Hood Canal Summer Chum Climate Forum

March 9, 2017

Kitsap Conference Center, Bremerton, WA

Topic One – The PDO and Potential Effects on Summer Chum

1a. What is the current prevailing perspective on what constitutes an existing PDO regime (with respect to pattern, periodicity, duration, mini-regimes within a major regime)?

- PDO fundamentally linked to Aleutian low; definitely an atmospheric phenomenon
- PDO is not everything and recently role of second North Pacific GO (NPGO); NPGO explained
- Some lower trophic levels appear more sensitive to NPGO than PDO
- PDO signals show variability; variability on scale of year-to-year and decade-to-decade
- Emanuele Di Lorenzo analysis presented
    - Slide showing conceptual linkages among several atmospheric forces (e.g., PDO, NPGO, NIPO)
    - Figure does not provide a sense of how strong the linkages are, but BOND thinks that info needs to be considered
- Sergei Rodionov paper looking at time series of PDO
    - Used different criteria to estimate regimes over time and changes/shifts in regimes
    - Varied model settings to be more of a lumper or splitter in identifying regimes or mini-regimes
    - His technique works for comparing assigned PDO regime shifts and Aleutian low conditions
- BOND explained analysis of multiple parameters and how they vary with apparent PDO conditions
    - PDO and PS Air temperatures in spring (April through June) (1944-2016) definitely show a positive relationship, but not 1-to-1; more often extremes in air temperature do not line up with PDO
    - PDO and mean stream flow in spring (1944-2016) varied by river system studied
        - Duckabush – negative correlation (Positive PDO, less stream flow; negative PDO, more stream flow)
        - Duckabush and Dungeness – stronger relationship; Skokomish not as strong a relationship
    - PDO regime slide 1999-2012, 1999-2006, 1979-1998 – No big changes in SST, air, Duckabush flow between regimes, but slightly stronger when regime data extended through 2012 (instead of only 1999-2006)
- Conditions associated with various PDO regime are changing, that is, past PDO conditions may not be indicative of future PDO conditions. For example, the warm blob caused different conditions on the coast than were expected based on the PDO regime.

1b. What is the prevailing perspective on the current state of the PDO (warm or cool, its stability, when we might expect a major shift)?

- BOND presented a PDO slide showing recent data shifting to warm phase.
- BOND presented a slide and hypothesized that the PDO is returning to a more neutral condition and the anomaly value could be at 0 by summer.

1c. Question for Nick Bond (if unanswered after his presentation): In a paper you co-authored with James Overland in 2008, it states regarding being able identify when a regime shift occurs: "…most methods lack discrimination ability near the end of the record, just when it is most important for operational purposes." The paper then mentions a method described by Rodionov. What is the current thinking on being able to identify regime changes for operational purposes?

- BOND presented information on PDO Predictability from a recent dissertation (author not noted, was it Rodionov?) – can we forecast it?
    - Atmospheric model included PDO; asked in this model framework is PDO predictable (10-year forecast); how well did it predict SST
    - Model degraded rapidly with time; after 2 to 3 years, no predictability; so some predictability beyond just predicting persistence of current conditions, but not much
    - Very difficult to predict
        - Linked to ENSO and we can't predict ENSO well
        - Model outputs were sometimes right and sometimes way off

1d. Spatial and temporal patterns in coho smolt survival in the Salish Sea (2015 paper by Zimmerman et al., co-authored by Joe Anderson on the panel), as well as performance patterns in summer chum and pink salmon performance, suggest that PDO influences may be transferred differentially to the various parts of the Puget Sound complex; can you provide insights into how this might happen? (or what hypotheses could explain this)

1e. The patterns of performance response by summer chum and pink salmon to PDO regimes suggest that effects on performance occur relatively close to the natal streams of origin; it might be hypothesized that this is occurring due in some way to effects on the quality and quantity of food supplies for the emergent fry as they move into Puget Sound from their natal streams. From your perspective, is this a reasonable hypothesis and, if so, can you provide insights into how this might happen?

- Although questions 1d and 1e were not directly answered, they initiated a discussion about parameters linked to coho response.
    - Discussion turned to the observation that the timing of change within a year matters as biological responses are often on a timeframe of weeks to months. That is, thinking about conditions based on averages over time is often inadequate when considering biological responses. Need to know more specifically the timing of change within a season and/or if periods of extremes occurred during a given timeframe. For example, regardless of the

mean streamflow during egg incubation, the peak flow encountered during that time (or even within a highly sensitive subset of that time) will be more indicative of egg-to-fry survival rates.
    - It was postulated that what is important for summer chum is not the peaks in air temperature, but the timing of when the temperatures trend up (Time 0 versus X weeks later can make a big difference).
    - Mixing depth at time of outmigration may be most important and more information is needed on how PDO effects that is what needs to be researched and understood.
    - More broadly need to understand more about what PDO affects that contributes to the conditions encountered by summer chum being more or less favorable.
    - Need to understand the mechanisms driving the population response. Processes affecting salmon are operating at multiple scales of space and time. Need more of a mechanistic approach and better understanding of biological indicators.
    - In considering mechanisms and biological responses, it is important to consider how the changing environmental conditions may also be affecting predators, as well as prey. Both will affect summer chum responses.
- For summer chum, the conditions and prey resources available at the time they enter Puget Sound can be important for their survival.
- Temperature conditions in the upper water column were identified as eliciting a clear response by the fish population.
- The water column stratification conditions at the time of outmigration will influence available prey resources. Anything causing shifts in outmigration timing will affect the conditions encountered upon entry to Hood Canal.
- Variations in streamflow patterns into Puget Sound and Hood Canal could foreseeably affect differences in early marine conditions. Foreseeably, in warmer years when less precipitation is retained as snowpack, the spring/summer run-off could be less, but the water warmer.

1f. If the question immediately above is answered in the affirmative (i.e., it is a reasonable hypothesis), what methods might be employed to understand the factors responsible?

- BOND indicated there are several long-term atmospheric datasets that are available if people let him know what questions they are interested in analyzing. For example, Bill Peterson work off Newport; ocean low frequency response; when conditions changed off coast of OR, took about a year for lower trophic levels to switch; so conceivably biology responds slower.
- Need more of a mechanistic approach and better understanding of biological indicators.
- Currently not collecting data throughout the year. Main gap is during the early marine conditions experienced by summer chum. Current studies related to marine survival collect data between April and October. Winter data needed.

1g. Should delisting of summer chum consider how the PDO potentially affects summer chum performance and why it should or why it should not; and if so, how might this practically be done?

- A general concern regarding lack of understanding of the mechanisms of what summer chum need and how those conditions are influenced by PDO and other variables.
- In absence of full understanding, it was recognized that people will be required to make decisions with available information.
- A precautionary approach should be taken such as proposed in Lestelle et al. (2014). That is, do not base delisting decision on population viability measures during favorable PDO conditions. Need to understand population viability during less favorable conditions.
- Also, delisting decision needs to consider more than whether there are more fish. It needs to consider whether habitat limiting factors have been addressed and how the DPS is faring among all VSP parameters.

1h. Harvest regimes are being updated to take into account the state of the PDO—minimal harvest levels would occur during a warm phase regime with higher impacts allowed during a cool phase regime; this approach would require being able to monitor and forecast the state of the PDO with respect to biological response of summer chum. Can you advise on how this might be done?

- As described in notes for 1c, there is a model that predicts PDO somewhat during first 2 to 3 years, then falls apart. Most of the success of the first 2 to 3 years attributed to an assumption of some persistence of current conditions. Apparently any rapid swing in conditions would not be well predicted.

1i. What insights, comments, or questions would you offer on the how human caused alterations to nearshore habitats or Puget Sound water quality or food webs (i.e., through direct influence into the Sound's characteristics) might influence the effects of PDO within the Sound—and conversely, how restorative actions might also influence those effects?

- Not discussed separately from discussion described for earlier questions

Topic Two – Climate Change Effects and Role in Recovery

2a. How might climate change patterns affect the state of the PDO (its stability, its strength, its periodicity)?

- Not discussed

2b. What might reasonably be expected with regard to how the coefficient of variation (CV) for key environmental factors will change over the next 10 to 100 years, i.e., if the average condition of certain environmental factors trend over this period, how do expect the variability to change?

2c. What environmental factors are likely to demonstrate the greatest increases in CV? Conversely, do you think that some factors may demonstrate reduced variability, and if so, which ones?

- Projections of multiple parameters presented; provided more information on trends in average conditions rather than changes in variability
    - Ocean acidification, sea level rise, and storm intensity projections presented
    - Storm surge and waves are not expected to increase, but surge is expected to be carried further inland due to higher water levels
    - Not projecting increase in winds, despite seeing recent high events
    - Average Puget Sound temperatures are projected to change substantially by 2100, but not average precipitation.
    - No statistically significant changes in annual streamflow has been documented yet.
        - Anticipate a transition from snow influence to rain which will result in flashier flows; so variability could go up within a year, not necessarily year-to-year
        - Need to be careful when using peak flow statistics for a year because they ignore conditions during 364 days in a year
            - Important information is lost among the data contributing to annual means, e.g., the frequency of flow exceedances in the year
            - Variability biased toward outlier events; should expect variability when choosing the very highest point along the tail of flow distribution
            - Hard to infer trends from observations due to variability
            - <u>There is clear evidence that in future the change will exceed variability</u>
        - In rain dominant systems, there will not be smoothing of flows such as provided by snow; no delay to delivery of flow because falling as rain; so given expectations for variable storm events, there will be increased variability of flows

- As noted by the question, variability matters. While the projections tend to provide smooth trends in one direction or another, a single extreme event can wipe out a year class.
- Overall, yes there is some expectation that variability may increase over time to a certain extent. There may be some increased peaks, but it is unclear if similar adjustments to low end of range will offset the increase in peaks and therefore result in no change in variability.
    - There may be greater variance, but those changes may not be symmetrical changes to current conditions (i.e., there may be an increase in the variability of the peaks, more so than the changes observed at the low end).
        - McClure has statistician contacts to help apply asymmetrical changes to a model input.

2d. What might reasonably be expected with respect to how CV in population performance measures (e.g., spawner abundance, intrinsic productivity) might change over the next 10 to 100 years as a result of changes in CVs of environmental factors?

- Not discussed

2e. As a result of climate change, what environmental factors are likely to adversely affect average population performance of summer chum? What environmental factors may beneficially affect population performance? Are there compelling reasons to believe that performance on the average will either be adversely affected or beneficially affected?

- Western Hood Canal watersheds are most vulnerable to climate-induced transition from mixed rain and snow systems to rain dominant. This brings higher peaks in winter and lower lows in summer.
    - As discussed earlier the individual events matter, not just long-term averages. The single events are crucial for the fish, not the seasonal total; higher magnitude storm events will have higher effect on fish
    - If there is a particularly high peak flow during incubation, then egg-to-fry survival plummets (from 60% to 3% depending on event)
- The lower flows and warmer temperatures in the summer, may cause adults to delay moving into rivers and delaying spawning.
- Not known how winter water temperatures may change. Data from Salmon Creek indicate that 1C increase in temperature equates to 12 days faster incubation.
- Discussion of “jackpot theory” and Donaldson’s early growth hypothesis led to discussion of concern about conditions available to outmigrating fry if they incubate faster and outmigrate earlier.
    - Beauchamp noted there are certain size selective forces acting on fish. It appears fish need to be a certain size at certain points of life stage. The progression for how

they achieve that size before the point may vary. For example, in Lake Washington, outmigrating chinook and sockeye appear to benefit from achieving a certain size before outmigrating. Chinook move through the lake in spring and need to grow very rapidly to achieve desired sizes. Sockeye remain in the lake for one year of rearing and grow more gradually to achieve their size at outmigration.
    - Analysis of archived otoliths can help inform whether rapidly growing fish during early outmigration are surviving to adulthood at higher rate.
- Hypothesized that a delay in spawning may occur due to changed river conditions (lower flows, warmer water) and this could shift egg incubation period. If this occurred, outmigration may occur at approximately same time as it currently does.
- Hood Canal mid-late winter conditions not well studied; expected to be much less food available (hypothesized to be due to less light available to fuel food web in winter; also hypothesized to be related to mixing depth).
- Implications for stratification
    - Expect more freshwater input in winter
    - Opposite in summer, less input in summer, but warmer water
    - Could affect water exchange with ocean
- 2015 drought significantly reduced exchange between PS and ocean (~75% decrease)
- There is so much uncertainty community dynamics related to climate change that we are unable to predict whether better or worse.
    - Not all creatures respond to change at same rate, especially considering different trophic levels; we have little info on how Puget Sound operates
        - Need a conceptual model.
        - Bond offered to look back to historic data to look for examples; offered to look for years when streamflows went low early so the data can be compared to fish data.

2f. What insights, comments, or questions would you offer on the how restorative actions might ameliorate potential adverse effects of climate change on the habitats (all aspects) and food resources of summer chum?

- Not discussed

Topic Three – PDO and Climate Monitoring Indicators

3a. NOAA is monitoring indicators related to the PDO within the Pacific Ocean. What indicators are being monitored in Puget Sound that can be used to help understand how the different parts of this water body are being affected?

3b. As in the question immediately above, what indicators are being monitored in the Puget Sound complex to assess status and trends with application to climate change?

- Answers to 3a and 3b combined.
- Bond described several long-term datasets that are available
    - Newport group – can provide long-term datasets including copepod time-series data
        - Recent years showing disproportionate number of southern species
    - PDO/ONI (ENSO) chart
        - ENSO peaks lead the PDO peaks with notable exception of blob years
    - Bill Peterson – stoplight plot of conditions by year since 1990s; being used for forecasting salmon returns
        - Good match between model and returns; 2017 numbers low
        - NWFSC website; salmon forecasting
    - Ecology marine water quality data
    - NANOOS; NVS application on their website
    - SST anomaly forecasts
        - Are making forecasts of the physical conditions
        - Not predicting warmer water near coast of north Pacific
        - Some signs of El Nino
    - USGS stream flow data
    - Can learn a lot by making forecasts; the process of forecasting can be illuminating
    - Need to better determine the mechanistic factors related to recruitment
- Fresh described additional information sources and lines of inquiry.
    - Lower Columbia forecasts use PDO input.
        - Particularly useful to evaluate PDO influence because approximately the same numbers of fish going out each year because of hatcheries.
    - Need to develop conceptual model to then populate with parameters; need hypothesized mechanisms
    - "Stoplight" charts have been prepared for coho and chinook. These charts show the relative condition of a series of indicators over the last approximately 20 years. Green means more favorable, yellow less, red unfavorable.
        - A stoplight chart could be prepared for chum. Would require some advanced thinking about conceptual model of what matters for summer chum returns and analysis to strengthen the model.
    - A word of caution
        - Correlation between indicators and chinook
        - PDO has periods of good predictor and periods of not good predictor
        - You have to understand the mechanisms to really understand the indicators

        - Things affecting salmon operate at multiple scales of space and time
        - Presented preliminary analysis of ocean effects on chum R/S using 16 years of data. Included initial indicators he thought were important.
            - Good ocean, poor ocean
            - Early marine life (1st year) is critical
            - Higher R/S when good ocean
            - Newport line of copepod data can be applicable up to mid Vancouver Island
            - Might be useful to take summer chum, develop conceptual framework, and investigate indicators affecting R/S numbers
- Stratification will be a good index to include for Puget Sound (more nutrient loading and freshets); by June see strong stratification
- In thinking about whether climate change should affect delisting decisions enough to change recovery targets, there is a need to develop clear hypotheses of how and where climate change affects the population. In the Marine Survival Project, there were 14 hypotheses for why steelhead and chinook were dying. This list got winnowed down in thinking about what can be studied. The development and screening of hypothesis was a good exercise to go through. It helped identify how to monitor and drive delisting criteria.

3c. What indicators would you prioritize as the most important to monitor?

- The Marine Survival Project has 3 years of widespread sampling at about 90 sites; funding for future is uncertain
        - Limited understanding of summer chum (seems like some relationships discussed during the day are from fall chum applications and may not apply to summer chum).
- There is a need to start winter sampling of zooplankton community so it is year-round.
        - Currently only April to October sampling
        - Currently taking zooplankton samples near Thorndyke (sill); nothing south of Thorndyke Bay;
            - Also sampling Admiralty Inlet; vertical tows easier, oblique tows more difficult
            - more stations would be good
            - timing for summer chum
        - Although existing zooplankton data start in April, it still provides some information that may be applicable to summer chum
            - Hans described the following when asked if he sees any shifts with time in zooplankton community?
                - some portion of summer chum; peak changes from beach seine to trawl; not all fish moving offshore as quickly as expected; Micah Wait will have summer chum data and how quickly things are moving out – includes genetic study; defers to Keister for zooplankton composition shifts
- Start with the development of a conceptual model of summer chum life cycle and identify where climate may affect that life cycle

    - Match monitoring to those points with strong climate and life cycle interaction
- Spatial structure's most productive component is Quilcene, but hasn't always been that way
    - Recommended to focus research on Quilcene. Work to understand why the summer chum return rates are high. Also provides opportunity to learn even if numbers drop (can investigate what contributed to a decline if it were to occur).
    - While asking why Quilcene doing so well, need to think about why the east side populations went extinct more (one thought is that the hydrology is very different on the east side)
- Stream temperature data needed; USGS data relatively limited for Hood Canal
- Otolith analysis using extensive collection from adults; could answer questions if look at earliest part of otolith
    - Otoliths from adults are from the survivors; can answer life history strategies that work, variability, if have juvenile ones could also answer what life histories are not producing survivors
- Need population status monitoring at multiple life stages (eggs, fry, adults); will allow better identification of mechanisms