



SUMMARY MEETING NOTES
Salish Sea Forage Forage Fish Needs Assessment Workshop
January 25, 2011
Peace Arch Park, Blaine, Washington

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Introduction

Forage fish, including Northern anchovy (*Engraulis mordax*), Eulachon (*Thaleichthys pacificus*), Pacific herring (*Clupea pallasii*), Pacific sand lance (*Ammodytes hexapterus*), Surf smelt (*Hypomesus pretiosus*), and Longfin smelt (*Spirinchus thaleichthys*), are small energy-rich schooling fishes that feed other fish, birds and mammals in the Salish Sea, including several species that are federally listed as threatened or endangered. Our understanding of the basic biology and population status is better for some forage fish species than for others; some are harvested, and some are not.

In an effort to identify major information gaps and actions needed to protect forage fish, the Northwest Straits Commission (Commission) and SeaDoc Society brought together 25 scientists and managers who are working in Washington state and British Columbia. The purpose of the workshop was not to rank research and other efforts, but to catalyze conversation in support for a transboundary collaborative effort. Discussions initially focused on five species: Pacific herring, sand lance, surf smelt, eulachon, and Northern anchovy; Longfin smelt was added based on participant input and general agreement. People were asked to identify actions that would help advance conservation and recovery of these six species in three categories: science, management/policy, and education/outreach.

Caroline Gibson (Commission) welcomed the group and introduced the subject matter, thanked people for attending, and introduced meeting facilitator Hilary Culverwell. Following a brief roundtable of introductions, Hilary gave an overview of the agenda and introduced Joe Gaydos (SeaDoc Society), who highlighted both organizations' interest in forage fish. Joe stressed that the intent in bringing this group together is to share knowledge about what is happening relative to forage fish on both sides of the border, and in doing so identify areas where additional research is needed, where we have information but are not taking adequate action, and where information exists and should be more effectively used to inform the general public and/or policy-makers.

Current research and other activities

Participants were invited to briefly describe their current work on forage fish, and share any personal impressions about relevant needs or threats (alphabetical order):

David Beauchamp (University of Washington)

Dave studies food web ecology, specifically juvenile salmon foraging ecology. For approximately 10 years he has been working with Dick Beamish (Dept. of Fisheries and Oceans) to collect offshore samples of epipelagic fishes.

- Data show a relationship between the size of juvenile Chinook salmon in July and their offshore survival. This correlates with feeding rates, related to the availability of crab larvae, suggesting that Chinook are food-limited prior to open ocean migration.
- Offshore mid-water trawl surveys found that herring biomass is ten-fold that of juvenile salmon in Puget Sound, and overlap in diet preference results in herring eating 10-40 times the biomass that salmon are eating. There is a need to see how salmon are performing spatially and temporally from prey supply, competition, and predation perspectives; and including the prey perspective of larger species such as dogfish and resident Chinook salmon. Stock assessments found 10-25% herring are from resident fish. Is spawning occurring at local hot spots or is it more broadly spread?
- Conducting low-level hydroacoustic surveys to get basic information on spatial structure of pelagic fishes during daylight hours, to look at how higher densities are distributed.

Dave noted that these are pilot projects exploring estimates for carrying capacity of planktonic feeding fish, which will hopefully provide data on spatial and temporal bottlenecks. Future interests include stable isotopes, and investigating bioenergetics models to determine whether consumption rates can regulate population dynamics. The geographic focus is the North Basin of Puget Sound.

Joe Bizzarro (PhD Candidate, University of Washington)

Joe is working with Gary Greene *et al.* on a deepwater Pacific sand lance project in the San Juan Archipelago, and looking at the patterns, distribution, and spatial analysis of sand lance in sand wave fields. Using GIS to assess sand wave field habitat components, including physical factors,

wave height, depth, and fish density.

- Also doing a pilot project looking at sand lance burrowing capability and habitat preferences, as well as physics, morphology, and behavior of burrowing. Early results show a preference for 0.25-0.5 cm (medium) grain size, though sand lance can burrow in more compacted sediments, despite this requiring greater force.

Jennifer Boldt (Dept. of Fisheries and Oceans)

For the last year, Jennifer has been involved with Pacific herring research in BC. One such project is an annual herring recruitment survey off the west coast of Vancouver Island, where the Strait of Georgia stock feeds in the summer. This survey collects fish with a mid-water trawl during daylight hours. Information collected includes the relative catch-per-unit-effort of pelagic fish, herring age composition and diet, and the diets of other pelagic fish, such as Pacific hake.

Lisa Christensen (Dept. of Fisheries and Oceans)

Lisa works in habitat management, with regulatory and policy coordination. Approving sea walls initiated an interest in forage fish, but the absence of a fishery resulted in limited data.

- Mapping intertidal spawning sites and habitat characteristics can help guide regulation and management; information can be used to determine if nearshore permits for alterations should be provided. People are expected to inform DFO of nearshore development work, but permits are not necessarily required.
- DFO is working to improve the integration of science into policy and management, including abundance/ availability of forage fish and larger predatory fish such as salmon.
- They are also looking at coastal geomorphic process, including drift cell movement. Vancouver Island has poor sediment and is prone to loss of spawning beaches.

Duane Fagergren (Puget Sound Partnership)

Duane shared personal anecdotal information on forage fish abundance in southern Puget Sound. Over the last 60 years he has observed changes in species composition, and Northern anchovy have become the primary forage fish. They appear to be there year around and attract huge flocks of double-crested cormorants, as well as grebes, mergansers, and seals.

Ramona De Graaf (BC Shore Spawners Alliance)

Ramona launched an outreach effort in 2007 (presentations, field manuals, Facebook, blogs etc.), which currently has 27 communities involved in volunteer forage fish survey efforts at 32 beaches.

- Guidelines developed by Dan Penttila are used to identify forage fish spawning habitat and help communities write bylaws for beach protection.
- Created an online forage fish atlas - on the *Community Mapping Network* - to provide information to management agencies for permitting in BC.



- Also collecting seine data on forage fish abundance, made videos of sand lance spawning, post-restoration monitoring of seawalls and riparian zones, and maintaining a database on forage fish for BC.

Correigh Greene (NOAA/Northwest Fisheries Science Center)

Correigh works with Casey Rice (NOAA/NWFSC) and Eric Beamer (Skagit River System Cooperative), and is interested in forage fish and nearshore marine ecology as related to Chinook salmon foraging.

- They have a 10-year time series in Skagit Bay from surface trawling; trying to link some of the data to disease work, landscape features and land use, and food web connections.
- This year doing an EPA-funded project examining the links between multiple levels of the pelagic food web (bacteria, autotrophs, zooplankton, fish and jellyfish) and land use in all five basins of greater Puget Sound.

Eric Grossman (U.S. Geological Survey)

Eric is working on seafloor mapping, using a combination of bathymetry and backscatter images to identify and characterize sand wave fields, *i.e.* 25m high fields seen off the Nisqually River.

- Hydrodynamic modeling to determine how coastal zone processes affect the mobility of these habitats. Looking at movement of organics, sediment matter, plants, benthic invertebrates, salinity gradients, river plumes and groundwater discharge into marine waters.
- Coring to determine how intertidal and subtidal habitats have changed over time from human influence, in an effort to provide an historical reference for restoration activities.
- Testing the differences between dense and fragmented eelgrass beds and how they provide energetic values.
- USGS also is working with many of the Coast Salish tribes, looking at large-scale water quality monitoring throughout the region via the annual canoe journey, and fixed buoys.

Doug Hay (Nearshore Research, Nanaimo BC; Scientist Emeritus, Dept. of Fisheries and Oceans)

Doug studies biology and habitat as factors affecting herring and other forage fishes. Herring spawning habitats are documented in all of BC back to 1928. Information is available on the Web and is used by management agencies; it has never been integrated with WA, but could be.

- The sustainability of the DFO website is uncertain in the face of potential future staff changes. A non-advocacy, independent platform would be best.
- Data show that abundant or good herring and eulachon spawning habitats do not necessarily mean high abundance of forage fish like herring or eulachon – because abundance may be determined by survival in the open sea. This is not a reason to avoid protection of spawning habitat.

- Seabird predation (*i.e.* marbled murrelets) on herring is primarily on the juvenile stages. Juvenile herring surveys have been conducted in the Salish Sea since 1991, and results could be integrated with information from surveys in WA.

Paul Hershberger (U.S. Geological Survey)

Paul *et al.* study disease ecology, in particular diseases of Pacific herring (a good host model) and the effects on wild populations. They use a combination of field surveillance and well-controlled laboratory studies, historically studies were in response to fish kills.

- Working in AK, BC and WA to develop forecasting tools to predict epizootics before they take off, in an effort to offer some adaptive mitigation strategies before fish kills occur. With Viral Hemorrhagic Septicemia (VHS), they now have several tools that they think will provide a good predictive model for these outbreaks.

George Hunt (University of Washington)

George and Emily Runnels (Master's student) have been studying the foraging ecology of marine birds and seals and their prey in the South end of San Juan Channel. Using dip nets they found that marine birds were primarily eating sand lance and herring. Acoustic surveys provided information on biomass and distribution of forage fish; overlaid with plankton, water metrics, and tidal cycles. Findings are disseminated through publications.

- Comparisons of data from the 1990s and today show drastically decreased bird flocks. Additional work aims to determine: are there fewer forage fish or diminished migration? Are they deeper? Are fewer zooplankton present?

This is a small-scale effort demonstrating the need to study their (prey) pelagic environment as well as their spawning areas. Bird species composition has changed, as has feeding preference. Species of major importance include common murre, rhinoceros auklets, marbled murrelets and multiple species of gulls.

John Incardona (NOAA/ Northwest Fisheries Science Center)

John focuses on toxicology of Pacific herring, largely in response to the long term impacts of the *Exxon Valdez* oil spill. The majority of spills occur on the land, so the focus has been on nearshore point-source pollution. Findings are disseminated through publications.

- Developing tools to assess the impacts of nearshore pollutants on nearshore spawning fish. From a 3-year assessment of the *Cosco Busan* spill in San Francisco Bay, they found dramatic impacts on herring spawning the first year with lingering chemical effects even after 3 years.
- Trying to assess the baseline health of nearshore spawning stocks for forage fish.

- Working with Jim West (WA Dept. of Fish and Wildlife) tracking chemical pollutants as they move through food webs in Puget Sound.

Theresa 'Marty' Liedtke (U.S. Geological Survey)

Marty is studying intertidal and deepwater distribution of sand lance, and is interested in expanding to look at drift cells and how fish might use eelgrass for foraging and rearing.

- Working with WDFW on a smelt genetics study, and investigating stressors associated with smelt in captivity.
- Would like to apply telemetry capabilities in the Sound to learn more about forage fish basic life history; looking at the ability of surf smelt to handle transmitter devices.

Jan Lovy (Herring Conservation and Research Society/DFO)

Jan began five months ago and will capture wild Pacific herring off the BC coast. Herring will be kept in net pens at Nanaimo to determine if confinement stress induces disease epizootics.

- Doing a general health screening of the fish using multiple tools, expect to do more work on VHS and other diseases. They have found that herring become residents around Atlantic salmon pens, and Jan is interested in the effects of disease transmission between the two populations.

Dayv Lowry (WA Dept. of Fish and Wildlife)

Dayv is doing a genetics study on surf smelt eggs with Marty Liedtke; preliminary data show only one stock population. Next steps:

- Look at outliers using samples from AK to definitively say that Puget Sound has a discrete population. Are they panmictic because the larvae settle out and return or because the adults have no site fidelity?
- Telemetry studies of surf smelt to determine movements and site fidelity.
- Will also be analyzing WDFW historical spawning beach survey data to look at trends, new findings, repeat samplings, seasonal variation, spawning beach grain size, and more in an effort to define habitat parameters correlated with presence and extent of spawning. One thought might be to create a predictive model for where these species prefer to spawn in order to focus future survey effort.

Steve Marx (The Pew Environment Group)

This year Pew developed a national forage fish conservation initiative (New England, Mid-Atlantic and Pacific) aimed at moving forage fish management into a precautionary management scheme. They are just beginning, and looking forward to working with researchers to focus this momentum on forage fish into better management practices in the U.S.

Wayne Palsson (WA Dept. of Fish and Wildlife)

Wayne has done systematic bottom trawl and ROV surveys on benthic fish throughout Puget Sound, and collected ancillary data on forage fish. Primary interest of the agency is stock assessments, with a focus on fisheries management.

- Found sand lance on sand wave fields in 2004; collect adults pretty consistently at about 300' depth in the Fall. Also detect longfin smelt associated with larger estuaries.
- (Speaking for Jim West) WDFW is using euphausiids, herring, and salmon to look at pollutant ecology.

Dan Penttila (Salish Sea Biological)

Dan is primarily doing intertidal spawning surveys related to forage fish beach restoration projects, including Cornet Bay State Park (Whidbey Island), and a 2000' beach nourishment project in Fidalgo Bay. He is also involved in the planning for possible restoration of a 3-mile stretch of beach between Everett and Mukilteo.

- Doing an historical grain size study in Fidalgo Bay looking at surf smelt and sand lance spawning with increased beach grain size. These are the first data to demonstrate beach coarsening due to shoreline armoring.
- Interested in the potential of deepwater spawning in San Juan Channel; worked with 5th Life Productions to document sand lance spawning at Penn Cove two years in a row.

Cliff Robinson (Parks Canada Agency)

Cliff *et al.* got into sand lance work when studying critical foraging areas for endangered marbled murrelets. They have identified habitat for young-of-the-year sand lance.

- Recently used acoustic multi-beam data to identify medium-course sand subtidal habitat for sand lance. Expanded efforts in BC to analyze multi-beam and backscatter data to identify sand wave fields and sample those for fish. Working on a GIS-based model to help identify new sand waves where sand lance might burrow (looking for evidence of deepwater spawning.) This has been more difficult than anticipated.
- Coordinates a summer eelgrass sampling project for juvenile forage fish at five sites off the coast of BC.

Anne Shaffer (Coastal Watershed Institute)

Over several decades Anne has worked on the Elwha Dam removal and linkages between pending impacts of upland sediment on nearshore areas.

- Studying kelp bed function (snorkel surveys conducted past 10 yrs); has found changes in forage fish abundance in kelp beds. Surveys are being repeated now. Anne is also interested in drift cell movement and other changes.

- Interesting beach seining observations along central Strait of Juan de Fuca: of 60 juvenile Chinook collected, 40 were from Columbia River, demonstrating the inland water connection to other ecosystems - possibly other systems in OR, CA and BC.
- Continuing intertidal spawning surveys in collaboration with Dan Penttila.

Tom Therriault (Dept. of Fisheries and Oceans)

For the last 20 years, DFO has been doing juvenile herring surveys (and multiple species) on 10 fixed transects at five stations throughout the Strait of Georgia, overlaid with oceanographic data and plankton samples. Originally designed for herring stock assessment, this is becoming a useful data series for ecosystem indicators.

- Conduct annual egg and larval surveys for eulachon in the Fraser River; use the survey counts in conjunction with river discharges to develop a biomass estimate for the Fraser River spawning stock. Eulachon are not penetrating as far up as they used to and the runs seem to be getting earlier (2-3 weeks) in general.
- Support the Ecosystem Research Initiative's 5-year program, which includes forage fish as one component of the ecosystem-level understanding of the different regions studied, primarily historical reference in the Georgia Straits.

Most of the forage fishes of interest to the U.S. and Canada have not been well studied, the focus is mainly herring with limited ongoing research on eulachon. A draft document is now in preparation for review by COSEWIC at their 2011 spring meeting, for potential listing of eulachon as endangered (alternate designations include special concern, threatened, or extinct). If listed by COSEWIC, it will then go to the SARA. The expectation is that given the (poor) status in Canada, listing is likely. DFO is therefore conducting a recovery potential analysis, designed to aid management if eulachon are listed as endangered, and evaluate the likelihood of their return to a recovered state.

Tina Whitman (FRIENDS of the San Juans)

Tina began intertidal beach spawning studies in San Juan County 10 years ago (comprehensive surveys 2001-2003), picking up when WDFW lost funding. Organization's focus is land use. Building from the documentation of spawning beaches, they have done multiple habitat prioritization projects as well as on the ground restoration projects removing shoreline structures (armoring, tide gates etc.) and occasionally supplying beach nourishment to restore spawning habitat. There is always a large education and outreach component (schools, shoreline property owners, land managers, realtors, excavators, etc) associated with all of the work done.

- Currently undertaking pilot studies including a sea-level rise/climate change impact risk assessment for forage fish spawning beaches (drift cell and pocket beach) as well as a pilot study on the cumulative effects of shoreline armoring on forage fish spawning habitat.

- Interested in future work to identify new forage fish spawning beaches in the San Juans, as well as to document changes in use and explore opportunities to use spawning habitat assessments to inform status and trends.

Tina Wyllie-Echeverria (UW/W-E Associates)

Tina is leading the biological component of the deepwater sand lance project in the San Juan Islands. They are studying five sand wave fields, characterizing the sediment, bathymetry, and the density of sand lance in the sediment using a Van Been grab. The objective is to develop a population assessment and identify other life history characteristics.

- They have been more successful in catching fish in winter than in summer, and have caught as many as 40-50 fish in a single Van Been grab. There is a potential for more collaboration, and they have graduate students conducting studies on behavior and feeding differences between burrowed and swimming sand lance.
- Collecting genetic material for future analysis; age and length, and comparing wave fields.

Tina offered to provide fish for people doing toxicology or other projects.

Current Management Policies: Washington State and British Columbia

Washington (Kurt Stick)

Much of the agency's work to date has been on Pacific herring. Currently, the only active commercial fishery is a herring bait fishery in Central and South Puget Sound. Maximum harvest guidelines were previously based on stock assessments from spawn deposition and acoustic/trawl survey estimates. WDFW eliminated acoustic trawl surveys in fall 2010, and is now only using data from spawn deposition surveys. There are area, gear, and time restrictions on the fishery, which targets juvenile non-spawning fish. The last 10-year mean harvest is approximately 300-400 metric tons. It's a valuable fishery - herring currently retail for \$4-5/dozen - but the published ex-vessel value is probably an underestimate because most fishermen sell back to themselves.

There is a commercial beach seine fishery for surf smelt, most landings over the last few years are from Saratoga Pass/Utsalady Bay. There are gear, time and area restrictions, but management is passive (based on fish receiving tickets), and no abundance estimates are available. Over the last 10 years landings have averaged 90,000 pounds per year. Commercial fishing is allowed for anchovy with the same regulations as for herring; though few landings of anchovy in recent years. A different license is required for anchovy than for herring; no limited license for anchovy (there is for herring.) There are no commercial landings of eulachon or sand lance in Puget Sound. Numbers are available on the recreational harvest of surf smelt, and a few studies have been done, but there is nothing precise and information is limited.

British Columbia (Tom Therriault)

British Columbia has an integrated management plan for surf smelt which is split between commercial and recreational fisheries. There is a conservation closure during the summer spawning period, but there no scientific assessment conducted to feed into the management for that fishery.

Due to the poor shape of the stock, no commercial fishery for eulachon has been allowed in the Fraser River area for the last 5-7 years, and it is unlikely that it will return. Surf perch have a limited management plan (limited science available in support for an integrated plan); there is little interest or commercial value in this species. The integrated fisheries management plan for anchovy ended in 2003, and the commercial fishery is closed. There is a management plan for Pacific sardine, for which scientific advice is based largely on the U.S. assessment of this transboundary species. The fishery is off the West Coast of Vancouver Island.

As in WA waters, Pacific herring comprise the largest inland forage fishery. Science is used to inform the management sector, which sets quotas. Data come from SCUBA surveys for spawned egg deposition and catch-at-age. All of the herring stocks have a fishing harvest limit cut-off level at 25% of the fishing biomass estimate. There are three types of herring fisheries in BC: the sac roe fishery, the spawn on kelp fishery in central and northern BC, and the food and bait fishery in January and February. The harvest of Pacific herring is substantially higher than the annual harvest in Puget Sound. Note that recreational aspects for all forage fish listed are still open.

Needs Assessment (not prioritized)

For these discussions it was decided to focus on actions and impacts thought to be scientifically relevant, achievable from a policy standpoint, and with the potential for large-scale impacts.

Current Threats/Common Issues to Multiple Species

Panelists were asked to identify threats to forage fish populations based on existing knowledge and/or best professional judgment:

- Degradation, destruction, or alteration of spawning habitats, and other important quantitative and qualitative changes. *I.e.* Submerged aquatic vegetation, quality of riparian habitat including large woody debris and overhanging vegetation, water quality in the nearshore region, and indirect effects from upland watersheds.
- Climate change and ocean acidification impacts, including alteration of spawning habitat availability or quality, food web alterations, and growth rate alterations.
- Lack of basic scientific information on life history, status, and trends, which prevents us from adequately informing management.
- Fisheries impacts; lack of information on surf smelt to determine what is sustainable, impacts of juvenile herring harvest, bycatch, and injury of fish by other gear.



- Current diseases, threat of novel diseases, and impacts from aquaculture and invasive species.
- Environmental stressors (various). Unknown mortality factors including food supply, competition, and predation. Ecosystem level impacts and changes to steady-states.
- Lack of positive public policy.
- Increased global demand for forage fish, overcapitalization of some fleets (outside of the Salish Sea), and emerging fisheries.
- Most forage fish use shallow nearshore environments for at least some life stages. Multiple human uses impact survival, including logging, aquaculture (*e.g.*, vehicles on beach), urbanization, and also green energy development such as tidal energy and wind farms.

Science/Research

- Develop a synoptic larval fish survey, aimed at capturing a snapshot of relative abundance for most forage fish species throughout the region. Conduct spring surveys of juveniles, since year-to-year larval recruitment varies greatly. Larval surveys over broad space and short time periods are conducted elsewhere in the world. Although expensive, this would provide a baseline and help develop predictive models. Understanding larval duration will be helpful for such studies.
- A cross-species review of forage fish in the Salish Sea might provide information that we can't gain from individual species. Scale of the study is critical, and an interdisciplinary approach is necessary to establish baseline status and trends.
- Identify spawning habitats and determine if any are resilient to sea level rise, in order to provide habitat protection for their sustained benefit. This requires completing WA and BC spawning habitat surveys. We need a better understanding of the relationships between forage fish and physical oceanography.
- Better understand population structure for each of these species, including the natural and anthropogenic drivers of population abundance. Particularly for lesser known species such as surf smelt and sand lance (some work is being done on surf smelt now.) Research needed beyond egg deposition presence and absence.
- Develop effective stock assessment tools for surf smelt and sand lance, and ultimately for anchovies, eulachon and longfin smelt. Herring are better understood.
- Great predictive models for salmon populations exist, but not for forage fish. *I.e.* How many eggs from beach spawning translate into fish hatching? Forage fish embryos are great indicators of the health of spawning beaches. Assess mortality of sand lance and surf smelt embryo viability relative to habitat quality.
- Attributes of geomorphology and beach attributes for spawning of some forage fish species are still unknown. Are there differences between WA and BC for habitat specifications between species? What are the effects of habitat degradation on egg mortality (shading, bank erosion, water pollution)? Are beaches populations sink? There are two aspects of egg loss: they disappear or are found dead.

- There was a deeper discussion of current monitoring efforts, and where improvements could be made to establish an effective monitoring program. In particular a seamless program between the U.S. and Canada to focus research efforts.
- What are the roles of kelp and other submerged aquatic vegetation in forage fish life histories?
- Inventory of key habitat types relative to life history stages. Are there cross-border differences? Consider location and distribution, foraging behavior, creating a shore zone atlas to guide policy.
- We need better information on the movement of adult forage fish. Tagging of surf smelt and otolith microchemistry are possibilities given available genetic information.
- We need to better define the trophic relationships of forage fish, including quantitative data on feeding behavior, zooplankton diet, and predation.
- Consider bioassays to assess the relative sensitivity of herring, surf smelt, and sand lance eggs to oil and other contaminants.
- Studies are needed on the processes and stressors impacting forage fish, as listed above, in relation to climate change.

Policy/Management

- The state of Washington and the federal government in Canada manage most forage fish species, yet there is still a need for transboundary management. Prior attempts were phased out (*i.e.* Environmental Cooperation Council (ECC) did this in the 1990's.)
- Research on forage fish is driven by individual investigators, and without an overarching driver to better manage forage fish in the Salish Sea. There may be opportunities to increase attention on forage fish by including them in U.S. plans such as the Puget Sound Partnership 2020 Action Agenda, West Coast Governors' Agreement, Sea Grant Regional Science Plan, Shoreline Master Plans, and Marine Spatial Planning; and in BC through the Coastal Zone Management Plan (enforced by municipalities), or other intergovernmental plans. Within Canada there is the Ocean Action Act, which considers large ocean management areas, but not the Salish Sea. Establish a LOMA for BC south coast?
- The Coastal Pelagic Species Fishery Management Plan (NMFS/U.S. West Coast) could be used to leverage financial support. Forage fish could be added as ecosystem component species. *Note the distinction between Puget Sound and coastal pelagic fish.*
- There is a need for better enforcement of coastal land use codes and development incentives to protect existing forage fish habitat.
- There is a need to establish a mechanism for continual updates on forage fish at the State and County levels. There is current dissemination through white papers, but lack of transboundary communication in part due to budget shortfalls.
- Review and update of policy language in relation to oil spill management, and an effort to reduce the risk for bunker oil spills in the region.
- There is a science need to examine fisheries management for “data-poor fisheries”, such as surf smelt. No current method to index or estimate the biomass of surf smelt. Is there enough concern about the health of the population to stop the average harvest of 90,000 pounds per

year? We want to ensure that all fisheries are sustainable, including the harvest and bycatch of species like surf smelt and sand lance. How are stocks being impacted?

Education/Outreach

- The Green Shores for Homes program in BC should be replicated for Puget Sound. Pilot projects are being established in Seattle and San Juan County. Ecosystem functions, such as drift cells, should be considered.
- We need to define the problem(s) surrounding forage fish and convey the value of conserving these species, to gain political capital in support of the science and policy needed for conservation. The message about importance of forage fish is not being heard at the levels of higher management.
- Need to develop an integrated education approach, to include backshore landowners.
- Groups such as COMPASS and the Marine Resource Committees help design and coordinate communications and translate forage fish efforts into cool media stories for communities.
- There is no big forage fish display at the Seattle or Vancouver Aquariums (a great one at the Port Townsend Marine Science Center.)
- Consider engaging the popular birding community to create interest. Birds eat fish.
- Develop new activities, such as the BC forage fish “Great Egg Hunt”, modeled after the Christmas Bird Count.

Synthesis of research and management plans

It was decided that the focus of discussions should be to identify actions and impacts thought to be scientifically relevant, achievable from a policy standpoint, and with potential for large-scale impacts. Forage fish are demonstrated indicators of Salish Sea ecosystem health, and were generally categorized as a group (and by individual species when applicable.) It is hoped that this document can be used to inform future forage fish efforts by interested entities in Washington state and British Columbia, including those of SeaDoc Society and the Northwest Straits Initiative.

Acknowledgements

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Appendix – Attendees

Participants

David Beauchamp (UW/School of Aquatic and Fishery Sciences)
Joe Bizzarro (UW/SAFS)
Jennifer Boldt (Dept. of Fisheries and Oceans)
Lisa Christensen (Dept. of Fisheries and Oceans)
Duane Fagergren (Puget Sound Partnership)
Ramona De Graaf (BC Shore Spawners Alliance)
Correigh Greene (NOAA/NWFSC)
Eric Grossman (U.S. Geological Survey)
Doug Hay (Scientist Emeritus, Dept. of Fisheries and Oceans)
Paul Hershberger (U.S. Geological Survey)
Jim Huinker (Dept. of Natural Resources)
George Hunt (UW)
John Incardona (NOAA/Northwest Fisheries Science Center)
Theresa Liedtke (U.S. Geological Survey)
Jan Lovy (Herring Conservation and Research Society/DFO)
Dayv Lowry (WA Dept. of Fish and Wildlife)
Steve Marx (The Pew Environment Group)
Wayne Palsson (WA Dept. of Fish and Wildlife)
Dan Penttila (Salish Sea Biological)
Cliff Robinson (Parks Canada Agency)
Anne Shaffer (Coastal Watershed Institute)
Kurt Stick (WA Dept. of Fish and Wildlife)
Tom Therriault (Dept. of Fisheries and Oceans)
Tina Whitman (Tina Whitman, FRIENDS of the San Juans)
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Organizers/Technical Support

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Dan Peterson (grad student, UW/SAFS)
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Tom Sanford (UW-Applied Physics Laboratory)