U.S. – Canada 2013 Research Planning Retreat

12-13 December 2013
Hilton Hotel Richmond, BC
Follow-up Document

Summary

U.S. and Canadian scientists affiliated with the Salish Sea Marine Survival Project convened in December 2013 to review the status of research planning and discuss how to proceed with integrating research components that would benefit most from U.S. - Canada collaboration. These included:

1) Trend Analyses and Modeling (salmon survival trends, ecosystem indicators, ecosystem modeling) – Objective: ensure methods used throughout Salish Sea are uniform or comparative and provide a framework for evaluating past and future data.

2) Core, Bottom-up Sampling Program (salmon, zooplankton[1], and physical characteristics) – Objective: ensure key data are collected, and in similar fashions, in the U.S. and Canada.

3) Data management and sharing (all) – Objective: determine mechanisms for data management and sharing among project scientists during the project, and identify approaches to broader more long-term data management and dissemination.

Workgroups member lists were established for each topic to help facilitate discussions, and these lists have been updated based upon the discussions at the retreat. Workshop attendees are also highlighted.

Trend analyses and modeling

Salmon Survival Trends and Life-History Analyses – Workgroup participants agree that the current approach to analyzing coho survival trends is a good basis for further survival analyses. They also agreed that Chinook should be the next species evaluated. Beyond a few sockeye populations, the other salmon species do not have comprehensive enough datasets for similar analyses. There was less agreement on the value of evaluating the effects of life-history characteristics (e.g., outmigration timing and size) relative to survival. Currently, the U.S. intends to invest more in evaluating this, while the Canadians largely reference a recent publication by Dr. James Irvine indicating no apparent difference in survival of hatchery coho with various release and outmigration times (2013)[2].

Ecosystem Indicators Summary – Workgroup participants concluded the ecosystem indicators development should proceed in a highly integrated fashion, at a high level. A general goal should be to

[1] And, to some extent, ichthyoplankton & insects.
[2] Irvine, J.R., M.O'Neill, L. Godbout, and J. Schnute. 2013. Effects of varying smolt release timing and size on the survival of hatchery- origin coho salmon in the Strait of Georgia. Progress in Oceanography (In Press), doi: http://dx.doi.org/10.1016/j.pocean.2013.05.014

develop a common suite of indicators for the Salish Sea. The group recommended, as a starting point, a list be drafted and distributed, including existing, proposed, and wish-list indicator datasets. They also concluded that the list should function as the tool for compiling all of the metrics that will be utilized throughout the project: for indicators/correlative analyses, ecosystem modeling, and bottom-up data collection.

The stoplight modeling approach was considered a good way to coarsely evaluate indicators across the Salish Sea basin and to ensure cross-talk between U.S. and Canada. However, both U.S. and Canadian scientists stressed the need to be able evaluate ecosystem effects at a finer resolution, within sub-basins of the Salish Sea. This is needed to capture factors affecting in-basin salmon survival variation, and to ensure that the scientists can weigh the effects of local vs larger-scale processes on survival. An early step toward determining the level of resolution needed will be to evaluate the coho and Chinook survival time series that are being completed. The group concluded that there are a variety of finer-scale indicator analyses approaches that can be applied within this framework, and that there is value in providing scientists the capacity to apply their individual expertise rather than coming up with strict guidelines regarding the approaches applied.

End-to End Modeling – Workgroup participants concluded that the primary modeling focus should be on establishing the association between circulation and zooplankton/ichthyoplankton (NPZ modeling). Relatively robust physical models have been established for the Salish Sea. Building in capacity to understand what drives phytoplankton and zooplankton productivity is the next logical step (this includes emphasis on the connection to spring bloom timing). Participants stressed the need for models to be able to account for the dietary value of different zooplankton taxa given the importance of this to upper trophic levels.

Participants agreed that end-to-end modeling should not be considered a way to perfectly characterize the ecosystem. Instead, the models are good for better understanding the mechanistic linkages within the food web, to evaluate the cumulative effects of multiple drivers, to better identify data gaps, to evaluate change over time, to build back to fundamental drivers of change, and to predict the outcomes of various scenarios to improve management.

Participants are concerned about the utility of modeling and ecosystem indicators given data gaps and limited time series. However, efforts that focus on substituting space for time may help. Also, establishing a fine-scale understanding of the situation now, modeling, and then using limited data to hindcast/predict the past looked like will help evaluate what may have changed for salmon over the past 30 years.

Core, bottom-up sampling program

The U.S. and Canadian scientists jointly agree that there is high value in implementing each aspect of the bottom-up sampling program (physical, zooplankton and salmon sampling), and there will be significant overlap in the approach. Both U.S. and Canadian scientists are developing sampling programs that build out from specific watersheds within Puget Sound and the Strait of Georgia. The U.S. is focused on the Nisqually, Snohomish, Skagit and Nooksack watersheds whereas the Canadians are initially focused on the Cowichan but have plans to build out to areas such as Campbell River, Baynes Sound, Fraser, and Powell River/Sechelt. The U.S. is utilizing the capacity of their large co-management structure combined with academic and federal Principal Investigators to man the salmon and zooplankton sampling activities, and the existing buoy and water quality sampling network to capture the physical properties of Puget Sound. The Canadians plan to implement a community-based sampling program, utilizing volunteers who will collect water quality and zooplankton data throughout the Strait of Georgia. The Canadians will also work with the academic and federal Principal Investigators for the sampling program and utilize them and others for salmon sampling.

Workgroup participants agreed to ensure key metrics are being identified and collected in comparable manners on both sides of the border to the best extent practicable. For evaluating the stage-specific growth of salmon, participants specifically discussed including the collection and analysis of scales, otoliths and IGF-1 together in Puget Sound and the Strait of Georgia where feasible to draw comparisons in the approaches. Many of the investigators have their preferred analysis method and all agree that performing multiple approaches helps compensate for the weaknesses of each and leads to more robust outcomes. For prey sampling, there is relative alignment between Puget Sound and the Strait of Georgia on the vertical tow approach for zooplankton, performed to assess the relationship between environmental variability and zooplankton community composition. Oblique tows at across multiple bottom depths from nearshore to deep offshore, performed to determine how the prey field for salmon and other forage fish varies spatio-temporally, are planned for Puget Sound and are being considered for the Strait of Georgia. Also, neuston tows are being further considered to ensure prey dynamics are captured in the very nearshore as well. The lack of targeted ichthyoplankton sampling still may be a gap; however, the proposed oblique tow approach will capture ichtyoplankton to some degree. The Principal Investigators agreed to share and comment on one another’s work plans and sampling protocol as the research is developed, and to utilize the joint data catalog proposed during the ecosystem indicators discussion as means to continue to calibrate the U.S. and Canadian efforts.

Data management and sharing

Participants discussed data management and sharing for the project. Participants generally agreed that data storage and accessibility are issues that should be addressed via this project. Near-term vs. long-term needs were discussed. Participants generally agreed that near-term solutions involve raw data storage and exchange and initial analyses, and should focus on data sharing among the project scientists in a relatively protected manner. The Basecamp password-protected project management utility has been used for some time in the U.S. and for the U.S.-Canada coho retrospective survival study. Participants agreed to expand the use of this utility as a solution for near term data sharing and management needs. For longer-term needs, data management and sharing will involve verified data sets, output from analyses, and ongoing data streams from monitoring programs. The target audience will be broader than the project scientists, with data publically accessible, as this will be the point where the output of this effort is being used to influence next steps in research and management. Workgroup participants discussed the Pacific Salmon Foundation’s Strait of Georgia Ecosystem Data Centre as a potential long-term solution that could be expanded Salish Sea wide. Also discussed were NANOOS (pacific northwest ocean observing system), and NOAA’s Ocean Ecosystem Indicators as potential mechanisms for the aggregation and dissemination of data over the long term. Certain data standardization processes, not discussed during the retreat, may simplify the dissemination and utilization of data. This information will be provided to a data management and sharing workgroup, who will pick up the discussion of long-term strategies.

Other matters

Evaluating **Top-down effects** and performing other research activities beyond the scope of the categories listed above were not discussed during the workshop. U.S. and Canadian scientists agree that a unified understanding of the mechanistic association between Salish Sea bottom-up processes and juvenile salmon survival is vital. However, LLTK, PSF and affiliated scientists have initially determined that less U.S.-Canada alignment may be of value when investigating the multitude of other factors that may be contributing to juvenile salmon mortality in the Salish Sea. To more broadly evaluate these factors, the U.S. and Canadian scientists will have more flexibility to focus on specific species, approaches, geographic areas, and distinct survival drivers. The results will then be shared, incorporated into cumulative factors and other comprehensive analyses, and will inform next steps in research on both sides of the border.

Participants discussed the need for some **common communications materials** so that they can speak to the project when doing presentations, etc. They also felt this would be good to ensure consistent messaging. PSF and LLTK will work on providing materials to the participants for them to use.

Next Steps

LLTK and PSF will work with participating scientists to perform the following tasks.

1. Set up projects on the Basecamp project management site to facilitate communications, coordination and information and data sharing. Include a data sharing statement that informs participants of data sharing intents, use rights and sharing limitations.
2. Establish a data catalog to calibrate data collection and ecosystem indicators and modeling activities, and to prevent duplication of efforts.
    - Establish and distribute a worksheet describing the primary indicators and metrics to collect data for.
    - Identify whether they relate to existing data, new data to be collected via the bottom-up sampling program, or both. If not proposed for collection, identify as wishlist.
    - Identify where specific datasets are and/or who is collecting the data.
3. Finalize coordination plan for the course of the project, including: workgroup retreats, information sharing, periodic communication among workgroups and advisory groups, etc.
4. Establish a data management and sharing workgroup, primarily focused on recommendations for approaches to ensuring broad utilization of data resulting from this project.
5. Continue to develop research activities – most immediate – a) share and modify protocol for bottom-up sampling program to ensure relative alignment, b) work together on developing and performing the Chinook survival trend analyses once the coho analyses are complete.
6. Have late spring/early summer follow-up conference calls with trends analyses and modeling workgroups to finalize initial research integration approach, including the following items.
    - Review list of primary indicators and metrics to collect
    - Confirm whether there is agreement on stoplight model
    - Determine whether there needs to be agreement on analyses approaches beyond stoplight.
    - Discuss the models available for NPZ work and determine whether one or multiple models should be applied to the Salish Sea.

- Confirm whether or not there is interest in jointly pursuing a Salish Sea-wide end-to-end ecosystem model. Confirm whether or not Atlantis is the way to go, acknowledging its limitations.

7. Complete a report summarizing proposed research activities, integration and coordination.
8. Provide project communications tools for the affiliated scientists (Powerpoint slide stack, joint web site)

Day 1 – Trend Analyses and Modeling - Notes

Objectives for the day - Review trend analysis and modeling workgroup activities and discuss integration

a. Survival trends
b. Life-history characteristics relative to survival
c. Ecosystem indicators: stoplight modeling, single- and multivariate analyses, other approaches
d. End-to-end, spatiotemporal ecosystem model for the Salish Sea

Opening

Brian R. begins the meeting by contributing his thoughts on the general project work. He gets asked, "Hasn't all this been done?" This work hasn't been done all together before; it's valuable to have all data at the same scale to really address questions about survival in the Salish Sea.

Canada has typically had a focus on chinook and coho, although recently interests have broadened (e.g., the Cohen Commission). However, most of the available information is for chinook and coho – and there is the capability to develop a full ecosystem-scale effort. For other species (e.g., steelhead), there are very little data. Canada can plan to begin compiling information, but will not be able to contribute much data in the near-term.

There has been some concern about promoting recreational fisheries, but Brian states that we can take advantage of the marketing and fundraising opportunities that will be created. Recreational fisheries provide large amounts of funding to PSF via the sales of salmon stamps, and that money can be used for this project. It's a good reason to emphasize the chinook and coho recreational fisheries in the Strait of Georgia. Brian remembers when the recreational fishery in the Strait was huge; it is not anymore, but there is great opportunity to return to the province. Therefore, restoring fisheries is important from the anglers' perspective and can provide motivation for funding.

Additionally, Brian has been thinking about how this program could be integrated into the Ocean Tracking Network (this would give us high traction for fundraising, but would be a serious commitment). We must have good planning and communication throughout the project, and be aware of potential collaborations like this.

Brian has no concern about reaching the $10M goal for Canada; he is very confident. Canada sees 2014 as the developmental, prototype year, wherein groups will be testing new techniques and forming new programs (e.g., contaminant testing). There are definitely projects on the table for 2014, but it will not be a roll-out of the full program. There is currently interest in developing an end-to-end Salish Sea model.

Ecosystem indicators

Correigh G. reviews the current status of U.S. ecosystem indicator work. There is spatial structure in adult returns (both between the coast and Puget Sound, and within Puget Sound). The Peterson Index (stoplight tables) is commonly used; a refined scale of the Peterson Index has been developed for Puget Sound which shows a fair amount of variability across years and basins.

Non-metric dimensional scaling (NMDS) using data from NOAA's 2011 intensive nearshore sampling effort show that bacteria, zooplankton, fish, and jellyfish populations are all spatially structured within Puget Sound. Therefore, there is increased interest in basin-specific forecasting.

At the SSMS project & NOAA ecosystem indicators workshops in November 2012, there were discussions about potential indicators and limitations. Most limitations concern biotic data; we have fairly good information on abiotic indicators.

Currently Correigh G. et al. have a submitted a proposal to use existing time series to assess appropriate Puget Sound indicators and whether improved forecasting will improve management practices. We need to think about what approach(es) to use, how this work relates to core sampling (better integration is needed), potential modifications (e.g., spatially structured indicators), and data management issues. Puget Sound does not have anything comparable to the Strait of Georgia Index, so the US can learn from Canada's experience on this topic.

- **Marc T.** says that once the data are in place, we can try different techniques to figure out what works and what doesn't. It's clear that we will need to use multivariate statistics, because we have a multivariate array of data. Bill Peterson condensed the data to univariate to develop his stoplight tables. Marc's experience has shown similar results using multivariate rankings and PCA.
    - We need to keep in mind 1) what regime we are in at the time of measurement and whether the ranking (e.g., red-green) of indicators is applicable to short or long timescales. There are issues with using relative scales that need to be acknowledged. And 2) what kind of resolution we can achieve with these approaches. In most ecological cases, awesome results still contain 30-40% unexplained variance.
    - Be prepared for correlations to break. Marc views broken correlations not as failure, but as information: something changed (e.g., regime shift). There is definitely value in linking among regions (e.g., Salish Sea vs. outer coast). Regions may not covary in sync, and the contrast between regions is a way of learning how different ecosystems work.
    - One method of strengthening conclusions of regressions is to include contrasts. It increases the amount of data – and lots of spatially-variant data can ameliorate to some extent the lack of a long time series. Specific focus on one area introduces the risk of missing large-scale conclusions, whereas integration over large areas allows for observation of large-scale patterns.
- **Dave P.** thinks that using the stoplight approach at a Salish Sea level is unlikely to be effective.

- **Brian R.** thinks it would be at an ecosystem level: many of the ecosystem components that interact with salmon display residency by basin, so it's important to base our efforts on that spatial structure. Small-scale processes often swamp large-scale signals; Brian suspects there will not be an obvious Salish Sea signal because regional signals will outweigh it.
- **Mara Z.** likes the stoplight approach in general, but it requires a long (10+ year) time series before the green-red scale becomes interpretable. Ecological data from various basins differ within years as well. Initially, we can use a space-for-time substitute (basin comparison for certain indicators can jumpstart our effort even before temporal information is available).

- **Correigh G.** explains some of the basin anomalies that he has found in the results of the intensive NOAA 2011 sampling project. **Ian P.** comments that he has taken a similar approach with Strait of Georgia data. Ian found the NPGO to be a powerful predictor (even more so than the PDO) and is intrigued by the spatial difference between the Strait and Puget Sound, since the NPGO did not come up as a good predictor in Correigh's work. The Strait of Georgia has lots of spatial variability, but also large areas of open water; Puget Sound has more spatial structure. This leads to questions like: are there common indicators shared among basins? What proportion of variability can be explained by common indicators? Can we reach a higher-level index to compare Puget Sound to the coast (etc.)? Details at a small spatial scale may be important, but they are easy to get lost in. **Correigh G.** agrees and says that the initial list of indicators for which we have data would be a good starting point to analyze cross-correlations in detail (this has not yet been done).
- **Ken D.** reminds the group that we are discussing multivariate data and suggests bringing in a variety of analysis tools and people with various expertise in this arena – more brainpower an approaches. He suggests we include ocean acidification data as well.
- **Marc T.** thinks that the reality is that effects are likely to operate somewhere between large-scale and local-scale. Our first step should be to look at the survival time series that we have in hand across populations, basins, and areas beyond the Salish Sea (e.g., coast), and to determine the extent of co-variation. Understanding whether the dominant drivers are large-scale (full North Pacific) or local will inform what type of indicators are needed.
    - **Julie K.** notes that this conversation is also very relevant to the development of appropriate scales to monitor zooplankton. The differences in survival indicate differences in basins, so we need to at least look at that scale.
    - **Dave P.** says that dominant processes can change over time (some years, large-scale processes dominate; other years, local processes dominate). We don't understand why yet, but it is important for forecasting that we are able to distinguish which are important in a given year.
    - **Pete L.** says that the strength of the stoplight approach is that it presents all potential drivers and does not artificially direct importance. We can look at both broad-scale and local-scale drivers on a probabilistic basis (#s of green vs. red). It's clear that Puget Sound basins have basin-specific ecologies, so we should be looking individually while also keeping broad factors in mind. The other question to consider when thinking about broad-scale drivers is whether there is a time lapse as effects/signals propagate throughout the Salish Sea. If there are differential effects of large-scale influences at a local-scale, can we model that qualitatively?
- **Dave P.** thinks that a high-level common platform is absolutely necessary to make meaningful comparisons. The group as a whole does not disagree.

- **Brian R.** says that the stoplight approach is analysis of actual data. He agrees with **Ken D.** that our first step should be mechanistic. Forecasting is important too, but it should be focused on later in the timeline.
- **Brian R.** asks whether there are also basin-scale differences in Strait of Georgia. **Marc T.** says that they have broken down chinook survival time series into three different regions: North Strait of Georgia, South Strait of Georgia, and the Gulf Islands. There are oceanographic differences among those regions. We have no indicator coho stocks in the Gulf Islands; that is an important data gap.
- **Brian R.** says that a student with David Welch has data showing that steelhead move in a circular pattern through Central Strait of Georgia. Are they following a current? food?
- **Correigh G.** suggests that if we have consistent sampling protocols, we can link indicator approaches across the entire Salish Sea.
- **Mara Z.** envisions a coast-wide common set of indicators at various scales (both broad and local). Over time, the dominance of large-scale vs. local indicators will become apparent, although there will be some amount of yearly variation. **Mike C.** says that the yearly and spatial variability is causing havoc and confusion. There is stock-specific survival, and we are unable to correlate that to indicators at a sub-basin scale. **Mike C.** thinks we need to focus at a sub-basin level; if we develop local indicators we can then roll up to a higher scale.
- **Michael S.** asks the group whether there is a relationship between the indicator framework and sampling going forward. **Correigh G.** says that if we start with the initial list, it's conceivable that we could compare basin anomalies from this year's (2014) fish and zooplankton sampling data.
    - **Brian R.** asks whether there are potential indicators with available data that are not included on the initial list. He thinks we need a separate spatial-temporal sampling design to capture sub-basin level and gives the example of covariation in Strait of Georgia larval herring and Chilko sockeye survival. There are obvious examples that allow us to discuss what is useful in our particular areas.
        - **Ian P.** says there are two key questions: 1) what can we do with the existing data? and 2) what data do we actually need? Models can tell us what key aspects we are currently missing.
        - **Correigh G.** says this gets into regional indicators (what has worked where), but we need to be looking for opportunities to use common metrics across the Salish Sea.
- **Dave P.** and **Ian P.** have modeled changes in Strait of Georgia and wind speed jumped out as an important indicator. Wind speed data from airports are widely available and high-resolution. **Correigh G.** says that their group has done something similar: synthesized weather station data at sub-basin scales. Those processes should be discussed to determine whether they are comparable across the border.
    - **Ian P.** says that they'd wanted synthetic aperture radar in order to pick up small-scale variations in wind. However, this technique might not work in Puget Sound, since it has a smaller area of open water.
    - **Ken D.** says that they have been collecting wind speed data on ferries, but do not know yet how to interpret it. They are also using CODAR to measure surface currents and look at the effects of tides and wind direction. Currently this work is only occurring in one region, but expanding coverage northward is in their future goals.

- **Chrys N.** points out that freshwater discharge rate and the timing of peak discharge is important in the Strait of Georgia (especially from the Fraser River). **Correigh G.** says that salinity is important in Puget Sound as well.
- **Ian P.** says we can monitor almost anything, but what is important? We need a sense of how parameters connect/relate to one another. For example, North Strait of Georgia and South Strait of Georgia respond differently to a single wind event. We need a set of measurements at least as sophisticated as the places are to pull those details apart. Also, salmon move a lot and are complicated.
- **Dave B.** comments that the current list talks only about existing time series. It is important to define what we have, what we are asking for in current proposals, and what is on our long-term, dream-big wishlist.
- **Ken D.** asks why the predator list does not include seals? Also, what about the change in *Neocalanus* timing? The ecosystem is not the same as it was in the 1970s, and it is not only bottom-up effects that precipitated that change. What are the differences between the 1970s ecosystem and the current ecosystem?
    - **Dave P.** comments that there is predation at varying scales within localized areas as well, so spatial scale is important (e.g., seals in Strait of Georgia vs. seals in Cowichan Bay). Predator concentrations can have a strong local-scale impact that may not reflect the full area. Localized areas may have more profound top-down effects.
    - **Correigh G.** notes that currently no seal time series exists that works for Puget Sound.
- **Ian P.** comments that one fundamental problem is that we are all natural scientists and are prone to missing the human component. Anthropogenic ecosystem pressures are a huge component for which we have very little information. There are probably many useful people-oriented indicators to consider (fishing, habitat loss, etc.).
    - **Correigh G.**'s 2011 work looked at land-use aspects and found fairly static measurements (no large yearly change). It was a poor predictor of variability, even though they found sub-basin within-year structuring. **Ian P.** says that a longer-term combination of both could still be informative; it is important to consider at what timescales we operate.
- **Dick B.** says there must be huge initial mortality for chinook and coho, and we really need to figure out what causes that. There are basically unstudied species (e.g., starry flounder) that eat juvenile salmon in the estuarine environment. We need to know more to understand potential indicators.
- **Chris H.** says that from Columbia River basin information, we know that SARs are related to smolt size and recent smolt history (the winter and spring before going to sea); the size and condition of smolts when they hit the marine environment could be important. Brian Beckman's work has shown that growth is a better indicator than size. There could be an indicator in the freshwater domain that is not monitored.
    - **Correigh G.** says that their team is working with Brian B. on IGF-1 in Puget Sound salmon samples. Also, the coho work that is ongoing should illuminate to some extent the contribution of the freshwater vs. marine domains. There was a series of papers a few years ago that suggested adult conditions at spawning determined the juvenile experience. Baby salmon may be "fated" to fail either via their parents or in the first few weeks of their life.

- **Brian R.** comments that Kristi Miller-Saunders' lab has developed genomic metrics to assess smolt fitness, and this is an effort that is definitely included in the Canadian plans going forward.
- **Lance C.** and **Correigh G.** point out that using CWT fish or otoliths from the Ricker trawl surveys, we can look at the relationship between size at capture and size at outmigration. **Chrys N.** says Dick B. has done this analysis with coho and shown a critical size-critical period relationship; however, the analysis has not yet been done with chinook in Strait of Georgia.
    - **Brian R.** says that otolith microchemistry is a gap; the capacity for detailed microchemistry at volume does not exist. **Marc T.** thinks UBC has the capacity for otolith microchemistry, although they are working mostly on sockeye otoliths at the moment. However, to get growth metrics, we can simply use otolith microstructure.
- **Michael S.** asks whether collected but unanalyzed datasets exist on the Canadian side similar to the U.S. side (e.g., the JEMS zooplankton time series).
    - **Dave P.** says that there are varying degrees of record-keeping on nearshore habitat metrics (especially kelp). Theoretically, if predator-prey interactions are mediated by the environment, then a change in the environment would alter the dynamics of those interactions. So, loss of kelp in nearshore habitats is one place where we might see obvious mechanistic changes. **Correigh G.** notes that there is also a sampling program in Puget Sound for eelgrass that may be able to be used as a time series – they definitely have observed a decline.
- **Brian R.** comments that many techniques (otolith microstructure, microchemistry, genomics) are possible to do but expensive. Some other metrics are easy to do and inexpensive, and might be informative. There are logistical problems of which stocks to focus on and how to catch enough fish to get statistically valid information on a specific stock. Not all stocks are represented in the current sampling methods.
    - **Dave B.** says that the strategy we have tried to take in Puget Sound is: 1) follow CWT stocks that are well-represented in catches with scales – old-school, cheap, and non-lethal techniques, and 2) look at the full population-scale and see whether the CWT patterns are mirrored. So far, all this work has been opportunistic, but there is potential to expand. The existing pool of returning adults can provide information on success compared to current juveniles. **Lance C.** and **Dave B.** will discuss this strategy later.
- **Ian P.** will put together some slides covering the work that has been done on Canadian indicators.
- In the past, there was some discussion on the U.S. side (mostly by Neil Banas and Parker MacCready) about using the long-term Collias dataset of stratification as a proxy for production. **Robie M.** says that the distribution of phytoplankton is strongly related to stratification in the Straits of Juan de Fuca and Strait of Georgia. Stratification is very important in models. It is tied to wind, but wind effects vary by location. We have to go deeper than the surface linkage to gain a mechanistic understanding.
- **Brian R.** thinks we need to put together an inventory for what is monitored quantitatively in the Salish Sea in order to maintain consistency of indicators and monitoring. We need a set of indicators at appropriate scales that we are committed to for the next 5 years.
- **Dave P.** asks whether residency is something that comes out of the currently monitored indicators and, if not, whether residency is useful to monitor. He has the impression that residency has

increased in the past couple of years, and that there were a lot of resident chinook and coho in the past.

- **Brian R.** says that residency has only come up as an issue in Canada when there were specific efforts to instigate residency (for anglers' benefit). For Strait of Georgia coho, there were huge yearly fluctuations in residency. The commercial fishery will never return, but resident fish are still valuable to the sport community.
- **Michael S.** says that on the U.S. side of the border, we are pairing toxics work with otoliths to investigate how residency has changed over time.

- **Ian P.** presents the Canadian work that was recently highlighted in a special issue of Progress in Oceanography. Araujo et al. identified the top 3 coho indicators as ranked in a Bayesian network: zooplankton biomass anomalies, calanoid copepod biomass, and herring biomass. This approach allows placement of quantitative values (by weighting variably) with probabilistic networks (vs. the qualitative good-bad/green-red stoplight method).
    - **Dick B.** says that the important relationship with zooplankton biomass is interesting but doesn't give us mechanistic information. We need to know why the fish are dying. **Ian P.** says that these are broad correlations, using the available data to identify what is more or less important. These analyses tell us where to start looking and, so far, they are consistent with food limitation. Where we have time series of drivers that explain variability in states and impacts, we can do an ecosystem assessment: redundancy analysis (basically, a multiple regression + PCA) to identify the drivers that describe regimes.
    - For the Strait of Georgia, some significant drivers were sea surface temperatures, wind speed, the NPGO, human population, recreational fishing, and hatchery chinook. Essentially, this analysis gives you a set of overarching variables that describe variability in the entire ecosystem. All of the time series currently used in this analysis are available online; anyone can access them and do an analysis like this on their own.
    - **Ken D.** comments that the cluster transitions produced by this analysis are close to El Niño transitions.

End-to-end ecosystem models

- **Chris H.** discusses the current state of ecosystem modeling. There are Ecopath with Ecosim (EwE) food web models for several Puget Sound sub-basins and for the Strait of Georgia. We would like to expand beyond the food web.
    - EwE is not particularly spatially explicit; it treats the study area as a box. The biases of modelers are built into these models. There has been good effort to model areas within the Salish Sea, but not much effort to standardize the level of detail within those models. Most of the current models were developed for making coarse predictions or ecosystem condition assessments. Given the lack of standardization across basins and the likelihood of some amount of connection among basins and terrestrial input/factors, these models are not sufficient to meet our needs.
    - **Chris H.** and others are trying to secure funding to develop an end-to-end Atlantis model for Puget Sound. Atlantis is a modeling approach that starts with physical circulation and splits the system into a series of polygons that are based on physical, biological, and management factors. PNNL or MoSSea models would fit into the physical circulation portion of the model;

that would inform bottom-up production to fish, macroinvertebrates, mammals, and birds, then management models could be overlaid. We submitted a FATE proposal to develop this model and address topics like: how does the complexity of Puget Sound circulation affect patterns of production throughout the food web in the context of salmon? How sensitive are the bottom-up processes that drive salmon production to human influences (e.g., eutrophication, management)? Given what we know, what is the relative effectiveness of different spatially-structured management strategies?

  - These models are all essentially cartoons of the system. They are not completely accurate, but are definitely more informative than no model. Modeling is an iterative process that improves with more and better data and identification of model issues (e.g., inappropriate parameters). Each year of this project should result in hypotheses and data gaps to inform monitoring programs. Sampling and modeling are complementary processes that form a positive feedback loop.

- **Michael S.** says that what we're trying initiate the modeling effort and then let the region sustain it, and to start getting information on linkages that we do not yet understand.
- **Mike C.** asks what the spatial and temporal degrees of specificity are. His ideal is a model that can work at the sub-basin level to look at the growth of fish over specific time periods for various life history types. **Chris H.** says Atlantis probably cannot do that; it is not designed to handle those very fine-scale measurements. However, the Atlantis model could help identify some of the localized forces that are important to a specific sub-basin.
- **Ian P.** asks whether the box-geography of the Atlantis model is consistent with the basin-scale differences observed by Correigh G. et al., and how difficult it would be to build for the Strait of Georgia (which currently has an EwE model). **Chris H.** says the box-geography of the model is finer-scale than basins and could be rolled up to complement Correigh G.'s basin-scale data. Building the model will be complicated, but Chris H. feels confident because one of the few experts in Atlantis modeling works in Chris H.'s lab. No Atlantis model so far has dealt with physical complexity on the scale necessary for Puget Sound. Once the model is built, there will be a lot of fine-tuning required to make it usable, and that will take some time.
- **Ian P.** says that circulation models for the Strait of Georgia include Puget Sound – is the inverse true? **Correigh G.** thinks that at minimum the effects of the Fraser River on the circulation of Puget Sound would be included, since they are likely quite large. **Chris H.** says the initial approach would be to treat areas west of Victoria to Strait of Juan de Fuca and south of the Fraser plume as boundary boxes, since Atlantis can model boundary boxes dynamically.
- **Ken D.** comments that other current modeling efforts that start with basic circulation are fairly advanced (e.g., MoSSea) and that models do well at predicting physical patterns, but linking from circulation to upper trophic levels of the food web has been problematic. Ken D. suggests building detailed models of zooplankton and ichthyoplankton life history, and cohort models to determine whether there is cohesion in outmigrant timing and food.
- **Jan N.** reports that although MoSSea's current capability is for hindcasting, the creation of the WA ocean acidification center supplied sufficient resources to expand the model to include biogeochemical data for ocean acidification forecasting. The model will be built into forecast mode over the next two years and will mainly be relevant to predicting effects on plankton.
- **Chris H.** says that he and Parker M. and Neil B. have been discussing the use of MoSSea as the circulation driver for Atlantis. The Atlantis developers have been trying to make the model as

component-oriented/modular as possible so it can be run with different circulation models or circulation/NPZ. Running multiple models is important to compare/contrast functionality and identify biases.

- **Michael S.** says that there has been discussion on building the NPZ piece for Puget Sound with a focus on spring bloom timing, because other regions have observed a strong relationship between spring bloom timing and zooplankton prey quality. Is this a good place to start?
    - **Dave P.** says yes, and that we could talk about upper trophic level modeling for the Strait of Georgia. EwE can reproduce changes across species using known fishery and estimated predation impacts. The important thing is that when environmental variation is added to the model that it explains variation across the whole suite. There can be delays in effects that the model can help resolve. However, it has poor capacity to model phytoplankton and zooplankton. There is uncertainty about what causes/mediates changes. The logical next step is to be able to put in drivers of phytoplankton and zooplankton and examine those relationships.
    - Dave P. thinks that the utility of Atlantis in particular is questionable; the amount of money invested to get marginal information does not outweigh reinforcing the work that has already been done and already exists. Dave P. is excited about the capacity to run iterative forecasts.
    - Ecosystem models are best used as a tool to do strategic planning, not for watershed-specific issues. Iterative scenarios (e.g., climate) allow us to identify potential outcomes with confidence boundaries, which species are most at risk, and gain a clear understanding of ecosystem processes at a broad level, which can then guide more detailed studies. None of the ecosystem modeling work can replace single-species modeling or regional efforts though; models cannot be infinitely detailed.
- **Ken D.** thinks our greatest opportunity is relating circulation models to upper trophic level models. We are missing information on developmental zooplankton and ichthyoplankton life history which is limiting our understanding of processes. Connecting circulation to upper trophic levels is the hardest part of modeling, but it could have the biggest pay-off.
- **Dave B.** says that one of the values of this forum is we can use models of different scales in different fashions: empirical modeling can capture quantitatively dynamic mechanistic processes that can then inform more strategic-level modeling. NPZ models fall apart at the Z and cannot bridge meaningfully to fish. We have the opportunity here to be clever about how we integrate those.
- **Jan N.** agrees with Ken D. and asks whether life history stages are included in higher trophic-level models. **Dave P.** says that capability is available if there are sufficient data. It's important to have a long-term time series if we want to be able to bound the lower-trophic end of the model with historic changes in phytoplankton/zooplankton – unfortunately, those time series do not exist in the Salish Sea.
- **Marc T.** values how ecosystem models can help shape thinking about ecosystem processes but notes that often potential linkages between timing of the bloom and prey quality are overlooked. Prey quality information is not well-captured in any of these models. Rana el-Sabaawi has found that the abundance of *Neocalanus* is related to fatty acid composition – is that related to the chemical composition of the phytoplankton? Bill Peterson developed a correlation between marine survival of salmon species and abundance of *Neocalanus* copepods (likely an indirect effect, since chinook and coho do not eat those copepods). Things like these are not captured in these models. The

recommendation from last year's SSMS workshop was that we are not trying to understand the entire ecosystem, but fish and fish survival. There must be a balance in our effort. How do we translate back to the fish from the ecosystem? There is a limit on how far we go down that road.

 - **Michael S.** asks what other approaches can be used to evaluate cumulative effects, top-down vs. bottom-up. **Marc T.** says that no matter what we do, we are excluding many cumulative effects because the ocean life stage is a black box. Jim Irvine submitted a proposal to SEF to model the full life cycle of Fraser River sockeye. It may be that early marine events are the primary driver of overall marine survival – Dick B.'s work supports that hypothesis, but it is still at the hypothesis stage.
 - **Ken D.** thinks we should not view our effort as a closed project with a firewall around it. If we stimulate people's interest, they might do work relevant to our goals without us funding them.

- **Stewart J.** says food quality plays a huge role in subsequent capability of a fish to succeed. However, other factors are also important, such as diet overlap among salmon species and other fish species. It would be a good goal for this group to identify small projects suitable for grad students that can inform models.
- **Chris H.** hopes that at least the effort he described is not viewed as a zero-sum game. He is seeking funding from several sources not directly related to the SSMS project, and would like to think the ecosystem modeling work would be done even if it were not part of the SSMS project. However, because it is, Chris H. can use his involvement to lobby for more funding. Remember that models are tools, not answers. Any opportunity we have to test a model and its sensitivity to things like prey quality should be supported.
- **Dave P.** gives an example of the importance of considering the full ecosystem. We now know a lot about Southern Resident Killer Whale predation on chinook salmon. How many other predators influence chinook? What is the diet percentage of chinook in, e.g., seal diets? We modeled how this could play out over time: 1-2% of the diet is a small change for the predator, but it doubles the impact on the prey population. Just one tiny change can shift impact on salmon populations; this is a profoundly important realization when thinking about species interactions. Projects suggested by modeling work can feed better data back into the model. Also, when thinking about an ecosystem context, charismatic megafauna and fisheries catch the eyes of the public. Dave P. also notes that the sea lion population is still under a log-increase scenario, and he doesn't think anyone has looked into that.
- **Ian P.** says there are several ways to look at cumulative effects: beta-analysis (includes expert opinion), directed experiments (manipulate factors, but can only examine a limited number of stressors simultaneously), and models/model scenarios. The general approach in the literature is a combination of all three.
- **Brian R.** thinks Dave P. identified a key sensitivity (species interactions). How many of these models can give us insights into these things? Who's looking at these things? We have good circulation models, good zooplankton and phytoplankton models; can those guide our sampling programs? We do not want to over- or under-sample. Brian R. recommends we get dedicated people onboard and form a workgroup to include modeling work and decisions as part of the program.
- **Dave P.** had started to identify the most sensitive indices for the Strait of Georgia, but has not completed this work.

- **Brian R.** asks whether everyone agrees that forming and funding a workgroup to build a modeling framework is a worthwhile expense.
- **Ian P.** would strongly encourage a multi-model approach. Multiple models are important for understanding biases/disadvantages of different models. We need model comparisons.
- **Angelica P.** thinks we need a better idea of what we really have or don't have in terms of modeling. We currently have lots of little pieces. Perhaps Atlantis could serve as a way to pull those pieces together. Different models have different strengths; we should use that to our advantage. So far, it is not possible to model the full food web and it would involve a lot of intensive work. If we have a better idea of what we are looking for, we can maximize each tool to allow us to progress. Angelica P. suggests not wasting time trying to link from physical data up to fish. We need people who have data on food quality to include that in models. We need a clear understanding of what is important and why it is important. We should see what we can do with what we have rather than work on the "holy grail" of ecosystem modeling to link absolutely everything.
- **Jan N.** asks whether the current NPZ models can link larval fish and zooplankton; Ken D. was suggesting a connection and those data could be valuable. Jan N. also agrees with Ian P. that we need to use multi-model approaches.
- **Dave P.** thinks there are two steps: 1) modeling at lower trophic levels is at a different resolution than upper trophic levels. That doesn't mean that lower levels can't inform upper levels though. If drivers identified by lower models are meaningless in upper trophic levels, that means that either we don't understand the linkages or that the models are wonky. 2) We have the ability from strategic upper trophic level modeling to predict outcomes based on the amount of variability in the environment, even without understanding the mechanistic linkage. Knowledge of whether the future is more/less variable allows better planning.
- **Brain R.** says the critical thing is to identify what you don't know you need. What is missing? **Dave P.** says forage fish are missing.
- **Angelica P.** says that physical-zooplankton models can inform monitoring and asks whether upper trophic levels would help decide what to measure. Also, models can clearly show mechanistic links between indicators.
- **Robie M.** asks how ecosystem indicators fit with models in terms of validation and model outputs. Also, we need to realize what is achievable in our timeframe. Coupling lower and upper trophic level models might come into the short-term category, but forecasting models are a long-term effort.
- **Pete L.** says that operationally, in the context of the stoplight approach, broadscale regional inputs like the PDO and output like Atlantis in some form are synthetically bringing together information and coming up with general future predictions to input into the stoplight model.
- **Chris H.** says that the integrated ecosystem assessment on the west coast involved looking at how indicators behave explicitly because those things were identified as diagnostic of the system. It was not just modeling with explicit attention to indicators, but also models that simulated the monitoring process. You need to account for how well you are sampling your indicators. What are your data actually telling you about the system? This is not just modeling the natural system, it is also modeling how you model the system.

Trends in survival analyses

- **Marc T.** and **Mara Z.** present the timeline, goals, and progress of the coho survival retrospective analysis.
- **Brian R.** asks what the criteria for selecting indicator coho stocks were. **Mara Z.** and **Marc T.** explain that the criteria were whether information was available to calculate marine survival (CWT/FRAM) and the length of the data time series. The ones identified are priority, although additional information from other stocks will not be ignored. **Chrys N.** adds that for early marine survival, we would look at a broader range of stocks and use the Ricker trawl data as an aggregate.
    - **Brian R.** suggests we could activate Langley, Chiliwack, and Lang as wild indicators. Additionally, we could do something at Cowichan and involve Gold Stream (pristine estuarine environment). Some of these have never been developed as an indicator, Brian R. is not sure about the quality/consistency of effort, and not all are tag programs. There is some tagging in the Gulf Islands, but those data probably do not meet the time series requirement.
        - **Dave P.** thinks that Cowichan would be interesting since temperatures hit 24°C in the summer, it has a significant amount of coho, the flows are low, and it is essentially all mainstem habitat. It would be worthy of observation in terms of monitoring; coho spend a whole year in those high in-river temperatures.
        - **Chrys N.** notes that Lang Cr was supplemented by Qualicum for a period of time.
- **Marc T.** says that identifying spatial scales of observable differences will be useful to guide what type of indicators we look at and the field effort required (e.g., do we actually need to sample every estuary to understand trends?). However, this doesn't explain mechanistically why the fish are dying.
- **Chrys N.** notes that large-scale drivers can also produce localized effects.
- **Mike C.** says he definitely wants comparisons at a regional scale, because they see spatial and temporal variability on a local-scale.
- **Michael S.** asks whether we have enough data to do analogous work on other species beyond chinook. **Marc T.** thinks that they do not have many stocks with marine survival estimates beyond coho and chinook. Chilko and Cultus sockeye may be useful, and Keogh steelhead. **Joe A.** says that Lake Washington sockeye might be useful, but the U.S. has almost no information on pink and chum marine survival: there are a few time series, but they are very short (~5 yr). **Dave P.** published sockeye work with fairly compelling evidence that the poor 2009 returns were due to low Salish Sea productivity; he says there is more evidence for sockeye than others might argue.
- **Brian R.** thinks that chinook should be fairly straightforward because of the Technical Recovery Team work. Canada has no wild indicator stocks for chinook though. **Joe A.** says the U.S. time series for chinook are much shorter than coho time series. The Chinook Technical Recovery Commission has put in effort, but analyzing marine survival trends will still be a lift for us, especially since chinook have a more complicated age structure.
- **Dave B.** supports the coho work group's effort to collect SAR data that are available for coho, and hopes the same thing can be done for chinook soon. **Michael S.** says that the coho work is scheduled to be completed by June 2014, then we will move to chinook which we anticipate completing by early 2015. **Brian R.** says that for Strait of Georgia chinook, much of that work has been done; it will not take long to put a dataset together.

Life history characteristics relative to survival

- **Michael S.** says that we have proposed to build a framework and evaluate this question using outmigration timing and size over time as indicators.
- **Marc T.** says that where possible, freshwater life history characteristics will be included in the coho analysis. But the first step is spatial covariation, then adding environmental coordinates.
- **Correigh G.** says there are a couple ways to look at life history variation: 1) focus on populations where we have good outmigrant and adult age class returns to separate out trajectories. We are missing subyearling survival rates for coho, but if we had age-structure data, we could probably solve for that missing piece. 2) life cycle modeling based on what we know about life cycles and size-dependent mortality to model how different strategies (subyearling vs. yearling) contribute to returning adult populations.
    - Correigh G. suggests a combination of both these analyses. There has recently been increasing recognition that subyearling coho can be a large portion of the outmigrant population (e.g., 70% of outmigrants on Big Beef Cr are subyearling), and also that they reside in estuaries and some populations may be very dependent on the estuarine habitat (similar to chinook). **Lance C.** comments that on the Salmon River, Kim Jones had 3 years of otolith data that showed 10-20% of returning adults were subyearling outmigrants.
    - **Joe A.** suggests the potential for density-dependent effects, but **Dick B.** says that there is also evidence that there are not significant density-dependent effects and, if there were, we would expect that life history to be eliminated but it has maintained.
    - **Marc T.** says that Carnation Cr has fry outmigrants; it's possible that other places do too.
    - **Lance C.** says that using otolith data to separate subyearlings and yearlings is still mostly in the proof of concept stage; they are probably underestimating the subyearling contribution if anything. Coho fry outmigrants are easy to identify though. Otolith microchemistry may be useful, but validation work needs to happen.
- **Mike C.** asks whether otolith analysis could split outmigrants from nomads (fish that move to saltwater and then back to freshwater). **Lance C.** thinks not; nomads would likely be lumped with yearlings, but refer to Kim Jones' work on nomads.
    - **Pete L.** says that if fish are going to survive, it's because they find good habitat; the extent that coho use estuaries or are nomadic depends on the quality of the estuarine habitat.
    - Anecdotal evidence from a heavily modified system on the south coast shows that millions of fry leave the system yet are not reflected in adult returns. **Correigh G.** thinks there is potential to look at this in Carnation Cr. **Dick B.** suggests Auk Cr as well.
- **Michael S.** asks whether otolith microchemistry should be considered in this project to look at survival, especially for smaller fish. **Lance C.** says that there is a great deal of infrastructure already in place for sample collection, so potentially a lot of leverage. The lab costs are $100 per sample. Lance C. says they will be doing this work anyway, regardless of whether it is included in the SSMS project – but the question is when the work will occur. As part of the SSMS project, it would likely get done sooner. **Mara Z.** notes that the challenges the Columbia River researchers have faced doing otolith microchemistry are not an issue in Puget Sound, because Puget Sound traps are all fairly close to saltwater (whereas traps on the Columbia River can be many miles upstream).

Data management and data sharing

- **Marc T.** thinks one of the big issues is finding a suitable place to store the data online that makes it accessible to others.
- **Stewart J.** asks about policies for data agreements and acknowledgements; data-sharing can be touchy and difficult. **Ken D.** comments that there are usually qualifications about data use, especially data not used for profit. **Brian R.** says that CA has a new national agreement wherein any publically acquired data are public access. **Chrys N.** points out that some information is not in accessible form (e.g., CSAS) and sometimes access is screened through boards/panels/etc.
- **Michael S.** says that data management and sharing has not been done with a uniform US-CA approach, so there will still be some work integrating the two sides of the border. Additionally, we need to consider who we are intending to share data with: local scientists in the near-term? Managers long-term? Identifying our primary audience informs where best to keep data. For a small group like this, we can easily share data on an internal, password-protected site. But for broader use, who are we advocating to work through (e.g., PSC, agencies)?
- **Stewart J.** says they maintain two public websites and that, if we choose that route, we need a maintenance plan. When websites are not maintained, they are not useful – especially large datasets, as they are cumbersome to host.
  - **Brian R.** suggests working with UBC, since they are working with the Biodiversity Museum already to host datasets on the cloud. **Stewart J.** comments that they also require people to apply to use their database which allows them to track usage and demonstrates utility. In Stewart J.'s experience, if you tell people they have to acknowledge the source then most will do so.
- **Brian R.** says that Isobel P. is running a program on data sharing for marine and relevant freshwater (e.g., discharge) information for the Strait of Georgia – a web available, open access system for all the data we can pull together. Isobel P. has one more year of outside support for that, then Brian R. plans to incorporate it into the Strait of Georgia side of the SSMS project.
  - **Isobel P.** adds that their current bibliography is approximately 10.5k; journal publications are trickier, but can likely get around those restrictions by linking to people's websites. There is a huge amount of metadata to be uploaded; they are making slow but good progress. The idea is that all the material will be immediately accessible under an open access policy. The website goes live in January with all of the bibliographic information, although they are still working on datasets – the archives are extensive and students are working on scanning it in. The data from the SSMS project could be housed long-term there.
- **Michael S.** says one of the near-term outcomes of survival work outside of this group is to feed into forecasting. NOAA has a webpage for assessment information; does DFO have a similar page? Is housing the output of some of our work on those sites a viable idea? **Chrys N.** says that DFO used to put out State of the Oceans reports on indicators in Strait of Georgia and outside Strait of Georgia.
  - **Mara Z.** thinks that ultimately the state and the tribes are responsible for forecasting. How could we make sure that there is a direct connection from the forecasting page to planning? **Mike C.** says co-managers have their own policy folks who make decisions, so everyone produces their own forecasts. The role of co-managers and their data usage needs to be discussed.

- **Michael S.** asks what data sharing beyond a project management site would look like in a couple of years. NANOOS could be a good example for physical data moving up to maybe zooplankton; it is an established tool for data sharing. **Ken D.** says that CA uses NANOOS and IOOS to some extent. The OTN is, for the most part, trying to coordinate with other cabled observatories (mostly NSF-funded).
- **Mike C.** was hoping we could establish more specific plans. Will we share all the data resulting from the SSMS project? Will it all be publically accessible? What are the publication protocols?
    - **Stewart J.** says that they had a requirement to share data on their granting agency's website and they dealt with the publication issue by adding a placeholder with contact information to the website but not uploading the actual data until after it was published. **Mike C.** does not support that strategy because immediate access to data is important for an effort like the SSMS project.
- **Michael S.** asks if the Basecamp project management utility (password protected) is a good way to begin data sharing among participating scientists. Chrys N. supports this idea stating that its been good for keeping up with the information discussed as part of the U.S.-CA coho survival trends study, and since it is already being used to varying degrees by scientists on both sides of the border. Other participants also generally support the idea of sharing via basecamp initially.

Day 2 – Core, Bottom-up Sampling Program - Notes

Objectives
Review core sampling workgroup objectives and proposed activities for simultaneous data collection

a) Juvenile salmon
b) Prey, primarily zooplankton
c) Physical characteristics and phytoplankton production

Juvenile salmon sampling

- **Dave B.** gives an overview of the U.S. fish sampling plans. The framework under which we are operating is using timing of size-selective mortality as a theme to look at fish from saltwater entry to outmigration. There is funding for four watersheds in Puget Sound (Nisqually, Snohomish, Skagit, Nooksack). We will be sampling prior to hatchery release, at smolt traps, delta regions of estuary (traps, beach seines), nearshore marine (beach seines) and offshore pelagic (purse seines and midwater trawls) with objectives of trying to identify the size-structure of a cohort as it moves from one habitat to the next and looking for changes in size-structure, and trying to identify periods where high mortality or growth conditions come into play. If we can track size distributions through time, where the survivors start diverging from the general pool of juveniles, that would be the basis for identifying a critical period. Those data will be based on fish lengths and scales, and we will also look at condition information and diets. Physical characteristics (e.g., temperatures) will be taken concurrently with fish sampling to later look at underlying factors that led to observed growth performance. The study was designed to ask questions: does size-selective mortality occur at specific life stages? are there effects of temperature, food supply, food quality, or growth? Julie K. will also be doing zooplankton sampling, so that we can assess feeding demand. Midwater trawls and purse seines can give us ideas about the predator community in terms of resident chinook and coho, which have been identified as potentially important predators on juvenile salmon. The emphasis is on identifying periods of critical growth, size, and effects on performance.

- **Brian R.** asks why Hood Canal was not included. **Dave B.** explains that there is not currently funding to include it. In designing the study, he tried to pair offshore areas with areas where fish outmigrate. In the future, more watersheds would be ideal, especially more urbanized watersheds.
- **Chris H.** asks whether beach seines will catch other predators (e.g., starry flounder). **Dave B.** says that beach seines get some sculpin and there will be opportunistic sampling of other predators. They did an assessment in the early 2000s and didn't find much evidence, but there are many potential predators. However, this study is focused on juvenile salmon, not assessing the predator community. **Correigh G.** says that the beach seining efforts in the Skagit catch salmon predators routinely. **Dave B.** says that only catches the smaller-sized predators; gill net catches have much larger predators in the same area.
- **Marc T.** says that it is important to list explicitly the questions and hypotheses in this design in order to help Canada design comparable efforts.
- **Marc T.** comments that the Ricker's ability to sample Puget Sound is in question, particularly in July. There are other pressures such as the potential for oil exploration that may divert the Ricker from its previous sampling routine. Strait of Georgia will definitely continue being sampled, but Puget Sound is not a given. They would be happy to lend nets if we fund a charter vessel for July, but they cannot commit to bringing the Ricker into U.S. waters until they are certain they can meet their own requirements.
    - **Brian R.** comments that CANFISCO has vessels which are not currently fully utilized. They could provide seiners and a trawler (the Frosti). Maybe we could get a commitment from them on the Frosti for midwater trawling.
        - **Dick B.** points out that one advantage of the Frosti is that you can work at night, where we have very little data.
        - **Dave B.** will send Brian R. a schedule of what he would like to see in terms of midwater trawling in the U.S. Dave B. also notes that purse seines and midwater trawls are not redundant; midwater trawls are the only way to get true depth-stratified samples while purse seines only go down to ~25 m.
        - **Chrys B.** comments that DFO intends to charter a trawler in the first 10 days of June as part of a sockeye project. They want either the Frosti or the Viking Storm.
        - **Brian R.** asks whether the purse seine has been designed yet. **Dave B.** says he is working on it. **Chrys N.** offers to share their seine designs, although **Marc T.** cautions that they've also had to work around gilling issues.
- **Marc T.** asks how this study links back to salmon decline and variability in marine survival. **Dave B.** says that for Puget Sound chinook, there is evidence based on diet sampling and bioenergetics modeling that early marine growth is important for survival to adult return, and that corresponding low and variable feeding rates indicate that food limitations affect early marine growth. **Marc T.** comments that Dave B. has said that prey quality does not link strongly to survival and asks whether he has used direct measurements for Puget Sound prey or borrowed parameters. **Dave B.** says a mix, not actually tested, but they are the same

prey (i.e., not different species among years like in the California Current copepod community). **Marc T.** says that in the Strait of Georgia, *Neocalanus* copepods show huge interannual variability in fatty acid composition, so we shouldn't lean on those assumptions. Also, Marc T. would like independent consumption estimates to relate to growth. There are other ways to quantify feeding rates that do not rely on bioenergetics models: 24-hour fish collections or chemical tracers. On the west coast of BC, they have been taking advantage of known chemical accumulation rates (stable cesium or mercury) to derive feeding rates. The accompanying lab work indicates that this method does well at measuring feeding rates. Also, they do not see the patterns that Dave B. has proposed. **Francis J.** says that his group has been independently measuring temperature-specific maximum consumption rates as verification. **Dave B.** says that field corroborations of the Wisconsin bioenergetics model show that it is performing well and it is very useful as a diagnostic tool. **Marc T.** says those field studies are wrong. Dave B. and Marc T. agree to disagree.

- **Michael S.** reviews the hypotheses and objectives listed in the current plan (paper copy provided to all attendees).
    - **Dick B.** asks how the competition piece fits in as relates to salmon specifically, since many things eat zooplankton and competition could occur throughout the ecosystem. **Dave B.** says we learn more about ecosystem interactions as we radiate out from our focal species. **Dick B.** would suggest including groundfish in this hypothesis.
    - **Isobel P.** asks how the focal diseases were chosen in the disease hypothesis. **Michael S.** explains that Paul H. (our disease lead) thought it best to focus on what we already know about survival patterns to identify which diseases might be primary contributors to mortality. This led to a focus on *Nanophyetus* as a potential disease, so now we are investigating whether *Nanophyetus* is an issue for steelhead and opportunistically for chinook and coho. **Mike C.** notes that *Nanophyetus* was originally proposed specifically because of the rapid onset of mortality (which is necessary to explain steelhead mortality that occurs within 2 weeks of saltwater entry) and that for chinook, other factors like BKD come into play.
- **Brian R.** discusses the approaches proposed on the Canadian side of the boarder. In their original (2009) proposal, project 7 was going to be broad nearshore early spring sampling for fish distribution. Following last year's workshop, they began discussing a different approach more like what Dave B. described (above), and they tried that approach at Cowichan this year. The Cowichan estuary is fairly intact, but it is segmented by docks/wharfs and a long, confined channel. It's difficult to monitor fish dispersal from a 1D river to a 3D offshore habitat, and they learned a lot from their spring effort. Now, the plan is to intensively sample a few systems. They may include Quinsam this year, although there are major currents outside that estuary so it may not be as representative. They are also considering the major chinook and coho systems on Taxeda Island, which are very different in that they are altered and have minimal estuary habitat, and sampling on the east coast of the island.
    - **Rusty S.** notes that 30-40k Cowichan fish are being PIT-tagged this year. **Brian R.** asks where the Columbia River scientists get all their PIT tags (and how they can afford them). **Stewart J.** says he got tags from China for a cheap price.
    - **Chrys N.** says they also have a proposal in for a project sampling on the Fraser River; the focus would be on sockeye, but they would also sample chinook and coho.

- **Michael S.** asks what data are missing across the border that makes Puget Sound/Strait of Georgia comparisons difficult.
    - **Chrys N.** says that archival samples have the potential to alleviate data gaps on their side of the border: they keep a component of fish catch frozen so they are available for genomics, fish health, etc. as the opportunity arises.
    - **Marc T.** says that he and Brian B. have been collecting IGF-1 data for the Strait of Georgia and for Puget Sound over the last two years in offshore trawls, and would like to think about whether it is feasible to collect in nearshore habitats as well. Also, Stewart J. was interested in DNA/RNA rations and otolith microstructure/microchemistry for growth as well.
    - **Brian R.** says that Canada has been developing genomic plates to assess fitness. **Joe A.** describes Ken W.'s steelhead GWAs study this year, which looks at what genes are elevated in the fish that survive relative to the fish that don't. **Dave M.** clarifies that a GWAs study gives you information on the whole genome, not specific genes. **Brian R.** says what they've done was a major study on sockeye (Kristi Miller-Saunders' work) where plates were developed to look at a wide variety of processes to figure out what was going on with Fraser sockeye, by seeing what got turned on as the fish returned to the river. **Stewart J.** says that this technique still needs validation, and the latest work shows that much of what Kristi M. was seeing as back-to-river signals was also associated with senescence. However, Stewart J. agrees that archiving DNA samples, fin clips, etc. is great for future analyses.
    - **Brian R.** says that the U.S. and Canada have all the same basic metrics. It's now a matter of documenting and verifying them. **Stewart J.** suggests that we share current standard operating protocols (should be already written up) across the border to ensure that we are collecting comparable samples.
- **Brian B.** says that IGF-1 appears to be showing regional differences and in the Strait of Georgia is highlighting low-growth areas. It could be used as a diagnostic. Chinook in Puget Sound is low compared to Strait of Georgia.
    - **Dave M.** says there are a few places where water is stirred so hard by the tides that prey aggregations are unlikely. **Rusty S.** says it's hard to sample those sites too.
    - **Brian R.** asks how sensitive IGF-1 is to prey changes. **Brian B.** responds that it is fairly sensitive: a day to half a week. The signal takes 3-4 days to propagate. Stocks in different places have different signatures, and stocks that mix in the same place are more similar.
    - The cost of analysis is $10-15 per sample. **Marc T.** says that Brian B. has funding through 2014 and hopefully past that. **Michael S.** says the U.S. is incorporating IGF-1 sampling in North Puget Sound, but not for the entire range.
    - **Dick B.** asks what IGF-1 says about the first few weeks of marine life. **Brian B.** says that if survival is growth-dependent, it will tell you that. If it isn't, then it won't. IGF-1 mostly reflects consumption (and to some extent stress, if stress is significantly affecting feeding).
    - **Chrys N.** asks whether any comparisons of IGF-1 data and otoliths have been made. **Brian B.** says there are many datasets where you could do this. **Michael S.** says our proposed collections include scales, otoliths, and IGF-1, and we should continue on that path for both sides of the border where feasible. **Rusty S.** comments that there are scale retention problems in midwater trawl catches, but **Dave B.** thinks that we can get enough scales anyway.

- **Stewart J.** asks how many fish we need to actually collect to do a meaningful analysis on any given population. And, if it's not possible within permit limits, can we change our plans? **Mike C.** thinks this is another opportunity to use hatchery fish, since we can take a great many hatchery fish but wild take numbers must stay low. **Brian B.** asks whether midwater trawl catches are split into populations. **Dave B.** says that we try to track CWT cohorts, and will be taking genetic material so there could be some population resolution. Dave B. reiterates the idea of a two-tiered process, where first we track the cohorts as data are available and second we look for relationships with the general pool of juveniles as a whole.
    - **Brian B.** comments that they have protocols for re-trawling off the coast, because it is common that they do not get enough fish in a trawl to have a sample. **Chrys N.** says that neither Strait of Georgia nor Puget Sound have the issue of lots of 0 catches.
    - **Stewart J.** remains concerned about sample sizes and epidemiology; the number of fish that have to be lethally caught to get a large enough sample size is shocking.

Prey/zooplankton sampling

- **Brian R.** has been discussing with Eddy Carmack, Dave M., and John Dower how to get a representative snapshot of a large, dynamic environment. Eddy C. recommends small, community-based sampling. He has designed a sampling platform for small vessels that could be run by local communities and is now testing it on his own boat. The cost of one of these packages for a vessel with a winch is $12k, so it is realistic in terms of cost. However, there is a need for lots of training and checking-in on a regular basis to ensure standardization among boats and samplers. **Brian R.** has no concerns about getting volunteers. As long as we cover fuel costs, there will be lots of interest and the opportunity to capitalize on local knowledge. We may not save a large amount of money in the long run, but it would give us lots of coverage. **Brian R.** would like input from the researchers that will actually work with these data on whether they will be useful and what their specific spatial and temporal sampling needs are. It may be feasible to station a couple vessels in certain locations for more intensive sampling; we want to be flexible enough to meet the researchers' needs.
- **Julie K.** comments that we have a similar effort underway in Puget Sound. There has been significant progress on development of a Puget Sound zooplankton sampling program. The items included in the Puget Sound plan were limited by available budget, and ideally there would be several more sampling locations. The sampling costs are mostly equipment and fuel; actual collection costs are in-kind. Sampling will occur every two weeks from March through September, and samples will be processed at the UW. There are at least a couple stations per Puget Sound basin, and their locations were determined in part by where continuous physical data over the sampling period would be available (from ORCA buoys in Puget Sound). The objective of this project is to determine whether prey availability affects juvenile salmon and monitor important prey, and also to develop plankton indicators of salmon survival and environmental change. One question that was not included in the S-K proposal and is not yet included in any funded Puget Sound project but that would be important information to obtain is the dietary quality of prey items. We want to be able to describe variability in prey quality: species changes and composition changes.
    - **Julie K.**'s protocol (distributed among group) contains two types of sampling: vertical bongo tows for zooplankton indicators and oblique bongo tows for prey availability. All prey sampling will be surface/upper water column tows during daylight, so they serve as an index rather than the actual availability of prey for fish to eat.

- We hope to refine our efforts by oversampling in the first year and subsequently reducing our effort. Preliminary locations were chosen based on inputs of oceanographers and where data are available, and are being refined during conversations with samplers and others familiar with the locations and the fish distribution in those areas. In the absence of fish information, locations where physical data show recurrent aggregations would be chosen. We intentionally avoided places that had very dynamic circulation because high variability is difficult to understand without a long time series. **NOTE:** the decision was made to change oblique tow depth to 30 m because seines and midwater trawls will sample that.
  - **Marc T.** suggests maintaining flexibility at this stage, since once the mutual retrospective analyses are complete they will give some indication of the monitoring scale necessary to capture potential variation in observed survival. For coho, at least, we will have a better idea about spatial coherence within the next year, and that can guide sampling efforts.
  - **Correigh G.** comments that we know that plankton are very spatially structured.
  - **Chrys N.** asks whether there are any long plankton time series in Puget Sound – there are a few sites sampled over time in Strait of Georgia. **Julie K.** says there are not really long time series for plankton in Puget Sound. There is one site sampled since 2003 under the JEMS program, and Julie K. has a variety of short time series (e.g., almost 3 years of monthly samples at a Central Puget Sound site) where samples were collected but unanalyzed.
  - **Joe A.** asks whether we should focus sampling in places where we know survival is poor, like South Puget Sound. **Julie K.** asks what spatial scale of sampling we would need to address variability in South Puget Sound. Julie K. thinks that comparisons among basins with high/low survival would tell us more.
  - **Brian B.** says that juvenile fish are an important part of juvenile chinook diets off the coast. However, they never catch those fish, so they do not know how they play out in terms of the prey field. Brian B. suggests the Salish Sea program consider this as a potentially avoidable data gap. **Dave M.** says that Julie K.'s protocol and gear will not catch those fish. Zooplankton sampling will not give an abundance of young-of-the-year herring, but it can serve as a proxy for survival because it indicates how well-nourished the juvenile fish are. **Julie K.** agrees that it is a gap in the current program.
  - **Chrys N.** asks how important consistency in the sampled depth strata between basins would be. The Strait of Georgia has different protocols and sampling depths; will those data still be comparable? They have only done vertical tows. Also we need to standardize mesh size. Chrys N. notes that there is variability in their methods depending on boat, and that much of their data remains unanalyzed. **Marc T.** comments that, with the platform that Eddy C. is putting together, some of those protocols could be revised. **Julie K.** says that, within Puget Sound, some basins are shallow and some are deep, so we are already having discussions about depth. The current idea is vertical sampling at about 100 m depth contour to the bottom to get a realistic picture of the full community. We decided 100 m because *Calanus* generally are not found until 70+ m bottom depth.
    - **Julie K.** would like input from the fish perspective on nearshore/offshore zooplankton sampling. **Dave B.** would like to see prey field samples taken at

offshore sites that are not influenced by the slope zone; 100 m depth is sometimes still close to shore in Puget Sound.

- **Brian B.** thinks euphausiids are important in deeper areas; there are definite community differences depending on depth in the water column.
- Strait of Georgia has not been doing oblique tows.
- **Stewart J.** thinks that a 50 m tow might address issues like zooplankton patchiness: fixed sites to understand the community, but there should also be some relationship between what fish you catch and what zooplankton are there.
- **Mike C.** thinks we really need standardization across the entire Salish Sea, for both zooplankton and fish. These studies that are being discussed are all limited by funding; let's identify what we'd really want to do for a full-scale US-CA Salish Sea effort. We need additional things to work on – can we discuss night, depth, fish abundance, ocean conditions, capability of groups, etc.?
- **Ken D.** comments on the possibility of taking lower physical circulation models up to zooplankton and adding zooplankton life histories to models: we need information on eggs and early nauplius timing from diapause – and getting those data requires deep tows. This addresses the match-mismatch hypothesis.
- **Dave M.** says that in terms of zooplankton patchiness, you will find euphausiids and amphipod patches where there is steeply sloping bottom topography, and copepod and crab larvae patches along fronts. Dave M. is sure that fish target fronts, plume edges, and tidelines to find food. Those flow-field features are not fixed like bathymetry is. To model those zooplankton aggregations would likely be a behavioral modeling effort rather than a growth/survival model.
- **Julie K.** suggests the Strait of Georgia folks switch from sampling within 10 m of the bottom to within 5 m of the bottom, because otherwise they will miss a lot of *Calanus*. **Dave M.** clarifies that this would be for vertical tows only; for oblique tows you would need to be more careful.

▪ **Chrys N.** asks whether one sample is sufficient or whether repetitive samples are necessary. **Dave M.** would prefer to sample many locations instead of one location many times. **Julie K.** adds that the data show that doubling your effort to do a replicate tow does not double the information that you get.

- **Chrys N.** is concerned that if a boat is sampling for fish, then adding extra zooplankton sampling is too much effort. **Dave M.** says that in his experience, the largest amount of time is deciding to stop the ship and sample. If you do a 0-200 and 0-50 tow, the incremental time for the second is about 5 minutes extra. It is not a big burden on ship time, as long as you have committed to the deep tow already.

▪ **Marc T.** asks about the analyses that remain unfunded. For example, what kind of preservation allows for fatty acid analysis later? **Julie K.** says that preservation for fatty acids has not been built into protocols yet, since it wasn't set forth in the S-K proposal. It requires vacuum-sealing and freezing quickly, so it would be a big lift for all sampling groups to do. However, some larger boats may be able to handle it.

- **Dave M.** suggests that including night-time sampling to get euphausiids, crab larvae, and amphipods at the surface would be one of the most useful things to do. In the Strait of Georgia, they have large ships dedicated to a 24-hour sampling schedule that samples as much of the water column as possible and gets down into the euphausiid layer. It's a good design to do a shallow tow in deep water and a full water column tow, because you get prey availability and zooplankton community by doing both. At night, the available prey changes because some zooplankton do diel vertical migration. **Julie K.** thinks that night sampling in Puget Sound is not yet feasible; she is worried about community burn-out. We need an easy routine that community groups are willing to keep up without funding. **Dave B.** says that fish sampling will occur at night, but that their boat likely will not have time to switch to zooplankton sampling. He has advocated for an inexpensive, fast boat for zooplankton night sampling. **Dave M.** says slower boats are actually better for night sampling; he suggests the Coast Guard hovercraft (used at UBC to stand by while doing ocean work) or the Coast Guard auxiliary inflatables that are manned by volunteers. **Dave P.** says that those inflatables are 21' vessels with two 150 horsepower engines and a winch; they'd be able to handle bongo nets.
- **Dave M.** says that if the objective is to monitor the zooplankton community, we want to sample most of the water column with a net that is capable of catching most kinds of zooplankton (from large euphausiids to small copepods). It can be done with a small boat if needed. Oblique tows if well-done can be better than vertical tows, but it is much more difficult to do them well. To catch ichthyoplankton, we would need a net with mouth area of at least a square meter and bigger, more powerful winches. A fishing boat with a boom could work. If there are enough samples with multiple gear types, we could assess avoidance biases (e.g., euphausiids avoid nets fairly well). Dave M. would also suggest using acoustic backscatter to monitor euphausiids.
- **Chrys N.** asks how to sample nearshore. **Julie K.** recommends shallow oblique tows, but isn't confident this will tell us what we want to know. The shallowest station targets 20-25 m water depths. **Correigh G.** comments that Jeff Cordell is very interested in samples from those shallow depths; he thinks there are important dynamics in the nearshore prey communities.
    - **Marc T.** and **Brian R.** have a paper on the Campbell River that used very shallow zooplankton sampling to comment on the abundance of zooplankton at coho hatchery releases. It is a 5+ year time series. Marc T. will send the paper to Julie K.
- Insects and epibenthic species will be undersampled using Julie K.'s protocol; other protocols would need to be developed to assess those groups. **Julie K.** reminds the group that since the strongest correlations with survival for hatchery chinook occur offshore, we are focused on the pelagic prey community.

        - **Julie K.** says that adding neuston tows for insect sampling should be easy for boats to do as long as they have a neuston net and additional tow time, and analysis can be fairly quick as long as only insects are targeted.

- **Dave M.** says that since the original zooplankton proposal in the 2009 Strait of Georgia plan, the knowledge base has improved. The zooplankton community in Strait of Georgia is dominated by fairly large crustaceans, and it looks more like a high-latitude oceanic community than a shallow estuarine community. There are also very large interannual variations in how much zooplankton is in the Strait of Georgia with a predominant decadal cycle. Jellyfish vary independently of crustaceans.
    - **Angelica P.** comments that it is very unlikely that variations in primary productivity are large enough to account for the decadal fluctuations in zooplankton; it is more likely something to do with transfer efficiency and match-mismatch in timing. It's possible we could get at the transfer efficiency question by comparing zooplankton data with sediment time series. Does primary productivity feed zooplankton or the benthos? Another reason we need to understand zooplankton is to assess prey availability for forage fish species.
    - **Julie K.** comments that if large-scale changes are driving zooplankton variability, maybe it doesn't matter as much what depths and locations we monitor – basins should operate together.
- **Marc T.** will send out a map of planned zooplankton sampling locations in the Strait of Georgia for 2014.
- **Chrys N.** suggests putting a workgroup together to continue discussions, especially about ichthyoplankton, neuston, and epibenthic sampling.
- **Dick B.** thinks we need to discuss zooplankton analysis – can we do it in a timely manner? **Michael S.** says that Julie K.'s goal is to have collaborators do coarse-level analyses on their own so that it is a smaller lift. However, ecosystem indicator samples would likely not be outsourced. **Brian B.** suggests a lab in Poland, but **Dave M.** doesn't trust that lab based on his past experience with them.

Physical sampling

- **Jan N.** gives an overview of the current physical oceanography work in Puget Sound, including continuous data recording ORCA buoys, real-time profiling data, and NANOOS NVS data explorer.
    - **Rusty S.** will send Jan N. the contact for the naval base CTD cast data.
    - NANOOS will host any contributor's data and in some cases provides links to data on the contributor's website, though **Dave M.** comments that NANOOS does not always update their data in real-time. **Angelica P.** says they send their data to NANOOS on a yearly basis.
- One concern in physical sampling when talking about moorings vs. CTD casts vs. monthly WA Dept of Ecology sampling is the appropriate temporal scale to capture blooms. Continuous data and vertical profiling is very important for this – even a timescale of once weekly sampling is not enough to capture bloom dynamics and other variables. For example, the ability to predict oxygen or chlorophyll-a in Puget Sound rapidly erodes once you get beyond one sample per day. However, the monthly DOE database spans decades and is likely to continue, so we see that as a very complementary effort to the continuous buoy data. Discrete sampling programs can give important spatial resolution, while the fine temporal resolution of the buoys is also essential.

- **Brian R.** asks if there are comparable efforts in the Strait of Georgia. **Angelica P.** says that there used to be a program on Halibut Bank, but there is nothing like that now. She proposes to instrument Halibut Bank. **Ken D.** says that VENUS has fluid plans and multi-frequency upwards-looking sonar equipment in the Strait of Georgia. They are testing a vertical profiler in Saanich Inlet, but decided it was too risky to put inside the Strait.
- **Jan N.** thinks that stratification and phytoplankton variability remain valuable questions to pursue.
- **Brian R.** has talked to shellfish growers and thinks they would contribute funds if we monitor pH. **Jan N.** says that to some extent we are already doing that; the new equipment in Baynes Sound has a pH sensor. The state of Washington has granted money to establish an ocean acidification center at UW, which Jan N. would like to keep coordinated with the SSMS project. There are efforts underway now to develop cheap pH sensors and high accuracy pH sensors, and tools like deployable DIC sensors. **Ken D.** says that currently VENUS does not have the capability to monitor pH, although they are testing Durafets.
- **Robie M.** says that they have one mooring in the South Strait off Vancouver and another in North Strait. They have 6 years of ADCPs, sediment traps, oxygen, and pH and have recently started to do full chemistry sampling for DOC. Shellfish growers actually need carbon and saturation levels. **Jan N.** and **Robie M.** agree to continue discussions to make sure the Puget Sound work is complementary to the Strait of Georgia effort.
- **Ken D.** says that as part of another open ocean project, they are planning an intensive study period in 2014 built around VENUS sites up to the phytoplankton level, including satellite imagery to look at the Fraser plume effects. Sampling will begin in May/June of 2014.
- **Robie M.** comments that the sediment trap data show that Strait of Juan de Fuca is very important. **Jan N.** says that there is the JEMS program in Juan de Fuca, which is monthly CTD sampling and also one zooplankton sampling site that Julie K. mentioned.
- **Marc T.** sent out cruise plans for 2014 so that the group can see the planned locations and timing of CTD casts and bongo tows.

Other - communications

- **Dick B.** says we need a story about what's happening to juvenile salmon and a little bit about adults, and we need to tell that story to the general public. At least we need a webpage to send people.
- **Brian R.** and **Michael S.** have discussed the need for an integrated communications group and will make that a short-term priority. The Long Live the Kings board has already requested exactly this.
- **Brian B.** comments that Bill Peterson has a coastal site that's very useful, and it takes 2 full-time people to maintain.
- **Chrys N.** suggests promoting our work through social media. **Dick B.** thinks that the contacts we've all made individually are more important than media.
- **Brian R.** and **Michael S.** will put together a common presentation and framework for communications for anyone dealing with communities and fundraisers to help maintain consistent messaging.