Running notes

# Meeting Sept 29 2021

**Goal of the project:** To reassess the relationship between sea louse abundance on out-migrating wild juvenile salmon [in the Broughton Archipelago?] and productivity of wild salmon populations in a stock-recruit (SR) analysis.

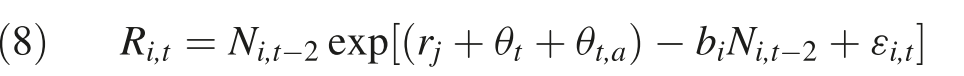
Terminology: Population = river population. I.e., a unique combination of species and spawning location as differentiated in NuSEDS.

### Scope

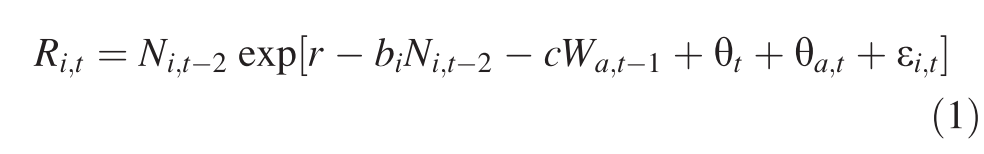
* BATI is funding the project by verbal agreement, need to prepare written proposal. Otherwise a lot of flexibility on topic and scope.
* Term: Feb 1 - August 31, 2022 (7 months)
  + Cole finishing MSc in Dec
  + TAing over next 3 months
  + Not much time in the next 4 months to start on this, but can get a head start on data requests etc. as needed
* Species?
  + Goal for BATI to know how salmon are doing
  + Focus on pink salmon, but keep options open if things go well to branch out to other species
* Area

### History of similar analyses in the Broughton

* [Krkošek, M., Ford, J.S., Morton, A., Lele, S., Myers, R.A., and Lewis, M.A. 2007. Declining wild salmon populations in relation to parasites from farm salmon. Science (80-. ). **318**(5857): 1772. doi:10.1126/science.1148744.](https://www.science.org/doi/abs/10.1126/science.1148744)
  + First look at population-level effects of sea lice on **pink salmon**
  + Did not account for sea louse abundance, but merely compared productivity between regions with and without salmon farms
  + Only used spawner data; did not account for catch in a SR analysis
* [Connors, B.M., Krkošek, M., Ford, J., and Dill, L.M. 2010. Coho salmon productivity in relation to salmon lice from infected prey and salmon farms. J. Appl. Ecol. **47**(6): 1372–1377. doi:10.1111/j.1365-2664.2010.01889.x.](http://doi.wiley.com/10.1111/j.1365-2664.2010.01889.x)
  + Focused on **coho salmon**
  + Performed proper SR analysis accounting for catch
* [Krkošek, M., and Hilborn, R. 2011. Sea lice (*Lepeophtheirus salmonis*) infestations and the productivity of pink salmon (*Oncorhynchus gorbuscha*) in the Broughton Archipelago, British Columbia, Canada. Can. J. Fish. Aquat. Sci. **68**(1): 17–29. doi:10.1139/F10-137.](http://www.nrcresearchpress.com/doi/abs/10.1139/F10-137)
  + Focused on **pink salmon**
  + Improved on Krkosek et al. 2007 by
    - Accounting for catch in a Ricker SR model
    - Including random effects for
      * year to capture variability in among years shared by all populations (e.g., due to shifts in ocean conditions)
      * area nested within year to account for shared variation among populations within an Pacific Fisheries Management Area (PFMA)
      * Population to account for intrinsic differences among populations that are consistent through time



* + - Performed model comparison using AIC and Likelihood Ratio Tests
* [Marty, G.D., Saksida, S.M., and Quinn, T.J. 2010. Relationship of farm salmon, sea lice, and wild salmon populations. Proc. Natl. Acad. Sci. **107**(52): 22599–22604. doi:10.1073/pnas.1009573108.](http://www.pnas.org/content/107/52/22599.abstract)
* [Krkošek, M., Connors, B.M., Morton, A., Lewis, M.A., Dill, L.M., and Hilborn, R. 2011. Effects of parasites from salmon farms on productivity of wild salmon. Proc. Natl. Acad. Sci. **108**(35): 14700–14704. doi:10.1073/pnas.1101845108.](http://www.pnas.org/content/108/35/14700)
  + Considered **coho and pink salmon**
  + Used four different metrics of lice on farmed salmon as coviariates
* [Peacock, S.J., Krkošek, M., Proboszcz, S., Orr, C., and Lewis, M.A. 2013. Cessation of a salmon decline with control of parasites. Ecol. Appl. **23**(3): 606–620. doi:10.1890/12-0519.1.](http://www.esajournals.org/doi/abs/10.1890/12-0519.1)
  + Built on Krkosek et al. 2011 PNAS by using louse abundance on wild juvenile salmon as the covariate, instead of some metric of louse abundance on farmed salmon, thus providing a more direct test of the potential impact of lice on wild salmon populations



* + Data and code [here](https://github.com/sjpeacock/Peacock2013EcolAppl).
* [Peacock, S.J., Connors, B.M., Krkošek, M., Irvine, J.R., and Lewis, M.A. 2014. Can reduced predation offset negative effects of sea louse parasites on chum salmon? Proc. R. Soc. B Biol. Sci. **281**: 20132913. doi:10.1098/rspb.2013.2913.](https://royalsocietypublishing.org/doi/10.1098/rspb.2013.2913)
  + Focused on **chum salmon**
  + Found no evidence of relationship between log(R/S) and sea lice on wild juvenile salmon, unlike Peacock et all 2013 did for pink salmon
  + Code and data … somewhere.

### Data

* Sea lice monitoring data for the Broughton up-to-date and available [here](https://github.com/salmoncoast/Sea-lice-database).
  + **Caution**: estimating annual abundance using model-based approach rather averages due to shifts in the timing of sampling from year-to-year
  + Include random effect for week of sampling when estimating annual abundance
* Spawner data from NuSEDS; publicly available [here](https://open.canada.ca/data/en/dataset/c48669a3-045b-400d-b730-48aafe8c5ee6).
* Catch data managed by Area Managers. See [here](https://www.pac.dfo-mpo.gc.ca/fm-gp/maps-cartes/areas-secteurs/index-eng.html) for outline of PFMAs.
  + Exploitation rates available through the PSF’s [Salmon Watersheds Program Data Library](https://data.salmonwatersheds.ca/data-library/)?
  + These data have been compiled at least up until 2018 at the CU level for the analysis that went into the biological status assessments in the PSE.
  + Eric Hertz (PSF; ehertz@psf.ca) may have updated data that are not yet in the Data Library. At the very least, he knows who the current Area managers are who have this info.
  + PSF outsourcing data compilation and “massaging” for north and central coast to LGL; the data and code for this is here: <https://github.com/LGLLimited/nccdbv2>
  + Other DFO Contacts:
    - Pieter vanWill - Area 12 Manager for DFO
    - Brian Spilsted -
* Atkinson, EM, CE Guinchard, AM Kamarainen, SJ Peacock & AW Bateman. 2020. The status of Pacific salmon in the Broughton Archipelago, northeast Vancouver Island, and mainland inlets. A report from Salmon Coast Field Station. Available from [www.salmoncoast.org](http://www.salmoncoast.org)
  + Did not look at sea lice, but performed river-level stock recruit analyses for all species of salmon throughout the Broughton.
  + Used data up to 2017

### Statistical approach & questions

* Species to focus on?
* Are we merely looking to add more years of data, or how can we improve on the methods previously applied?
  + Start simple and get something in the bag
    - Initial analysis does a GLMM approach, using some random effects to account for different spatial and temporal scales of shared variability
  + Think about what could be done to improve on this if time allows or for future research
  + Adress 2015 high lice numbers and think about how we can test hypotheses from Bateman 2016 that following returns will be low.
* Broader scale analysis including other regions? Data on sea lice not available…
* Just update SR analysis, or also look at relationships between farm lice and wild lice a la Peacock et al 2013?
  + This component is important for BATIs objectives and worth adding on.
  + Look at what are the critical farms around Knight-Tribune convergence. Seems like this cluster of farms is driving the relationships that we’re seeing.
* Possible extensions from Andrew:
  + Incorporating spatial structure beyond just random effects that we currently have
    - Better accounts for straying among populations (what *is* a population?)
  + Work in uncertainty in spawner counts, exploitation data (e.g., in a integrated population model)
    - State-space model incorporating observation and process error
  + Random-walk time-varying productivity analysis (non-stationarity)
    - Strong evidence that productivity has varied over the last decade
    - Could have regional time-varying productivity, with f

Cole Notes

* Redoing just the pink analysis - if possible would be nice to do chum and coho as well
  + Doing the data requests is easier, but the coho and chum data would need age data etc
  + Whatever analysis we decide on, do pink, start that writeup, then do coho if there’s time, then do chum if we somehow have the time
  + DEFINITELy do the data requests for all three -- chance for this to balloon, so knock off pink first if we can/have to
* Re the data
  + For the new numbers, peter van will (sp?) it should be okay to go ahead, but might be difficult
  + In the PSF catch data, the scale of catch records is not always as detailed as we want - we can reach out to peter again
  + For the central coast control areas (it’s not area 12), maybe he has access to those data or can send an email from them
* Data
  + Spawner data are readily available
  + Catch data - DFO has no central repository for this, the area managers need to agree to give it to you, and then they do things differently in each area
  + Idea is to compare between the central area (area 12 manager is the peter guy) but the areas 7-10 are the reference areas in the north
  + Eric hertz does the salmon explorer website
  + There is ONLY area level catch
    - So you partition your catch data via escapement rate
  + Online the pacific salmon explorer is up to 2018 but there are more recent data that might not have been uploaded
  + It is worth reaching out to the DFO folks and getting the datasets -- if all else fails, we can use the CU-level data for exploitation rates and whether we can get river level
  + Andrew says he wouldn’t trust what we get (steph said that something might have been massaged into the CU unit)
  + For area 11, we know there are farms but we don’t have good sea lice data
* Contacting people
  + Eric, peter van will, each area manager --- and then wait and see which threads come up
  + EXACT REQUESTS
    - Steph can contact eric and cc us
      * Update: Email sent to Eric but no response yet. Exploitation rates by CU available from the PSE data library ([here](https://drive.google.com/file/d/134kw81C8TNa9wqowc8MmVXfVKUpsEIwX/view?usp=sharing)) and include pink salmon up to 2019 for some CUs, but info is patchy.
    - Pieter {[Pieter.VanWill@dfo-mpo.gc.ca](mailto:Pieter.VanWill@dfo-mpo.gc.ca)} has been good, cole to contact him - looking for areas 7-12, this is the catch data and/or exploitation rate data (Peter is area manager for 12, so may not have 7-11 in hand, but we should ask)
      * Top priority pink, second priority coho/chum
      * “Thanks for sharing data with the regional report, we want to follow up with [more recent analysis] and we’re hoping for updated data for BATI/salmon coast”
      * Pieter might have all these data, if he doesn’t, he is the person most likely to just say “i’ll just send an email”
    - Emma has data possibly on the salmon coast website (?) - ask her for these data
* In the proposal
  + What are the deliverables (i.e. important first pass ones) then what are the interesting questions we’ll get to if we have time
  + Three obvious things for possible extensions
    - Incorporate spatial structure beyond the spatial random effects (have some more geographic spatial structure work in)
    - Uncertainty in the input data (uncertainty propagation)
    - State of salmon report, emma did a random walk time varying productivity rate -- steph’s previous stuff has a fixed productivity that is then affected by sea louse counts, but we could merge those two approaches because the time-varying approach is increasingly common
* Analysis stuff on the table
  + Could do something a bit more interesting than the previous version
  + We want to have juvenile sea lice and the farmed fish lice as covariates
    - Andrew says we should also then include the important farms (didn’t get which ones but there are a few) -- farms are sources of infection the broughton -- steph says “is there an optimal grouping of farms that predict lice on juveniles and how does that compare to the flow predictions”
  + Andrew says start simple and get something in the bag with the knowledge - stick with the well thought out simple but solid analyses that steph initially did
    - Andrew says that we do have a clear follow-up that should be working in - the prediction they made about the 2015 high lice numbers, we can talk about how we want to build that in
    - Fit the stock recruit models without that year and then hold out 2015
    - Could apply to all years since then that could be more relevant moving on -- could just be the leave one out approach and see where we go
    - thought: just turn it into a forecast? Depends on if covariates are forecastable i guess, maybe uncertainty too high

* + - https://cdnsciencepub.com/doi/abs/10.1139/cjfas-2016-0122