory Board

Deborah Brosnan
Sustainable Ecosystems Institute
Portland, Oregon

Tom Cowan
Northwest Straits Commission

Gary Davis
Channel Islands National Park
Ventura,California

Leslie Dierauf
U.S. Fish & Wildlife Service

Wally Gudgell
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Gary Greene
Moss Landing Marine Laboratory

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Terrie Klinger
UW Friday Harbor Marine Laboratories

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The Whale Museum

Wayne Palsson
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Canada Department of Fisheries and Oceans

Sam Ridgway
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Glenn Van Blaricom
UW School of Aquatic and Fishery Sciences

Jacques White
People for Puget Sound

Dennis Willows
UW Friday Harbor Marine Laboratories

GUEST SPEAKERS

The following individuals were invited to participate in the First Biennial MEHP Science Symposium because of their exceptional expertise and unique perspectives on managing and conserving the marine resources of the Pacific Northwest inland waters ecosystem. The MEHP thanks Jim, Gary and Wayne for joining and enhancing our program today.

Jim West is a Research Scientist with the Washington Department of Fish and Wildlife. Jim received a Bachelor of Science degree in Marine Biology from Southampton College, and a Master of Science degree in Zoology from the University of Hawaii. He has been with WDFW since 1990, where he studies artificial reefs, the function of nearshore habitat as nurseries for juvenile rockfishes, drift algae habitats, and toxic contaminants in marine and anadromous species. In 1997, Jim authored a report, *Protection and Restoration of Marine Life in the Inland Waters of Washington State*, which documented with urgency the decline of numerous marine wildlife species in the inland waters ecosystem.

Gary Davis is a Senior Scientist with the National Park Service. While his base of operations is Channel Islands National Park in Ventura, California, Gary is currently serving as the NPS's Marine Protected Areas Specialist. In this position, he is charged with establishing monitoring programs for all federal marine reserves in the U.S. Gary obtained his Bachelor and Master of Science Degrees in Biology from San Diego State University. From 1968 to 1980, he conducted research in Everglades, Biscayne, Dry Tortugas, and Virgin Islands National Parks. In 1980, he returned to California to develop a prototype ecological monitoring program at Channel Islands National Park. He assumed his current position in 1997. Gary serves on the Marine Ecosystem Health Program Advisory Board.

Wayne Palsson is a Research Scientist with the Washington Department of Fish and Wildlife, where he has been studying saltwater fishes in Puget Sound for 25 years. After graduating with a Bachelor of Arts degree in Zoology from UC Berkeley, he earned his Master of Science degree in Fisheries Science at the University of Washington. Wayne's research on groundfish resources in Puget Sound focuses on stock assessment, management and ecology. Wayne and his co-workers have been examining the response of rockfish, lingcod and other fishes to no-take refugia, and considering how a refuge system can be designed for conservation and management needs. Wayne serves on the Marine Ecosystem Health Program Scientific Advisory Committee.

MEHP Science Symposium Schedule

9:30	Welcome	K. Gilardi and J. Gaydos
9:40	Keynote Address: Protection and restoration of marine life in Puget Sound and the Georgia Basin revisited: 1996 to 2002	J. West
	Session I: Marine Protected Area Science	
10:10	Update on U.S. federal marine reserves	G. Davis
10:35	Using multibeam bathymetry to characterize rockfish habitat in San Juan County, Washington marine reserves (1)	H. G. Greene and J. Tilden
11:00	Larval rockfish dispersal trajectories in the Georgia Basin/Puget Sound region of Washington state (2)	T. Klinger
11:25	Genetic population structure of Northwest Straits green sea urchins (*Strongylocentrotus droebachiensis)*: The impacts of harvesting and marine protected areas (3)	C. Biermann
11:50	Evaluating nearshore buffer zones in the San Juan Islands NWR system relative to their function as marine protected areas (4)	C. Don and K. Koski
12:15	LUNCH	
	Session II: Status and Conservation of Marine Fish	
1:30	Status and conservation of marine fishes in Puget Sound	W. Palsson
1:55	San Juan County Forage Fish Assessment Project: Distribution of surf smelt and Pacific sand lance spawning habitat in San Juan County (5)	L. Moulton
2:20	Island County Forage Fish Habitat Assessment Project (6)	G. Wood
	Session III: Monitoring/Measuring Ecosystem Stressors	
2:45	Documenting variable oceanic influence on water properties and plankton as a possible stressor on biological communities of the Inland Sea (8)	J. Newton
3:10	Expansion of COASST to the San Juan Archipelago and Northwest Straits (9)	J. Parrish
3:35	Assessing habitat quality or site quality for migrating sandpipers: Use of plasma metabolite analysis (10)	D. Seaman
4:00	BREAK	
4:15	Spread and impact of the introduced Japanese seaweed *Sargassum muticum* in native kelp forests of the San Juan Archipelago (11)	K. Britton-Simmons
4:40	Testing a charismatic paradigm: Consequences of a growing sea otter population for nearshore benthic communities along the south shore of the Strait of Juan de Fuca (12)	G. Van Blaricom
5:05	Effects of commercial geoduck (*Panopea abrupta*) harvest on benthic infaunal communities of Puget Sound (13)	G. Van Blaricom
5:30	Killer whales as sentinels of marine ecosystem contamination (14)	P. Ross
5:55	Closing Remarks	

Using multibeam bathymetry to characterize rockfish habitat in San Juan County, Washington Marine Reserves, USA

H. Gary Greene
Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, California 95039

Janet Tilden
Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, California 95039

The establishment of marine protected areas (MPAs) has recently become an important part of marine resource management efforts around the world and in San Juan County. Rockfish are economically important bottomfish whose populations have declined since the 1970's to such an extent that they are being considered threatened or endangered under the Endangered Species Act. During October of 2000, Moss Landing Marine Laboratories, Center for Habitat Studies surveyed five sites within the San Juan Archipelago (SJA) using a RESON 8101 multibeam bathymetric system. Both bathymetry and backscatter data were collected, although the system was maximized for the collection of accurate bathymetry. The main objective of this survey was to gather high-resolution bathymetric data to be used in mapping adult and juvenile rockfish habitat as part of an effort to identify potential marine reserves within the SJA. Sites were chosen based upon previous knowledge of the area's physical, oceanographic, and biological conditions. Surveys were undertaken within San Juan Channel, southern Haro Strait, and southern Rosario Strait. Areas of rugged rocky seafloor were identified using both qualitative and quantitative methods, and were interpreted to be potential adult and juvenile rockfish habitat. Potential habitat bridges radiating outward from protected areas were outlined based upon visual interpretation of multibeam imagery. Three voluntary no-take zones (VNTZs), Pile Point, Charles Island, and Bell Island, established by the San Juan County Marine Resource Committee in 1997, were evaluated based upon the presence of potential adult and juvenile rockfish habitat and the existence of possible habitat bridges that radiate outward from the protected areas. Results show that Pile Point, Charles Island, and Bell Island VNTZs appear to contain viable refugia for adult and juvenile rockfish and prospective habitat bridges that radiate outward from the VNTZs. Alternative reserve locations were also identified that may provide protection for species other than bottomfish.

Larval rockfish dispersal trajectories in the Georgia Basin/Puget Sound region of Washington state

Terrie Klinger
School of Marine Affairs, University of Washington, 3707 Brooklyn Avenue NE, Seattle, Washington 98105-6715

Lance Morgan
Marine Conservation Biology Institute, 15806 NE 47th Court, Redmond, Washington 98052

We propose to use trace element analysis of otoliths from adult and larval rockfish in the Georgia Basin/Puget Sound region to determine the sources from which larvae originate and the oceanographic regions they occupy during the larval dispersal phase. The elemental composition of fish otoliths has been used successfully to identify stock structure, recruitment patterns, and dispersal pathways for a number of fish species from tropical and temperate regions. The technique has great potential for use in the Georgia Basin/Puget Sound region because of the strong riverine and oceanic signals provided by inputs from the Fraser River and Strait of Juan de Fuca, respectively. We propose to use two species of rockfish as model systems. Copper rockfish (*Sebastes caurinus*) and quillback rockfish (*S. maliger*) are species of local importance. Both have shown sharp declines in abundance over the last few decades, and both are now important regional conservation targets. The research we propose is highly relevant to problems of bottomfish recovery, marine conservation, and marine protected area design. The results of our research will indicate whether populations of these rockfish species constitute open populations characterized by substantial long-distance larval dispersal, or whether these are closed populations in which larval dispersal is spatially limited. Our results will help guide the design and implementation of marine protected area networks in the Georgia Basin/Puget Sound region and throughout Washington state.

Genetic population structure of Northwest Straits green sea urchins (*Strongylocentrotus droebachiensis*): The impacts of harvesting and marine protected areas

Christiane Biermann
University of Washington, Friday Harbor Laboratories, 620 University Road, Friday Harbor, Washington 98250

Paul Bentzen
University of Washington, School of Fisheries, 3707 Brooklyn Avenue, Seattle, Washington 98105-6715

We plan to analyze the population structure of an ecologically and commercially important invertebrate species, the green sea urchin (*Strongylocentrotus droebachiensis*) in the Northwest Straits area. We will investigate both its abundance and the genetic relatedness between different population patches. This species will serve as an easily accessible model for the diverse biota in this region. Marine protected areas (MPAs) are the principal management tool in the conservation of marine species and habitats. The criteria for the selection of protected areas include the capability to support healthy populations and to supply larvae (propagules) to other sites, both inside and outside reserves. To select the most effective network of protected areas, we need to understand the paths of migration or dispersal of organisms. Most marine species have at least one free-swimming or drifting stage in their life history that is subject to being moved around by currents. The microscopic larvae of sea urchins are not very strong swimmers; hence their dispersal reflects physical oceanographic processes. Once they arrive in a suitable habitat, they can survive for decades. The genetic affiliation of a population therefore represents migration integrated over a long time period. It will be interesting to compare this average migration to the results of the local drift card studies, which illustrate dispersal at one point in time. We can then use the migratory (drift) path of sea urchins as a representative model for managing other rare or valuable species and the resources on which they depend.

Evaluating near-shore buffer zones in the San Juan Islands National Wildlife Refuge System relative to their function as marine protected areas

Richard Osborne
The Whale Museum, PO Box 945, Friday Harbor, Washington 98250

Terrie Klinger
School of Marine Affairs, University of Washington, 3707 Brooklyn Avenue NE, Seattle, Washington 98105-6715

Presenters:
Kari Koski,
The Whale Museum, PO Box 945, Friday Harbor, Washington 98250

Cristen Don,
School of Marine Affairs, University of Washington, 3707 Brooklyn Avenue NE, Seattle, Washington 98105-6715

The San Juan Islands National Wildlife Refuge System and Wilderness Areas consist of 83 small islands and rocky reefs in San Juan, Whatcom and Skagit Counties in northwestern Washington state. These refuges were federally designated in 1976 as "no take" terrestrial reserves and are intended to confer protection to marine birds and mammals by protecting important nesting, loitering and haul-out sites. In addition to the terrestrial components of the reserves, federal guidelines recommend that each reserve be surrounded by a 200 yard buffer zone in which boating is discouraged (Murray, 1998). We propose that these buffer zones constitute defacto MPAs, and that compliance with the federal recommendation will increase substantially the amount of protection offered to living marine resources in San Juan Archipelago. The objective of the proposed study is to quantify the potential and actual contributions of these near-shore buffer zones to marine protection within the San Juan Archipelago. We believe that the San Juan Islands National Wildlife Refuge System provides a politically feasible means of enhancing protection for marine resources through the implementation of existing management strategies, without requiring that new protected areas be set aside or removed from public use. This project builds upon a 5-year effort by The Whale Museum's Soundwatch Boater Education Program to opportunistically implement the refuge system buffers through education (Osborne et al., 2001), and a pilot study initiated in 2001 by The Whale Museum and the Washington Maritime National Wildlife Refuge System to promote voluntary compliance in buffer zones around two of the reserves. Here we propose to 1) formally map and evaluate the physical and biological attributes within buffer zones throughout the refuge system based on existing data, 2) undertake systematic surveys of vessel activity around the reserves, and 3) intensively patrol and educate the boating public at five of the reserves.

San Juan County Forage Fish Assessment Project: Distribution of surf smelt and Pacific sand lance spawning habitat in San Juan County

Lawrence L. Moulton
San Juan County Marine Resource Committee, 1012 Shoreland Drive, Lopez Island, Washington 98261-8416

Stephanie Buffum
Friends of the San Juans, PO Box 1344, Friday Harbor, Washington 98250

This study consisted of a field survey of beaches potentially used for spawning by surf smelt (*Hypomesus pretiosus*) and Pacific sand lance (*Ammodytes hexapterus*) in San Juan County, Washington. This was a cooperative study of the San Juan County Marine Resources Committee, the Friends of the San Juans, Washington Department of Fish and Wildlife (WDFW) and the University of Washington Friday Harbor Marine Laboratories. Previous investigations by WDFW had identified spawning on county beaches, but surveys were prematurely terminated. This study extended the surveys on a county-wide basis to identify beaches that qualified for protection under the Washington State Hydraulic Code Rules.

Results to date have verified previous results and have extended the amount of known spawning habitat. Eight new surf smelt spawning beaches have been identified, resulting in a total of 30 beaches with documented spawning by surf smelt. There was no addition to the 8 beaches previously identified as supporting spawning by Pacific sand lance. As a result of surveys to date, a total 9.71 linear miles of forage fish spawning beach are afforded protection under the Hydraulic Code Rules.

Island County Forage Fish Habitat Assessment Project

Don Meehan
Island County Marine Resources Committee, Washington State University Cooperative Extension, PO Box 5000, Coupeville, Washington 98239

Gary Wood
Island County Marine Resources Committee, 797 Engle Road, Coupeville, Washington 98277

Surf smelt, sand lance, and herring all were known to spawn extensively on the shores of Whidbey and Camano Islands, where native eelgrass beds and sandy or graveled beaches nurse forage and foragers alike; a habitat that conceals salmon smolts from migrating adults returning via the same shared submerged vegetation 'highways.' The three local species each spawn on a different habitat sub-section, in differing seasons, or employ unique timing strategies; and many runs mimic salmonid journeys to their own birth sites. Unlike smelt and sand lance, herring do not beach themselves, instead secreting billions of adhesive eggs en mass onto the strands of *Zostera marina* eelgrass beds, until they are milky white. Collectively these schooling millions of near-identical "forage fish" species are at the dietary core for salmon, rockfish, shore birds, diving birds, and a host of marine mammals. Recent photography of 'herring balls' and 'schooled candlefish' undergoing simultaneous, frenzied consumption waves by birds, barracuda, otter, salmon, orcas, and humpback whales breeching up through the whole frothy soup with jaws agape, attest to the nutritional popularity of these arguably indistinguishable fish.

This project was designed to locate, map and protect the county's active beach and healthy nearshore spawning areas. "No net loss" state regulations have long protected such spawning sites against loss of habitat in hydrology permits (WAC 220-110), but only where spawn is properly detected and the habitat so designated. Similar "no net loss" policies apply to eelgrass as well, in state law. With absent comprehensive and accepted mapping however, such laws are powerless. Actual protection of these habitats depends upon complete and comprehensive spawn deposition site inventories, uniformly sampled, collected, identified, and GIS-located for use by planners, resource managers, and developers alike with absolute confidence in their accuracy. The year-2000 MEHP grant of $17,000 (100% to reimburse Biologist costs) was the first funding awarded to this original one-county effort sponsored by its citizen-volunteer Marine Resources Committee (MRC). Subsequent co-sponsors and co-funders have since expanded the scope of work to encompass all seven Northwest Straits counties, with hundreds of thousands of dollars recently awarded to that regional undertaking by the Salmon Recovery Funding Board; Northwest Straits Commission and NOAA/National Fish & Wildlife Foundation grants. Indeed, what has become the largest geographic forage fish habitat assessment/mapping project in the world started with the MEHP's initial grant.

The primary objective of the forage fish assessment is to biologically identify beaches utilized as spawning areas by surf smelt and Pacific sand lance, and subtidal regions supportive active herring spawning. This project employs the San Juan County MRC's Early Action Grant training and collections protocols (Penttila & Moulton, June, 2000). With the supervision of Department of Fish and Wildlife marine biologists, volunteers were trained to assist field collections according to these protocols. The collected samples are then verified by laboratory analysis, and reported by locale and date. GIS maps are finally submitted for county use in planning and permitting. The ongoing, regionalized project enabled

qualified DFW marine scientists to train and lead competent volunteers to sample and resample the county's smelt and sand lance spawning beaches, gathering depositions and submitting them for laboratory analysis. Other teams gathered eelgrass and other seagrass samples containing egg deposits. The sampling and collections will span all seasons for two years. Analyzing and mapping the data generated by the collection protocols and reported samples will result in reliable identification of areas requiring existing legal protections. Once completed, the Forage Fish component of the MRC's largest Nearshore Project will establish a baseline for future monitoring, possible MPA designation, and enable other measures to guide the county's shoreline users, planners, developers and property owners.

Documenting variable oceanic influence on water properties and plankton as a possible stressor on biological communities of the Inland Sea

Jan Newton
Washington State Department of Ecology, Environmental Assessment Program,
PO Box 47710, Olympia, Washington 98504-7710

Jeff Cordell
University of Washington, School of Aquatic and Fishery Sciences, Box 357980, Seattle,
Washington 98195-7980

Several studies have established that water properties such as temperature, salinity, oxygen, nutrient, and plankton concentrations show considerable variation interannually in the Strait of Juan de Fuca and that a significant source of this variation is related to climate and associated ocean changes. Variation in nutrient availability and primary production can have wide-ranging effects on marine systems, since this is food at the base of the food web. The objective of this proposed work is to document variability in levels of oxygen, nutrients, and plankton within the incoming oceanic waters at the boundary of the Inland Sea by maintaining a database of time-series of these observations from three stations in the eastern Strait of Juan de Fuca. Our first hypothesis is that a large portion of the observed variation in water properties and plankton in the Inland Sea is related to variability in climatic and/or oceanic forcing, which will be assessed. Secondarily, we hypothesize that the variation in water properties and plankton is important to the success of populations of other marine organisms in the Inland Sea, due to stresses such as the availability of food, low oxygen that affect communities in addition to other stressors such as habitat loss and chemical contamination. This is a scientific investigation with a conservation application. Documenting the variability in water properties and plankton and understanding the degree variation is influenced by external forces (ocean, climate) is critical to interpreting success or failure of marine organisms and to evaluating the efficacy of MPAs and other conservation approaches. Currently, there are no long-term, ongoing, time-series of water property measurements or of plankton in these Straits that we know of. Virtually nothing is known about how the variability in zooplankton species in time and space relates to the fish and other higher organisms that feed on them. For some dwindling salmon stocks, gaining an understanding of what affects them during their residence in nearshore marine waters may be particularly critical. Not only are plankton species assessments essential for trophic-linkage implications, but exotic zooplankton species are just beginning to appear in this area and it is important to know when and if new species become established, given the profound ecosystem-level effects of planktonic invaders elsewhere in the world and the region.

Expansion of the Coastal observation and seabird survey team (COASST) to the San Juan Archipelago and Northwest Straits

Julia K. Parrish
School of Aquatic and Fishery Science, University of Washington, Box 355020, Seattle, Washington 98195-5020

With support from the MEHP, COASST recruited 28 volunteers at 13 sites, implemented a "smart" web-based data entry system, and can equip more than 50 volunteers. We initially concentrated our efforts on the San Juan Islands because strong partnerships with The Whale Museum, Friday Harbor Laboratories, and the local Audubon chapter had already been developed. Within the San Juan Islands, four training sessions and 2 follow-ups were more than sufficient to accomplish our goals for site and volunteer composition. More recently, we have added beaches in Puget Sound as well as other San Juan Islands (Lopez, Shaw and Indian).

By recruiting heavily in the San Juan Islands, we created a concerted network of volunteers at a diverse array of sites on both San Juan and Orcas Islands (19 and 9 volunteers at 8 and 5 sites, respectively). In fact, four of COASST's San Juan locations were beached bird survey sites for Adopt-A-Beach (AAB) in the late 1980's and early 1990's. Because COASST recently inherited the AAB dataset and has re-initiated surveys at some of their former sites, we now have a longer historical baseline against which we can examine future trends.

Our results for 2000-2001 are outlined in COASST Reports 00-01 and can be downloaded at www.coasst.org. In summary, COASST volunteers documented two significant mortality spikes across all regions: one associated with post-fledging events (e.g., juveniles starving at sea) and the stress of the post-reproductive season (e.g., adults exhausted after breeding) and two "winterkill"events, when strong storms and other extreme temperature, wind, and weather events affected marine birds. Of local note, despite the relatively low incidence of beached birds in the Northwest Straits, two were found entangled in fishing gear - equaling the total in all other regions combined.

Assessing habitat quality or site quality for migrating sandpipers: Use of plasma metabolite analysis

Dana Seaman
Centre for Wildlife Ecology, Simon Fraser University, 8888 University Drive, Burnaby, British Columbia, V5A 1S6, Canada

Tony D. Williams
Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, V5A 1S6, Canada

Christopher G. Guglielmo
Biological Sciences, University of Montana, Missoula, Montana, 59812-1002, USA

Robert W. Elner
Environment Canada, CWS, Delta, British Columbia, V4K 3N2, Canada

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We have been investigating the usefulness of a novel technique to assess the relative quality of habitats or sites used by migratory shorebirds: estimation of fattening rates from plasma metabolite analysis. In migratory birds, rate of mass gain (fattening) at stopover sites is a critical factor affecting timing and probability of success of migration. Site-specific variation in fattening rates should therefore be important in determining habitat use which, in turn, is important to consider in land acquisition or stewardship decisions. Validation studies of captive birds have shown that plasma triglyceride and glycerol levels (obtained from blood samples) can predict mass change in western sandpipers (*Calidris mauri*) over time periods of 2-7 days. This encompasses the average lengths of stay at stopover sites during migration in this species. We propose collecting blood samples from migrating western sandpipers captured by mist-netting at 6-9 sites in the Puget Sound/Georgia Basin region to determine inter-site variation in fattening rates. For each site we will also obtain information on invertebrate prey availability (from mud cores), diet (from fecal samples), and foraging behaviour. The overall aim is to combine information from three very different approaches (metabolite analysis, invertebrate sampling, and foraging behaviour) to make an assessment of variation in the quality of migratory stop-over sites. Captive birds will be used to investigate factors which might influence plasma metabolite levels (e.g. diet) and which might confound the use of this technique in free-living birds. Marine wetlands (mudflats, salt marshes) are essential habitats for large populations of migratory shorebirds, yet they are one of the most highly threatened habitats in the Pacific Northwest. For example, there is growing evidence that Nearctic shorebird populations may be declining across North America. Western sandpipers, as one of the most abundant shorebirds using the Puget Sound/Georgia Basin region, have been identified as a key indicator species for monitoring the health of sandpiper populations and their marine habitats. In addition, determining which habitat types and locations are appropriate for acquisition, and evaluation of the effectiveness of protecting estuaries in maintaining population targets of western sandpipers (and thereby other shorebirds) have been identified as key management requirements by the Canadian Wildlife Service. Similar information is also of interest to the U.S. Fish & Wildlife Service in Washington State.

Spread and impact of the introduced Japanese seaweed, *Sargassum muticum*, in native kelp forests of the San Juan Archipelago

Kevin Britton-Simmons and J. Timothy Wootton
The Univeristy of Chicago, Department of Ecology and Evolution, 1101 East 57th Street, Chicago, Illinois 60637

The introduction of species into habitats outside their normal geographic range is accelerating as human mobility increases. Introduced species have the potential to radically alter the structure and function of native ecosystems and are a leading threat to biodiversity. The Japanese alga *Sargassum muticum* has been invading kelp forests in the San Juan Islands of Washington since its introduction nearly fifty years ago. Despite its widespread distribution as an exotic in North America and Europe very little is known about how *S. muticum* impacts native communities. Subtidal kelp communities in the San Juan Islands are important habitat for a wide variety of animals including invertebrates, fish, mammals and birds. Furthermore, the kelp species that dominate these plant assemblages add three-dimensional structure to the habitat and are important sources of carbon in coastal food webs. Therefore, any widespread effects of *S. muticum* on these algal communities are likely to have broader consequences for the nearshore ecosystem in this region.

We are using an experimental approach to explore the dynamics and consequences of the *S. muticum* invasion in the San Juan Islands. During the past 2 years our research has focused on three main questions: 1) What effect does *S. muticum* have on native kelp communities?, 2) What role do different native species play in resisting invasion by *S. muticum*?, 3) Do spatially complex habitats provide a refuge for native kelp species from competition with *S. muticum*? Our results show that *S. muticum* displaces native algae and has a negative, indirect effect on the green urchin (*Strongylocentrotus drobachiensis*) which may alter subequent invasion dynamics. In addition, we found that the identity of native species that are important for resisting invasion by *S. muticum* changes as the invasion progresses. While some native algal species are important for inhibiting *S. muticum* recruitment, others reduce survivorship of *S. muticum* once it has recruited. Finally, preliminary evidence suggests that spatially complex habitats may provide a refuge for native kelps from competition with *S. muticum*.

Furthermore, our research will provide insight into the phenomenon of biotic resistance by experimentally evaluating the role of native functional groups in resisting invasion by *S. muticum*. Our results will provide additional insight into the impacts of this ongoing invasion on the native plant and animal biota of the San Juan Islands. Furthermore, our research on the role of native functional groups in resisting invasion will enhance our (presently limited) understanding of the phenomenon of biotic resistance. By increasing our understanding of the dynamics and consequences of this invasion, we may also gain insight into possible mitigation strategies. This study will provide critical information regarding how important a threat *S. muticum* is to the integrity of the coastal ecosystem in this region.

Testing a charismatic paradigm: Consequences of a growing sea otter population for nearshore benthic communities along the south shore of the Strait of Juan de Fuca

Glenn R. VanBlaricom
Washington Cooperative Fish and Wildlife Research Unit, School of Aquatic and Fishery Sciences, Box 355020, University of Washington, Seattle, Washington 98195-5020

The Washington population of sea otters (*Enhydra lutris*) is expanding into coastal habitats of the Strait of Juan de Fuca. Sea otters are known to have important trophic effects on coastal biological communities, and may facilitate increased biodiversity in some cases. Foraging by sea otters is known to be detrimental to the sustainability of shellfish fisheries for many species, including clams and Dungeness crabs. Growing sea otter populations may influence operational policies for transport of petroleum products through the Strait. The increased numbers of sea otters may also attract the interest of coastal tribal communities seeking to restore traditional harvests of marine wildlife. Recent data suggest that natural physical disturbance processes in the Strait will limit the role of sea otters in enhancing local biodiversity as sea otter populations expand. The proposed project will resample 19 sites along the south shore of the Strait first sampled in 1997. The 1997 survey assessed populations of invertebrates and plants likely to be influenced, directly or indirectly, by foraging sea otters. Sea otters had not influenced any of the sites in 1997, but have since foraged in at least 6 of the 19 sites. The primary purpose of the proposed 2001 resurveys is to provide new data as a means of testing the hypothesis that sea otters will enhance local biodiversity. Results will be significant to managers charged with resolving the multiple resource interactions associated with a growing sea otter population.

Effects of commercial geoduck (*Panopea abrupta*) harvest on the benthic infaunal communities of Puget Sound

Glenn R. VanBlaricom
School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, Washington 98195-5020

There is widespread concern that physical disturbances associated with marine benthic fishing operations may be damaging marine ecosystems and increasing extinction risk for component species. Most marine benthic fisheries are pursued with large equipment, on a large scale, in deep water. As a result, mechanistic insight to ecological effects of recurrent disturbance associated with fishing activity is difficult to obtain. The commercial fishery for geoduck clams (*Panopea abrupta*) in the semi-enclosed marine waters of Washington and British Columbia is successful, highly productive, and geographically widespread across the region. Harvesting is done by divers in shallow waters (5-20 meter depth) relatively close to shore. There is little understanding of effects of physical disturbances associated with the fishery on benthic communities in Puget Sound or other regional inland marine waters. Because of the minimal depths, proximity to shore, and relative protection from oceanic weather and seas, the geoduck fishery represents an excellent opportunity for detailed understanding of the interactions of benthic fisheries and benthic communities in marine habitats. We will use diver-collected core samples and visual transect data to test hypotheses that disturbances associated with geoduck fisheries alter the structure and dynamics of benthic communities, and that fishery activity alters the availability and distribution of physical microhabitat and biogenic structure. We will design experiments to separately evaluate contributions of three categories of physical disturbance associated with the fishery (local liquefaction, hose dragging, and general diver activity) to habitat and community modification, if it is found to occur. In addition to hypothesis testing, we will develop a spatial-temporal disturbance-recovery model, linking fishing disturbance to major features of benthic community structure. Our data will place geoduck fishing activities in a more meaningful and better understood community ecological context, will be useful to managers in linking geoduck fishery management to marine conservation goals, and will contribute to improved information about effects of marine benthic fisheries on communities in general.

Killer whales as sentinels of marine ecosystem contamination

Peter S. Ross
Institute of Ocean Sciences, Fisheries and Oceans Canada, PO Box 6000,Sidney, British Columbia, V8L 4B2, Canada

Steve Jeffries
Washington Department of Fish and Wildlife, Marine Mammal Investigations, 7801 Phillips Road SW, Tacoma, WA 98498, USA

The southern resident killer whale (*Orcinus orca*) population depends on the availability of prey in the shared coastal waters of Washington state and the province of British Columbia during much of the year. Declining population numbers (down 20% since 1996) have raised concerns in both Canada and the United States, leading to an "endangered" listing in Canada in 2001 and a petition to list this population under the terms of U.S. Endangered Species Act (ESA). Reports have cited diminishing prey (salmon) abundance, heavy vessel traffic and high contaminant levels. Contaminants including polychlorinated biphenyls (PCBs) have been associated with adverse health effects in both humans and wildlife, including endocrine disruption, immunotoxicity and reproductive impairment. Our recent report citing northeast Pacific killer whales as among the most contaminated in the world underscores the need to better understand the source of toxic chemicals and their fate in killer whales at the top of the coastal food chain. We have initiated a two-year MEHP project (Year One: 2001; Year Two: 2002) to evaluate the levels and patterns of Persistent Organic Pollutants (POPs; approximately 250 chemicals, including the PCBs, dioxins and pesticides) in the primary dietary component of southern resident killer whales, Chinook salmon. In year one, we initiated a graduate student research project, set up working relationships with several laboratories, conducted preliminary experiments on stable isotopes and fatty acids, collected Chinook smolts and adults from two stocks in Puget Sound, subsampled, and prepared tissues for contaminant and other analyses. Contaminant analysis is complete. In year two, we carried out fatty acid and stable isotope analyses, interpreted data from these and contaminant analysis in the context of Chinook life history and ecology, killer whale data and food chain structure. This work will help to assess the relative importance of local versus offshore sources of contaminants. Results will be linked to contaminant data from i) concurrent studies of Strait of Georgia fish; ii) southern resident killer whales; and iii) Puget Sound harbor seals. Results will be further interpreted using multivariate statistical evaluation of contaminant patterns and a food chain bioaccumulation model. Results will also be related to our ongoing research into the effects of POPs on the health of killer whales. This project will help to bridge Canadian and U.S. approaches to assessing contaminant levels in shared waters. In this manner, we plan to better understand the state of contamination of the marine ecosystem in Puget Sound, the Strait of Georgia and Juan de Fuca Strait, and the risk that this contamination presents to killer whales and other high trophic level consumers.

Physical habitat attribute mediates biotic resistance to non-indigenous species invasion

James E. Byers
Friday Harbor Marine Laboratories, University of Washington, 620 University Road, Friday Harbor, Washington 98250

Richard Strathmann
Friday Harbor Marine Laboratories, University of Washington, 620 University Road, Friday Harbor, Washington 98250

A soft-shelled non-indigenous clam, *Nuttallia obscurata*, has invaded coastal soft-sediment habitats of the northeastern Pacific. In a survey of 35 sites within the San Juan Islands, Washington, USA, *Nuttallia* was found almost exclusively in sandy substrates, higher in the intertidal than most native clams (>1 m above mean lower low water). The distinctive distribution of *Nuttallia* suggested that tidal height and sediment composition may be important physical factors that control its refuge availability, regulating its exposure to predation and ultimately the success of its invasion. We tethered *Nuttallia* for 24 h in the high intertidal where it is typically found and in the low intertidal at an elevation where it was never found. Clams restrained to the surface suffered high mortality from crab predation at both tidal heights, whereas control clams with unrestricted burrowing movement exhibited high mortality rates only in the low intertidal. In a second experiment, we transplanted sediment within and between the two intertidal heights to measure effects of tidal height and sediment type on survival and burial depth of *Nuttallia*. At both tidal heights all clams placed on mud-cobble substrate, naturally common in the low intertidal, suffered high mortality rates (>60% in 24 h). *Nuttallia* on loosely packed sand substrate, naturally found in the upper intertidal, survived much better, however, because they buried deeper than in the tightly packed mud. Caged control clams at both tidal heights suffered no mortality. Apparently native predators are mitigating community level impacts of an invader by excluding *Nuttallia* completely from some beaches with improper sediment characteristics or relegating it in others to a zone not often inhabited by native species, thereby reducing potential competitive interactions. These findings show that a physical habitat characteristic can mediate biotic resistance to an invader and thus control invasion success and community-level impacts. Generally, such physical-biological interactions may explain some of the reported site-to-site variability in invasion success, as well as the patchy distribution of many soft-sediment infaunal species.

(Not Presented)

Cause(s) of developmental abnormalities among larvae from Puget Sound's once-largest herring population

Kerry Naish
School of Aquatic and Fishery Sciences, University of Washington, Box 355020, Seattle, Washington 98195

Paul Hershberger and Richard Kocan
School of Aquatic and Fishery Sciences, University of Washington, Box 355100, Seattle, Washington 98195

For unknown reasons, the biomass of herring at Cherry Point, a region in north Puget Sound that served as spawning shoreline for Washington's once-largest herring stock, has decreased from approximately 15,000 metric tons in the early 1970s to 800 metric tons in 2000. We have recently determined that naturally-spawned herring eggs at Cherry Point produce larvae with significantly greater incidences of developmental abnormalities than do those from other populations of herring in Puget Sound. Although it is difficult to determine whether the developmental abnormalities caused, or rather were a consequence of, the biomass decline at Cherry Point, they may adversely affect the survival potential of larvae and prevent the stock from rebounding to healthy levels. We proposed to determine whether these developmental abnormalities result from site-related effects, possibly environmental contaminants, or non-site-related effects, possibly negative genetic consequences associated with a dramatic reduction in the effective population size. Site-related effects will be ascertained by employing a series of *in situ* herring egg bioassays using gametes from a healthy stock of herring in Puget Sound. Fertilized herring eggs will be incubated at different locations along the Cherry Point shoreline for several days, and then returned to the laboratory. Resulting larvae will be analyzed for developmental abnormalities and compared to larvae from laboratory and field controls. We will also test whether developmental abnormalities in the population have a genetic basis. We will conduct basic common-garden experiments in which reciprocal crosses between artificially spawned larvae from three different stocks will be raised together in the laboratory. The growth and development of within-site lines will be compared with each other and with between-site hybrid lines in attempt to answer two hypotheses. First, that the differences in development rates and birth defects are due to genetic differences between the stocks and second, that an increase in heterozygosity in the hybrid lines will result in a decrease in the observed abnormalities. Results from these experiments may be used for management purposes to possibly 1) prevent similar declines from occurring in other stocks, 2) facilitate recruitment of new cohorts back to the Cherry Point stock and 3) provide baseline data on sustainable genetic effective size thresholds in declining or threatened populations of herring.

(Not Presented)