



Workshop Summary Report Salish Sea Fish Assemblage Workshop

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Introduction

Changes in the composition and abundance of fish assemblages within the Salish Sea region have long been a topic of interest for management, as they can result in a variety of possible consequences associated with species/population management, habitat conservation, and ecological shifts. The National Marine Fisheries Service (NMFS), Washington Department of Fish and Wildlife (WDFW), and SeaDoc Society organized a workshop to gather managers, researchers, and policy-makers involved in Salish Sea fish assemblages to share and discuss evidence of fish community change, impacts of change on species and ecosystem recovery, and to align management priorities and identify research needs. Further, the idea for a workshop originally was identified within the Endangered Species Act Recovery Plan for yelloweye rockfish and bocaccio of the Puget Sound/Georgia Basin (NMFS 2017)¹. It became clear that assessing rockfish assemblage change without the context of assessing available information on full fish assemblage change would be insufficient for addressing recovery needs. The goal of the workshop was to identify relevant time-series data, evaluate current research, and discuss how existing efforts may contribute to future management strategies.

In addition to the host agencies, workshop participants represented a collection of agencies and organizations including the Department of Fisheries and Oceans Canada, Puget Sound Restoration Fund, Seattle Aquarium, Samish Tribe's Department of Natural Resources, Port Gamble S'Klallam Tribe, Washington Department of Ecology, WDFW, University of Washington and more (see appendix for full list of participants and organizations). There were 12 presentations organized into three sessions that primarily focused on pelagic fish,

¹ Rockfish recovery plan: Puget Sound/Georgia Basin, Yelloweye Rockfish (*Sebastes ruberrimus*) and Bocaccio (*Sebastes paucispinis*), prepared by Office of Protected Resources, West Coast Regional Office, National Marine Fisheries Service, National Oceanic and Atmospheric Administration (2017).



unconsolidated soft seafloor habitats, and rocky habitats relative to fish assemblages within the Salish Sea region. Presentations covered a range of topics, providing information on monitoring methodologies, observed habitat changes, shifts in species abundance, trends in species presence and absence, and more (see appendix for presenters and presentation titles).

Several prominent themes emerged during the workshop, including:

- There is strong evidence of a decline in abundance for several species within the Salish Sea, most notably Pacific Cod (*Gadus microcephalus*) and several species of rockfishes,
- There is evidence of a decline in fish assemblage diversity, and
- Single species management strategies are largely ineffective given the interwoven food-web and habitat relationships among fish (and invertebrates) within the Salish Sea.

Participants expressed strong uncertainty regarding the potential impacts of climate change and changing ocean conditions on marine species, and future monitoring, and management responses, largely due to the lack of long-term monitoring plans. During the discussion period, workshop participants identified several calls to actions including initiating the development of a framework to coordinate long-term monitoring efforts, creating professional channels that increase cross-sector collaboration and communication, and needing to incorporate climate impacts within management plans. It became apparent that there are large amounts of unprocessed or historical (non-digital) data that are available for research and analysis, and participants discussed ways in which these data might be accessed and put to use.

The following summary report describes the content presented at the workshop and discussions that took place throughout the day.

Current Research and Emerging Themes

Workshop participants collectively acknowledged that fish assemblages within the Salish Sea have changed over the last several decades, most notably through declines in species abundance (e.g., rockfishes, Pacific Cod) and diversity. Over the course of the past two to four decades there is strong evidence of declines in abundance of a number of species in Puget Sound and the Salish Sea, including demersal fish, Pacific cod, Pacific hake, forage fish, chinook and coho salmon and several rockfish species. Some participants stated that single-species management is not an effective strategy for recovery, therefore it is imperative that alternative approaches to management are explored. Participants discussed the application of a broader approach to management, one that encompasses many different species and habitat types at



the ecosystem level. Shifting towards ecosystem-based management could lead to more successful recovery outcomes as it accounts for the full array of interactions that take place within an ecosystem, including humans, rather than focusing on single species or isolated issues.

In addition, as talks presented data that revealed changes in fish abundance and diversity, it was noted that there was a general lack of data that clearly identified possible drivers of change and the potential linkages among these drivers. While there are many drivers of change in the Salish Sea, it is unlikely that all, or even most, of these could be studied with available resources. However, by leveraging existing datasets, it may be possible to identify the most significant factors in order to identify management areas of high priority and allocate resources in the most efficient and effective way.

A common thread throughout the workshop revolved around climate change and how to plan and manage for uncertain changes in ocean temperature and water quality parameters, including pH, salinity, and dissolved oxygen. Participants agreed that climate vulnerability assessments must be incorporated into management plans and recovery plans must consider how climate change might impact the health of species and ecosystems into the future.

Several WDFW staff called attention to the large amounts of archived data available for processing and analysis, which could be of interest to researchers. Available datasets include Remotely Operated Video (ROV) data from numerous surveys, one of which covered all of Puget Sound in 2012-2013, biological samples and historical data containing raw data, field notes, and unpublished reports that could extend time series data by 20-30 years if processed.

Throughout the workshop, common barriers and challenges were identified across sectors. Some of these challenges include:

- a general lack of funding for non-salmon related research over the past decades
- the difficulty of maintaining funds for long-term monitoring programs,
- a lack of communication and coordination across agencies and organizations, and
- the inability to compare data sets due to differences in scale and gear selectivity.

Information Gaps and Research Needs

During the discussion segment of the workshop, participants reflected on important monitoring techniques and subject areas where there are little or insufficient data. One barrier that was



brought up on numerous occasions stems from the challenges associated with quantifying time-series data that are on different scales. Creating a method that standardizes data would be invaluable in determining fish abundance, species composition, and fish assemblage in the Salish Sea.

Participants identified the following questions as areas of interests, research needs, and data gaps:

- What are the anthropogenic and environmental drivers of changes in fish assemblages?
- Is there a pattern or cycle for recruitment? Are there any environmental drivers or indicators that can be used as reliable predictors of recruitment?
- How has fish movement and migration changed over time?
- How can spatially and temporally different datasets be used to understand what's happening in the Salish Sea and inform management?
- Could shifts in species assemblages influence a trophic cascade impact? Has this already occurred?
- How will warmer sea temperatures and acidic ocean conditions affect assemblages of fish and their predators?

Identified Next Steps

In closing, participants identified action items and next steps in order to continue momentum around topics and themes that arose throughout the day. A majority of presenters shared information gleaned from time-series data and long-term monitoring projects for numerous fish species and habitat types. While methodologies for data collection differ for a variety of reasons, participants questioned the feasibility of comparing time-series data sets. The group stated that a streamlined framework for collecting time-series data should be developed so that datasets can be compared. The development of a time-series data collection methodology could be used to identify trends, information gaps, and gain a better overall understanding of the state of the Salish Sea.

The group discussed the importance of maintaining communication as a way to provide updates on research and management and to share data, expertise and data opportunities. Workshop participants suggested having a coordinated workshop at least every other year to discuss data, research, observations, and management actions. Additionally, an activity was suggested where researchers with time series data compare trend graphics by printing data in



the form of a poster or long plots. From there, posters could then be mounted on a wall so that everyone can look across the entire spectrum of trends and identify trends over time and across assemblages. The group also considered ways in which historical datasets, biological samples, and unprocessed ROV data could be used; and proposed connecting with departments and students at the University of Washington and other academic institutions who can assist in review of archived data, take on small research projects, and progress our understanding of overall fish assemblages in the Salish Sea.

Acknowledgements

This workshop was co-hosted by the National Ocean and Atmospheric Administration and Washington Department of Fish and Wildlife, and was made possible with funds from the SeaDoc Society. Thanks to Dayv Lowry, Dan Tonnes and James Selleck for organizing and facilitating, Zoe van Duivenbode for coordinating and recording notes, and all the presenters and participants who shared their time, knowledge, and expertise.

Appendix A: Workshop Presenters, Participants, and Organizers

Workshop Presenters

*Presenter name in bold

Alan Mearns. NOAA. *Fish and Shifting Baseline Ecosystems in the Salish Sea*

Tim Essington, Tessa Francis, Correigh Greene, Lauren Kuehne, Dayv Lowry, Elizabeth Ng, Eric Ward. *Data synthesis to establish long term trends in demersal and pelagic communities in Puget Sound.*

Todd Sandell, Mike Burger, Chris Fanshier, Adam Lindquist, Patrick Biondo, and Dayv Lowry. *The Pelagic Fish Community in the Southern Salish Sea: Results of the 2016-17 Mid-water Acoustic Trawl Survey.*

Larry LeClair, Debra Bacon, Bobbie Marshal, Gregory Lippert, and Dayv Lowry. *Unpublished and/or little known marine fish data sources from the early records of the Washington Department of Fisheries: 1936–1975.*



Correigh Greene, Stuart Munsch, Eric Beamer, Casey Ruff. *Changes in nearshore benthic and pelagic fish communities in Skagit Bay – a 20-year retrospective.*

Jen Blaine, Robert Pacunski, and Dayv Lowry. *Characterizing nearshore fish assemblages on “soft” bottoms in the southern Salish Sea using quantitative bottom trawling: 1987-present.*

Lorenz Hauser and Dayv Lowry. *Conservation at the edge: the case for ESA listing of Pacific cod in the Salish Sea.*

Patrick Biondo, Hannah Faulkner, James Losee, Adam Lindquist, **Todd Sandell** and Phill Dionne. *The South Puget Sound Index Survey: A Study of Near-shore Fish Community Composition.*

Shawn Larson, Amy Olsen, Chris VanDamme and Jeff Christiansen. *Rockfish surveys in the Strait of Juan de Fuca and Puget Sound 2005-2017.*

Dana Haggarty and Stephanie Archer. *Rocky Reef Fishes in the Salish Sea*

Larry Leclair, Lisa Hillier, Robert Pacunski, Jen Blaine, and **Dayv Lowry**. *A synthesis of bottomfish species assemblage data from fifteen years of scuba surveys at seven locations in the southern Salish Sea: 1995-2005.*

Robert Pacunski, Wayne Palsson, and Dayv Lowry. *Characterizing nearshore fish assemblages and habitats in the southern Salish Sea using a drop-camera system: 1994-2004.*

Dayv Lowry, Robert Pacunski, Jim Beam, Jen Blaine, Andrea Hennings, Amanda Phillips, Mark Millard, and Lisa Hillier. *A synthesis of bottomfish species assemblage data from nearly a decade of remotely operated vehicle (ROV) surveys throughout the southern Salish Sea: 2008-2016.*

All Workshop Participants (including presenters)

Jameal Samhuri (NOAA Northwest Fisheries Science Center)
Genoa Sullaway (NOAA Northwest Fisheries Science Center)
Stuart Munsch (NOAA Northwest Fisheries Science Center)
Alan Mearns (NOAA)



Correigh Green (NOAA)
Greg Williams (NOAA)
Amanda Phillips (Washington Department of Fish and Wildlife WDFW)
Andrea Hennings (Washington Department of Fish and Wildlife WDFW)
Dayv Lowry (Washington Department of Fish and Wildlife WDFW)
Jen Blaine (Washington Department of Fish and Wildlife WDFW)
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Larry LeClair (Washington Department of Fish and Wildlife WDFW)
Robert Pacunski (Washington Department of Fish and Wildlife WDFW)
Theresa Tsou (Washington Department of Fish and Wildlife WDFW)
Todd Sandell (Washington Department of Fish and Wildlife WDFW)
Carolyn Tarpey (University of Washington)
Eleni Petrou (University of Washington)
Mike Canino (University of Washington)
Tim Essington (University of Washington)
Chris VanDamme (Seattle Aquarium)
Jeff Christiansen (Seattle Aquarium)
Joel Hollander (Seattle Aquarium)
Shawn Larson (Seattle Aquarium)
Julia Bos (Washington Department of Ecology)
Dana Haggarty (Fishers and Oceans Canada, Government of Canada)
Iris Kemp (Long Live the Kings)
Michael Schmidt (Long Live the Kings)
Stephen Schreck (Puget Sound Restoration Fund)
Brian Allen (Puget Sound Restoration Fund)
Matt Castle (Samish Tribe's Department of Natural Resources)
Hans Daubenberger (Port Gamble S'Klallam Tribe)
Tessa Francis (Puget Sound Institute & University of Washington Tacoma)
Hans Daubenberger (Port Gamble S'Kallam Tribe)

Workshop Organizers

Zoe van Duivenbode (University of Washington)
Dayv Lowry (Washington Department of Fish and Wildlife)
Dan Tonnes (NOAA)
James Selleck (NOAA)



Joseph Gaydos (SeaDoc Society)

Appendix B: Presentation Abstracts & Presenter Biographies

Opening Presentation

Fish and Shifting Baseline Ecosystems in the Salish Sea

Alan J. Mearns, PhD. Scientist Emeritus. NOAA

Based on four decades of monitoring we might say that fish populations in the Salish Sea are “degraded” compared to what they were in the early 1970s. Yet no one at this workshop assumes that the health of fish populations was “normal” four decades ago. We won’t fall into the trap that what we observed then was a baseline toward which we should aspire and manage... Daniel Pauley’s “shifted baseline”. That is why we seek information from earlier decades.

Here I simply want to remind us of what fisheries and environmental conditions were like in the Salish Sea leading up to the early 1970s. Commercial and recreation fishing was heavier than now, for all assemblages. Chinook and Coho salmon had high survival rates, higher than for outer coast populations. Demersal fish were heavily trawled, part going to mink farms. Benthic infauna biomass was increasing. While adult chinook were passing upstream in large numbers, flounders at the bottom of the Duwamish were afflicted with fin rot. Harbor seals were just starting their “recovery”, leading to their rapid re-colonization of the Salish. Bays and river entrances in the Sound were polluted with massive volumes of wastewaters and organic material from pulp mills and sewage: oyster larvae were killed and maimed by water samples taken off Everett and Port Angeles mills. Dated sediment cores revealed that both organic matter and toxic chemicals had just reached maximum concentrations, following rapid increases during, and leading up to, World War II. But there were a lot of fish.

During the 1970s to 1990s the Sound was getting cleaner and the fish were declining. Several scientists during the 1980’s hinted at something intriguing: basically, with all that organic material loading in the ‘40s to ‘60s, were we “feeding” the fish through enhanced secondary production? Then we started the “big clean up” and the fish declined. If that was the case, what were fish assemblages like well before that? Were they less productive at the onset of regional industrialization than in mid 20th Century? How many “shifted” baselines have we passed through during the past two centuries? I don’t have the answers, just the questions.

Biography



Alan recently retired after serving 38 years as an ecologist with NOAA's Office of Response and Restoration in Seattle and a previous 9 years with the Southern California Coastal Water Research Project (SCCWRP) in Los Angeles. A California native, Alan received his Bachelor's and Master's Degrees in Biology at California State University at Long Beach, and his PhD in Fisheries (1971) at the University of Washington. His core activities focused on marine pollution assessment and management. He was Leader of the Biology Division at SCCWRP, his teams assessing and monitoring the effects of California's major municipal wastewater outfalls, with focus on demersal fish and invertebrate communities, regional standardization of trawls and other sampling gear, diseased fish populations, food web structure and contaminant bioaccumulation. Returning to Seattle (1980) he served as ecologist for the Puget Sound Marine EcoSystem Analysis (MESA) program then the NOAA national Long Range Effects program and then the NOAA National Status and Trends Program. During the 1989 Exxon Valdez Oil Spill his affiliation shifted to NOAA's National Hazardous Material Response Division where he served as Leader of HazMat's Biological Assessment team, providing spill response guidance to the Nation's Scientific Support Coordinators and the US Coast Guard. He was immersed in responses to major spills around the US and internationally. As a Senior Staff Scientist he helped develop and apply 3D fate and transport models to assessment of spill response options including oil spill dispersion. He participated in and continues a volunteer-driven long term shoreline intertidal monitoring program, documenting interannual variability of selected shoreline sites in Prince William Sound.

As part of his salmon physiology research (1967-71) Alan lived and worked aboard a floating fisheries laboratory stationed in the heavily polluted Duwamish Waterway. In Bristol Bay he conducted research on salmon smolt survival following tagging. During his NOAA career he also participated in Miller and Moulton's review of historical Puget Sound fish monitoring data identification and, later, on two Status Reviews of Puget Sound Herring.

Section 1: Pelagic Fish

1. Data synthesis to establish long term trends in demersal and pelagic communities in Puget Sound.

Tim Essington, Tessa Francis, Correigh Greene, Lauren Kuehne, Dayv Lowry, Elizabeth Ng, Eric Ward

Unlike most major U.S. estuaries, Puget Sound has not been the subject of routine, standardized monitoring across time scales needed to evaluate the success or failures of restoration and recovery policies. While evidence accumulates that the Puget Sound food web



has undergone a fundamental shift, the absence of long term monitoring data hampers federal efforts to recover threatened or endangered species such as rockfish and Pacific salmon, state efforts to allocate catch for recreational and commercial harvest, and tribal negotiations over treaty rights to harvest. We are addressing this gap by compiling all available information on groundfish, salmon, and marine mammals, spanning 1940s to the present, to assess evidence for ecological change, and to link those to climate, fisheries management, marine mammal, and diffuse effects of human population density. A key step is standardizing sampling data to account for spatio-temporal variation in abundance that might obscure longer term trends. We will report on the results of this standardization and on findings that ensue from applying these standardization tools to historical data.

Biography

Tim Essington is a marine fisheries ecologist, who conducts quantitative research on populations and food webs, and the roles of anthropogenic activities on them. He is Professor and Associate Director of the School of Aquatic and Fishery Sciences, and is also the Director of the UW Quantitative Ecology and Resource Management graduate program. He has been conducting research on Puget Sound since he arrived in Seattle in 2003.

2. Title: The Pelagic Fish Community in the Southern Salish Sea: Results of the 2016-17 Mid-water Acoustic Trawl Survey

Todd Sandell, Mike Burger, Chris Fanshier, Adam Lindquist, Patrick Biondo, and Dayv Lowry

The WDFW conducted a mid-water trawl/hydroacoustic survey at 18 index reaches across the southern Salish Sea (SSS) from Olympia to the Canadian Border, and into the eastern Strait of Juan de Fuca, in order to characterize the composition of the pelagic fish and invertebrate community. Sampling occurred every other month from February 2016 to February 2017 and consisted of gathering hydroacoustic data paired with pelagic trawls, vertical plankton tows, and CTD casts. Trawling effort targeted areas of high acoustic density identified by the lead hydroacoustics boat and the elapsed time between sampling events was typically less than one hour. Although 96 different species of fish and invertebrates were captured in the trawls, nine species made up 96% of the overall catch. Catch data demonstrated that Pacific Herring, a common prey of salmon, groundfish, seabirds, and marine mammals, were the most abundant forage fish in the surveyed area, making up 61% of total catch. In Hood Canal, where herring abundance has increased markedly over the last few years, herring made up 89% of total catch. Herring were the most abundant catch in all four sub-basins, although they exhibited large seasonal fluctuations and were a minor component of the catch in June, August, and December. Northern Anchovy were infrequently captured but sometimes represented a large percentage of the catch for an individual trawl, particularly in the southern basin in the late



summer and early fall. Other notable forage species that made up significant portions of the catch included Pacific hake/whiting, shiner perch, and market squid. Overall, the study captured a “snapshot” of the pelagic species community in Puget Sound after an extended period of anomalously warm surface waters in the northeastern Pacific Ocean and will serve as a reference point for future studies.

Biography

Dr. Todd Sandell has led the Department’s Pacific herring stock assessment efforts in the Southern Salish Sea since 2015, and also coordinates studies focused on the biology and ecology of other forage fish species. He has been a field biologist for 22 years, studying juvenile salmonid biology, disease ecology and fish community trophic interactions in the upper and lower Columbia River, the San Juan Islands, Grays Harbor, as well as throughout Puget Sound. Prior to moving to Washington in 2010, Todd worked at the Hatfield Marine Science Center (Oregon State University) where he went to sea aboard commercial fishing vessels for eight summers and participated in the Columbia River Plume study and GLOBEC (Global Ocean Ecosystem Dynamics), a study of the Northern California Current.

3. Changes in nearshore benthic and pelagic fish communities in Skagit Bay – a 20-year retrospective

Correigh Greene & Stuart Munsch, NOAA Fisheries, Northwest Fisheries Science Center and Eric Beamer & Casey Ruff, Skagit River System Cooperative

Fish communities in Puget Sound have faced multiple potential pressures in the last 50 years, including changes in primary production, predator abundance, temperature and salinity, harvest practices, and shoreline modification. While long-term monitoring is lacking for much of this time period, the Skagit River System Cooperative commenced beach seining in Skagit Bay in 1995 and the Northwest Fisheries Science Center initiated surface trawling in neritic habitats in 2001. These datasets provide a window into the trends of abundance of nearshore fish communities. We examine these trends using statistical models that account for seasonal and spatial autocorrelation to compute annual estimates of abundance, and using multivariate models to examine whether annual trends in fish communities exhibited strong evidence of changes. We found strong evidence for change in both benthic and pelagic communities during this time period. We evaluate whether the above potential drivers may have strongly contributed to changes in both fish communities. In addition, data exist from sampling in the 1970s that provide a longer-term, if more snap-shot, comparison to longer-term trends.



Biography

Correigh Greene works for NMFS' Northwest Fisheries Science Center in the Watershed Program, where he focuses on population ecology of estuarine fish populations. He has been studying fish assemblages in Puget Sound since 2003, and has co-led (with Eric Beamer of the Skagit River System Cooperative) a long-term fish monitoring program in Skagit Bay since 2005.

4. Unpublished and/or little known marine fish data sources from the early records of the Washington Department of Fisheries: 1936–1975.

Larry LeClair, Debra Bacon, Bobbie Marshal, Gregory Lippert, and Dayv Lowry

Since its inception in 1921, the Washington Department of Fish and Wildlife (formally, the Department of Fisheries) has conducted research investigations in the waters of the Salish Sea. Several of these studies spanned the international border with Canada and regularly involved diverse partner governments, and other entities. For most of the studies conducted prior to the inaugural years of the information age, data exist only in the form of hand-scribed field notes, digital scans of these notes, internal reports, or memos; none of which are widely available to the research community at large. Some of the data have not been summarized at all. In recent years, the Department has embarked on an effort to locate, assemble, and catalogue records from its early Salish Sea field studies, and to rescue data sets that might otherwise have been permanently lost to posterity. The studies often include basic biological information on Salish Sea fish and invertebrates, such as lengths and weights, spatial distributions, presence/absence, and species compositions. We will highlight a select few of the early studies and discuss their potential for assimilation into ecosystem based fishery management models, estimates of historical biomass and species composition, and estimates of ecosystem change over time, within the Salish Sea. While comprehensive evaluation of the information contained in these data sets is not possible in their current state of repose, our hope is that collaborations engendered by increased awareness of the studies through workshops like this can facilitate the allocation of resources for permanent digital archiving and analysis.

Biography

Larry LeClair has worked as a biologist for the Washington Department of Fish and Wildlife since 1985. Over the course of his career he has worked on a diverse range of scientific studies and resource management issues. Currently, he is a member of the WDFW Marine Fish Science Unit working on Salish Sea marine fish conservation and restoration, stock assessments, and fishery management.



Section 2: Soft Seafloor

1. Characterizing nearshore fish assemblages on “soft” bottoms in the southern Salish Sea using quantitative bottom trawling: 1987-present

Jen Blaine, Robert Pacunski, and Dayv Lowry WDFW Marine Fish Science Unit

Since 1987, the Washington Department of Fish and Wildlife (WDFW) has been conducting bottom trawl surveys throughout Washington waters of the Salish Sea (i.e., greater Puget Sound) to estimate the relative abundance, species composition, and biological characteristics of bottomfish species. Occasional surveys have also occurred in Canadian waters (1997, 2000, 2001, 2003). While all of the surveys have incorporated the same depth-stratification since their initiation, and generally occurred in the spring, the overall survey design has varied, with surveys conducted at irregular intervals and at different spatial scales. Surveys in 1987, 1989, and 1991 sampled all of Puget Sound except the San Juan Islands sub-basin. From 1994-1997 and 2000-2007, surveys were conducted annually and focused on 1-4 of nine demarcated Puget Sound sub-basins. Starting in 2008, the WDFW implemented a synoptic survey design, with tows occurring annually at fixed index sites throughout all of the eight identified Puget Sound sub-basins (Discovery Bay was dropped as an independent locale). Despite these changes, the trawling procedure has remained largely consistent throughout the surveys. A total of 2302 tows have been conducted, with an average tow distance of 0.41 nautical miles. The catch from each tow was identified to the lowest taxonomic level, weighed, counted, and most returned to the sea. Fish and invertebrate density at each station was calculated by dividing the catch numbers or weight by the area sampled by the net. Key species of interest include Pacific Cod, Walleye Pollock, Pacific Hake, English Sole, North Pacific Spiny Dogfish, and skates, but all species of fishes and invertebrates were identified and recorded. This presentation will review the historical trawl surveys and summarize data trends from the more recent (2002+) surveys for several key taxa. While some taxa have experienced drastic abundance declines over time, a few show recent signs of resurgence.

Biography

Jen Blaine finished her B.S. from Wittenberg University (Springfield, OH) in 2006 and her M.S. from Washington State University (Vancouver, WA) in 2010. Despite being an invertebrate person at heart (yay sea cucumbers!), in 2013 she became a biologist for the Marine Fish Science Unit of the Washington Department of Fish and Wildlife. Jen has since become the lead bottom trawl biologist, managing both the annual bottom trawl survey and the resulting data. She has implemented additional sampling procedures (e.g., vertical plankton tows, stomach



contents) and the use of several new pieces of technology on the survey, and overhauled the old database to improve efficiency of data entry, facilitate internal and external data requests, and write reports. Jenis also one of the Unit's lead ROV pilots and an agency diver, and participates in these surveys frequently.

2. Conservation at the edge: the case for ESA listing of Pacific cod in the Salish Sea

Lorenz Hauser and Dayv Lowry

Puget Sound harbors a diverse fish assemblage with many species now at a fraction of their historical abundance. Some of these are protected under various state and federal regulations and both directed and incidental fisheries have been substantially reduced or eliminated. Many species are also represented by populations that are demographically isolated from coastal conspecifics. Such isolated populations, especially those at the southern edge of a species' distribution, may not only harbor a large proportion of the genetic legacy of a species, but also represent local adaptations that are crucial for the persistence of species in a rapidly changing environment. Here, we present genetic and ecological data on Pacific cod that not only demonstrate the discreteness of Salish Sea cod but also its significance for the species as a whole. Given the extremely low abundance of cod in the Salish Sea in recent decades, a consideration to list the population under the US Endangered Species Act seems, therefore, appropriate.

Biography

Lorenz Hauser originally hails from Austria, which lacks a coastline and major fisheries, but has an interesting fish fauna. After a MS degree at the University of Vienna, he did another one in Bangor, Wales, UK, and then moved on to a PhD on African freshwater clupeids at Swansea University, Wales, UK. After a postdoc in England, Lorenz accepted a faculty position at the University of Washington, where his research interests are centered on the interaction between the environment, species biology and genetic population structure. In pursuing this overarching goal, the research program of his group has developed along three principal themes:

- *The investigation of drivers of genetic population structure in marine species, not only for the identification of self-recruiting populations as units for management and conservation, but also to pinpoint mechanisms of dispersal and demographic variability. The group mainly works on Pacific herring, Pacific cod, rockfishes and Pacific halibut, but also sockeye salmon.*
- *The quantification of reproductive success, dispersal and gene flow, primarily in anadromous salmonids, with the aim to identify primary causal mechanisms leading to*



phenotypic diversity and divergence. This research concentrates on steelhead and sockeye salmon, but the group has also worked on brown rockfish in Puget Sound.

- *The examination of mutation mechanisms, patterns of variability and statistical analyses of molecular data, in order to improve their interpretation in a biological context.*

In his research, Lorenz always keeps in mind the practical applications of the group's findings. He therefore collaborate extensively with scientists and managers at local, state and federal agencies, as well as with other stakeholder groups. This doesn't only make the science more relevant, but also provides students in the group with contacts and experience in applied management.

3. The South Puget Sound Index Survey: A Study of Near-shore Fish Community Composition

Patrick Biondo, Hannah Faulkner, **James Losee**, Adam Lindquist, Todd Sandell and Phill Dionne

Beginning in 2015, the WDFW initiated beach seine surveys to capture nearshore forage fish in South Puget Sound. The effectiveness of this method for capturing other nearshore species, such as Cutthroat Trout quickly became apparent, and our desire to assess the composition of the nearshore fish community over time lead to the establishment of a quarterly beach seining study in 2017. Our quarterly surveys sample five South Sound beaches in January, April, July and October of each year. We quantify the catches of fish from each survey, record biometrics for a subsample of each species encountered, and, for forage fish, we retain samples for ageing and determination of sex and reproductive state. In addition to assessing community composition, these surveys provide access to fish and opportunities to collect genetics samples, assess fish health, and try new methods. Early seining efforts provided an opportunity to tag Surf Smelt and Cutthroat Trout. Tagging smelt with VIE tags revealed that, a) VIE tags are retained by smelt for up to nine months, b) male smelt spawn more frequently than females, and c) both male and female smelt were recaptured at the same sites, indicating some site fidelity in adults despite genetics suggesting a panmictic population in Central and South Puget Sound. PIT tagging and genetics samples from Cutthroat are revealing marine distribution of trout from different natal streams; and we have observed an increase in the prevalence of parasitic copepods on fish captured during the fall. The spatial and temporal extent of our surveys is currently small, but as we continue these surveys, we hope to assess temporal shifts in community composition and identify partners to work with to compare results on a regional scale.



Section 3: Rocky Habitat

1. Rockfish surveys in the Strait of Juan De Fuca and Puget Sound 2005-2017

Shawn Larson, Amy Olsen, Chris VanDamme and Jeff Christiansen

Since the early 1980s, biologists from the Seattle Aquarium have been informally monitoring bottom fish on rocky reefs in Neah Bay, Washington. These observations have produced an intimate knowledge of these reefs, and an informal record of abundance and distribution. Based on increasing concern over the long term stability of bottom fish populations in this area by both state and federal agencies, the aquarium formalized monitoring in 2005 with diver based video surveys to quantify bottom fish (rockfish and lingcod) diversity and abundance over time. Divers performed 100 m video transects devised to be non-invasive and repeatable for assessing diurnally active and sessile bottom fishes over time. Four transects were conducted each year in August from 2005-2015 at four permanently marked sites with a fifth site added in 2010. Surveys were all 100 m long and were surveyed in both the forward and reverse direction to gather information about fish disturbance or attraction to divers and gear. Species were qualified and quantified by biologists counting fish off of the archived video on large screen monitors. Statistical difference between numbers of fish observed during forward vs. reverse passes of surveys was not significant. Thus only fish counted on the forward transect pass were included for further statistical analyses. Over thirteen years there was an increase in diversity of adult rockfish and a decrease in density of adult schooling rockfish such as blacks and blues. There were several significant young of the year (YOY) rockfish recruitment “jackpot recruitment” events that occurred in 2006, 2008, 2011, 2012, 2014 and 2016. Numbers of adult and YOY rockfish densities were not significantly correlated with any environmental variables measures such as sea surface temperature (SST) and chlorophyll. This study may elucidate trends in rockfish diversity and abundance to advise management plans for rockfish conservation.

Biography

Shawn Larson has been working at the Seattle Aquarium as the Curator of Conservation Research since 2005. She received her PhD from the school of Aquatic and Fishery Science in 2003 and since then has studied sea otters, sixgill sharks, giant pacific octopuses, Hawaii reef fish and Salish Sea rockfish.

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2. Rocky Reef Fishes in the Salish Sea

Dana Haggarty, Stephanie Archer

The groundfish community in the Strait of Georgia has undergone a dramatic change over the last five decades, with reduced abundances of Pacific Cod, Lingcod and inshore rockfishes. Historically, groundfish species supported an important fishery in the Strait of Georgia, however, most commercial (and some recreational) fisheries have been closed due to low abundances. This talk will summarize trends in rockfish and lingcod stocks in the Canadian portion of the Salish Sea. I will report temporal trends from fishery independent longline surveys, biomass estimates from available stock assessments, as well as commercial and recreational fishery catch data. Spatial trends in benthic fish assemblages from Remotely Operated Vehicle (ROV) surveys will also be presented. Changes in fish communities will be discussed with respect to fishing pressure, climatic change, and changes in predation. I will also provide an overview on conservation measures that have been put in place to conserve fish stocks and to protect biodiversity such as Rockfish Conservation Areas, Sponge Reef Closures and a proposed National Marine Conservation Area.

Biography

Dana studies the Ecology, Conservation and Population Biology of nearshore fishes such as rockfishes and Lingcod. Her PhD. work focused on the recovery of rockfish populations in Rockfish Conservation Areas (RCAs). Her current projects focus on modeling rockfish habitat, the recovery of Yelloweye Rockfish populations, rockfish barotrauma, and Lingcod stock assessment. She collaborate with international partners, industry, academics, ENGOs and First Nations on longline and Remotely Operated Vehicle (ROV) surveys to monitor and assess fish populations and their habitats.

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3. A synthesis of bottomfish species assemblage data from fifteen years of scuba surveys at seven locations in the southern Salish Sea: 1995-2005

Larry Leclair, Lisa Hillier, Robert Pacunski, Jen Blaine, and Dayv Lowry. WDFW Marine Fish Science Unit



The Washington Department of Fish and Wildlife (WDFW) conducted systematic SCUBA-based underwater visual censuses at seven sites in central Puget Sound over a 15-year period beginning in 1995 (no surveys were conducted in 1998). Several of these sites were partially or entirely within designated Marine Protected Areas and all sites contained high-relief natural or anthropogenic structure known to attract actively managed and ecologically important bottomfish species. The duration of protected status for sites ranged up to thirty years (Edmonds Underwater Park), which is longer than any other location in Puget Sound and makes long-term evaluation of the effects of protection possible. Over 500 surveys were conducted at fixed transects in both spring and fall, and all bottomfish, as defined by Washington Administrative Code (rockfishes, greenlings, flatfishes, sharks, skates, sea perches, etc.), were targeted in the survey effort. In addition to being counted, the size of encountered fish was estimated to the nearest 10 cm, making it possible to compare species-specific size distributions between seasons, among years, and among sites. Here, we present an analysis of trends in abundance, biomass, and species composition for bottomfish within and among sites across time. Changes in assemblage composition were noted at the species level, but when aggregated to the genus or family level many of these differences faded. When species fill similar ecological niches, variation within a clade may not have significant ecological consequences. Our findings have recently been summarized in a comprehensive report and will inform fishery and habitat managers as they maintain sustainable fisheries and biodiversity, recover species of conservation concern, and identify species-specific critical habitats in Puget Sound.

4. Characterizing nearshore fish assemblages and habitats in the southern Salish Sea using a drop-camera system: 1994-2004

Robert Pacunski, Wayne Palsson, and Dayv Lowry. WDFW Marine Fish Science Unit; NOAA RACE Division

Rockfish (*Sebastes* spp.) populations in the southern Salish Sea noticeably declined in the 1970s, and by the mid-1980s, the Washington Department of Fish and Wildlife (WDFW) recognized the need for proactive management of these environmentally and economically valuable fishes. Along with increasingly stringent regulatory actions, the WDFW developed a drop-camera system to more thoroughly survey rockfish and other structure-oriented bottomfishes in nearshore (<37 m deep) habitats that are difficult or impossible to assess with other traditional survey techniques, like bottom trawls. From 1994 through 2004, nearly 5,300 camera drops were completed during nine Visual Assessment Technique (VAT) surveys throughout the inland marine waters of Washington State, and the results were used to characterize the habitat at each drop site and estimate the density of observed fishes. However, determining the area swept by the camera proved difficult and density estimates were subsequently considered an “index” of abundance rather than true density estimates. Other challenges with this technique included



detection of cryptic fishes in complex habitats, working in strong currents and at depths greater than 37 m, and attraction/avoidance biases of the system. Despite these problems, the system provided valuable information on species presence, substrate type, and habitat complexity throughout the nearshore, which can be compared to more current ROV survey data to look for shifts in species composition over time on a sub-basin scale. Data from these surveys continue to inform habitat-mapping efforts, and the fish presence data are now being used to build species distribution models to better understand the current and historical distributions of structure-oriented bottomfish species. Experience with the VAT system was also instrumental in the development of the remotely operated vehicle (ROV) program at the WDFW, which has become the primary tool for assessing rockfishes, including ESA-listed Yelloweye Rockfish and Bocaccio, in the southern Salish Sea.

Biography

Bob Pacunski is a research scientist with the Washington Department of Fish and Wildlife and has been a member of the Marine Fish Science Unit since 1991. Bob leads a small group of scientists and technicians that conduct stock assessments and habitat research on bottomfish in Washington and Canadian waters. His primary work involves the use of species-distribution models to design and conduct surveys of ESA-listed rockfish and other structure-oriented groundfish using small remotely-operated vehicles (ROVs). He also oversees the annual WDFW trawl survey, is a Senior Scientific Diver with the WDFW dive program, and serves as a member of the Federal Rockfish Recovery team that developed the Recovery Plan for ESA-listed Bocaccio and Yelloweye Rockfish. His expertise in the use of ROVs has led to a number of collaborative studies and surveys that have greatly enhanced the understanding of the distribution and abundance of many Puget Sound marine fish species. Bob has presented the results of his work at numerous local, national, and international meetings and conferences and has authored over 20 scientific reports and articles during his tenure at WDFW.

5. A synthesis of bottomfish species assemblage data from nearly a decade of remotely operated vehicle (ROV) surveys throughout the southern Salish Sea: 2008-2016

Dayv Lowry, Robert Pacunski, Jim Beam, Jen Blaine, Andrea Hennings, Amanda Phillips, Mark Millard, and Lisa Hillier. WDFW Marine Fish Science Unit

Assessing the distribution, abundance, and population status of marine species can be challenging, particularly given their selective utilization of discrete patches of particular habitat types. While a variety of methods and tools are available for such assessments, each has inherent biases and selectivity, and most are appropriate for sampling a limited range of habitats and species. Though benthic trawling has traditionally been used to monitor



abundance and distribution of bottomfish species for management in the southern Salish Sea, declines in populations of several key species and recognition that trawling under-samples high-relief, rocky locales led the Washington Department of Fish and Wildlife (WDFW) to explore non-consumptive, visual survey technologies beginning in the early 1990s. In 2008, 2010, 2012-13, and 2015-16 the WDFW used a remotely operated vehicle (ROV) to survey benthic-demersal fish communities over various geographic scales (including the whole of greater Puget Sound) using several survey designs based on different mapping and stratification methods. All of these surveys produced site-specific data on community composition, as well as species-specific estimates of habitat utilization, frequency of occurrence, and density. Variation in survey design, however, means that direct comparison among surveys must be performed carefully, and simply “merging” results is not appropriate. Here, we present species assemblage data from this suite of surveys, demonstrate spatiotemporal variation in these assemblages, and discuss implications for future survey efforts and management actions. Building on this decade of visual survey assessments with the ROV, the WDFW will perform a survey of greater Puget Sound in 2019-21 that samples benthic-demersal fish species in high-relief, structurally complex habitats, while maintain the use of an otter trawl to sample flat, low-complexity bottoms.

Biography

Dr. Dayv Lowry has been a research scientist with the Washington Department of Fish and Wildlife since 2010. He currently serves as head of the Department’s Puget Sound Marine Fish Science Unit where he oversees stock assessments and ecological research that support conservation and fishery management. He also serves on the North Pacific Fishery Management Council’s Scientific and Statistical Committee, where he helps to ensure that management of Alaskan fisheries is rooted in science. His areas of expertise are the behavior, anatomy, trophic interactions, and demography of marine species, specifically forage fishes (smelt, sand lance, etc.), rockfishes, and sharks. An author of over 50 scientific reports and publications, Dayv is a passionate educator and speaker who has appeared in documentaries about on the Discovery Channel, Animal Planet, and KCTS, and who regularly lectures on marine fish conservation and management at aquaria, universities, and other educational entities.