The role of marine mammal predation in recent B.C. fish stock collapses

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Preface: Fish stock collapses

- Some researchers have urged you to believe that the main cause of fishery collapse has been overfishing
- This assertion is false in general, and certainly for B.C.
- Recent B.C. stock collapses, not due to overfishing:
  - Herring
  - Georgia Strait chinook and coho salmon
  - Off-cycle sockeye stocks
  - Steelhead, Eulachon (will not discuss)

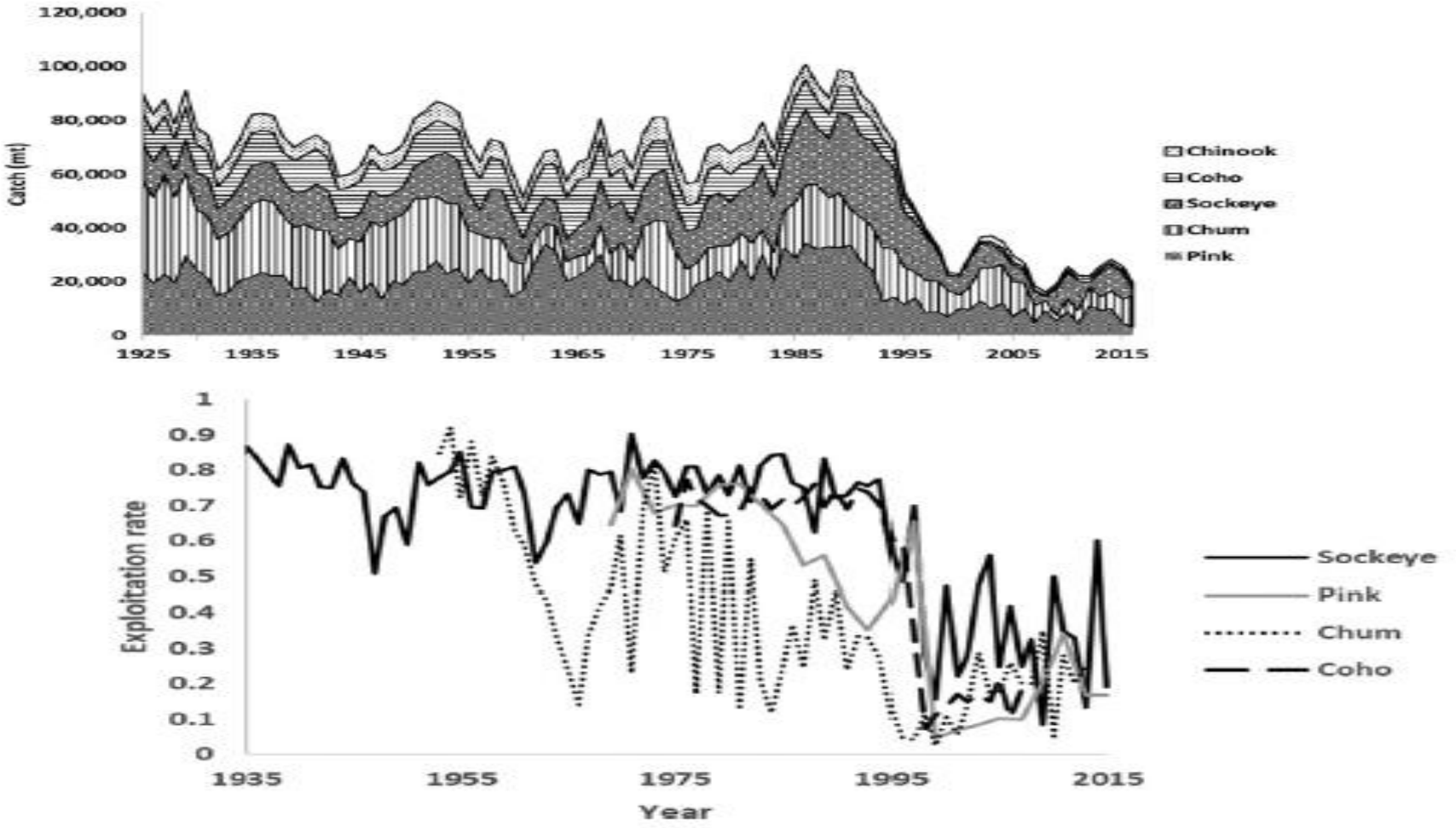
We have tried to assess pinniped impacts using two main methods

1. Statistical comparisons of fish mortality rate measurements with changes in pinniped abundance, i.e. **have increases in pinniped numbers been well correlated with space-time changes in mortality rates**?
2. Direct calculation of possible predation rates using prey abundance estimates and estimates of pinniped food consumption rates and diet compositions, i.e. **could pinnipeds be eating enough to account for the measured mortality changes**?

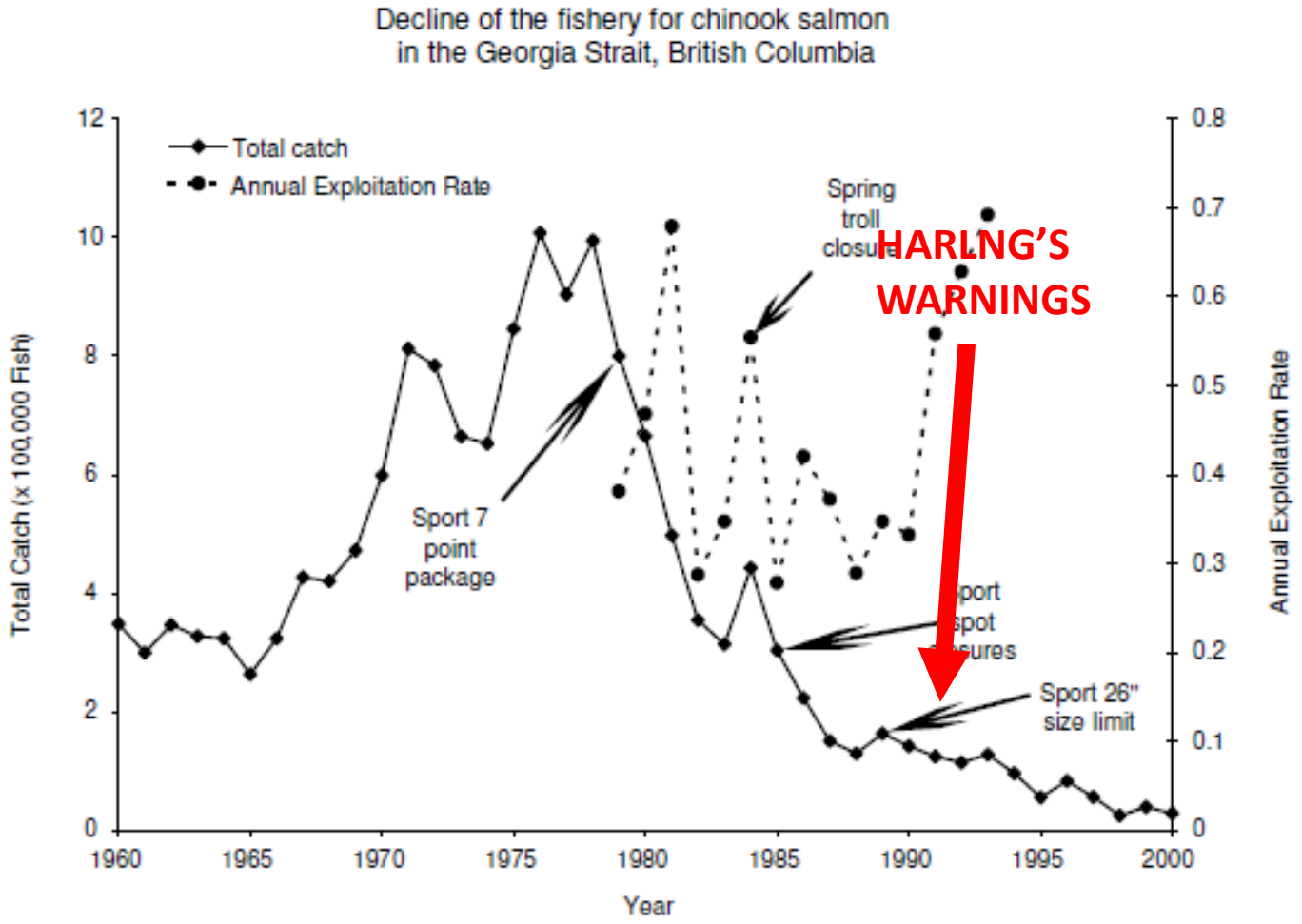
A word of caution: at least three things can go wrong with these methods

- Mortality changes are also correlated with other factors that have exhibited long term changes, e.g. water temperatures. **Correlation does not imply causality.**
- **We cannot be sure that the fish eaten by pinnipeds would not have died anyway**, due to factors like disease that may have made those fish the ones that were vulnerable to predation (non-additive mortality)
- **Predators can kill prey without eating them**, i.e. can cause mortality rates higher than expected from consumption rates, by causing prey to exhibit “risk sensitive” or “ecology of fear” foraging behaviors that reduce their growth and survival rates.

There has been a long history of sustainable salmon harvesting in British Columbia, but with severe reductions in exploitation rates in recent years



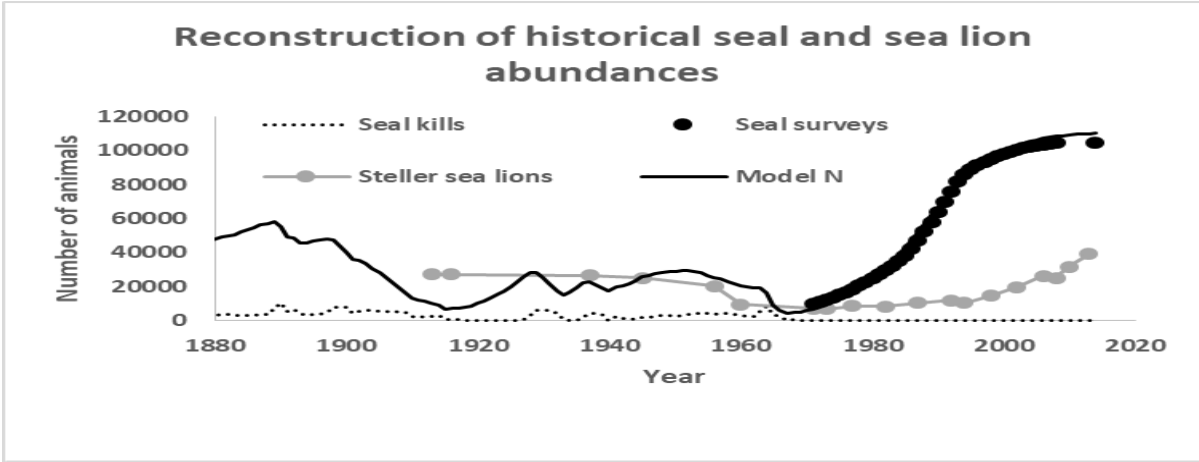
A sad history: all sorts of regulations were tried as the Georgia Strait sport fishery collapsed, but none reversed the decline

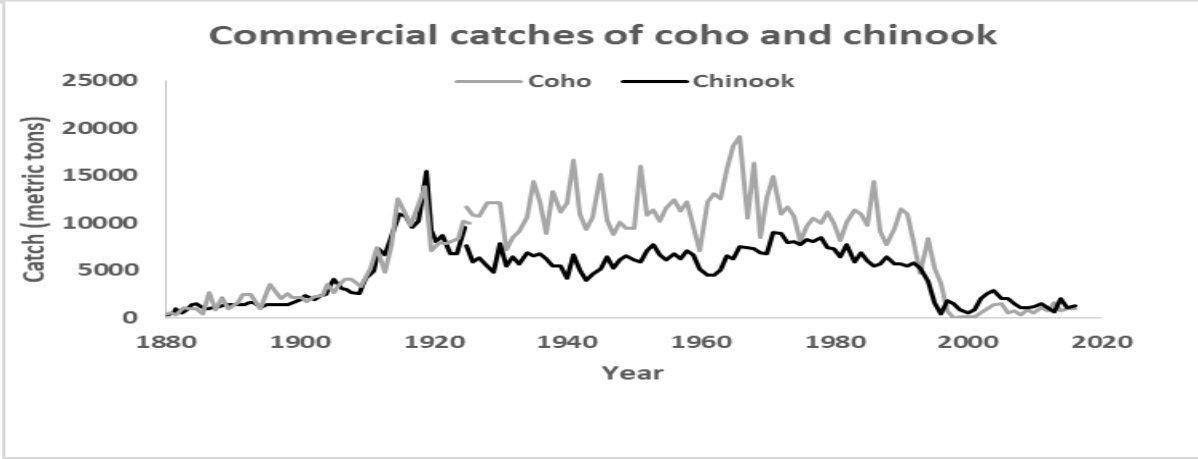


Walters and Martell 2004

Why I finally became suspicious: Peter Olesiuk's papers showing current pinniped population size is far larger than "natural"

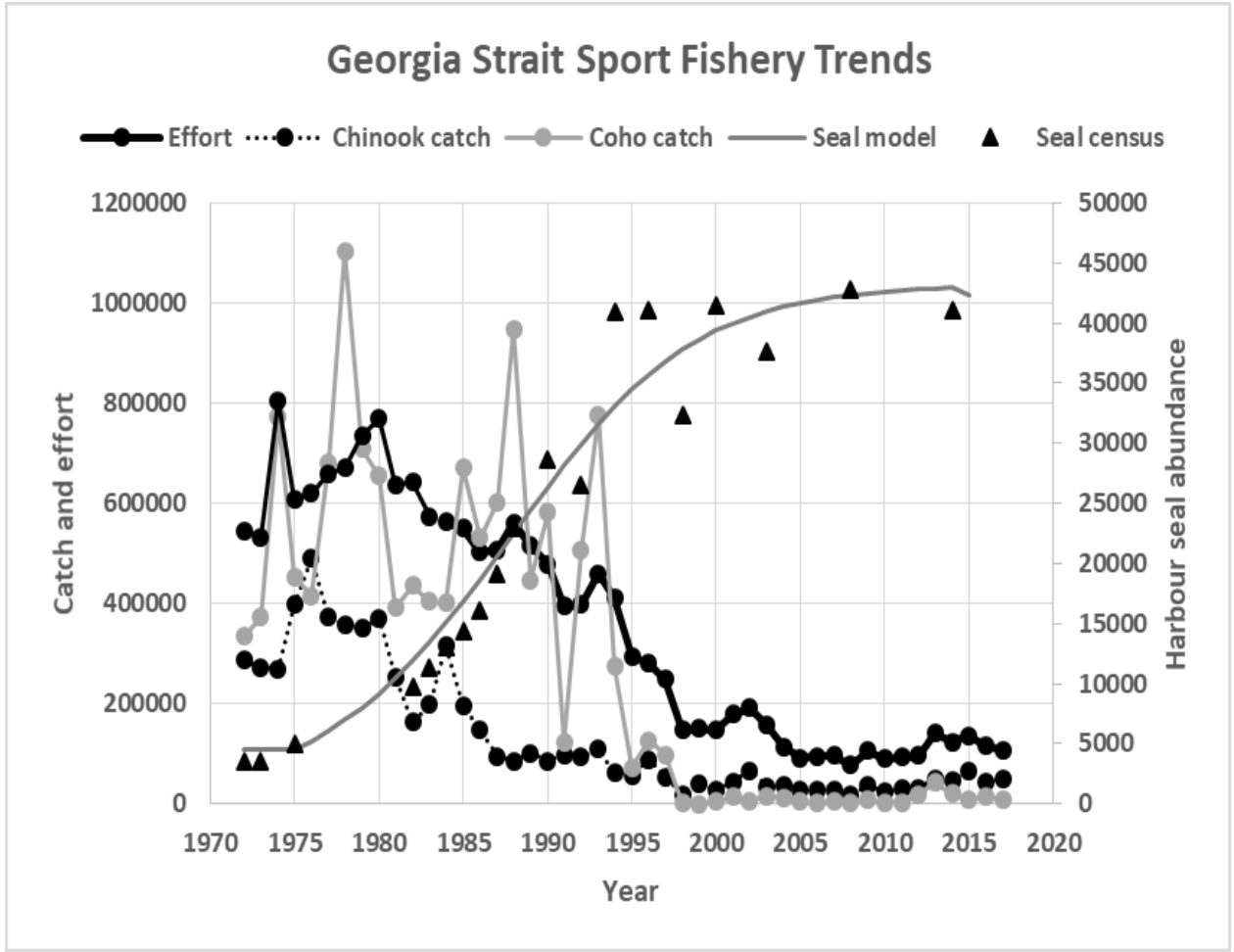
Steller sea lions now consume about 300,000 tons of fish per year, greater than the catch of all B.C. fisheries combined

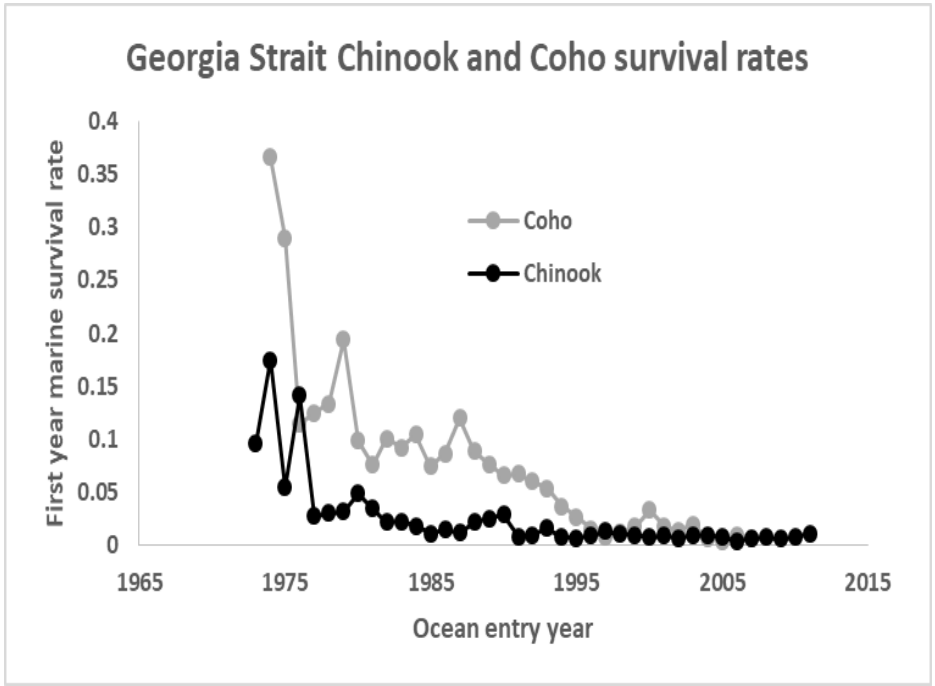




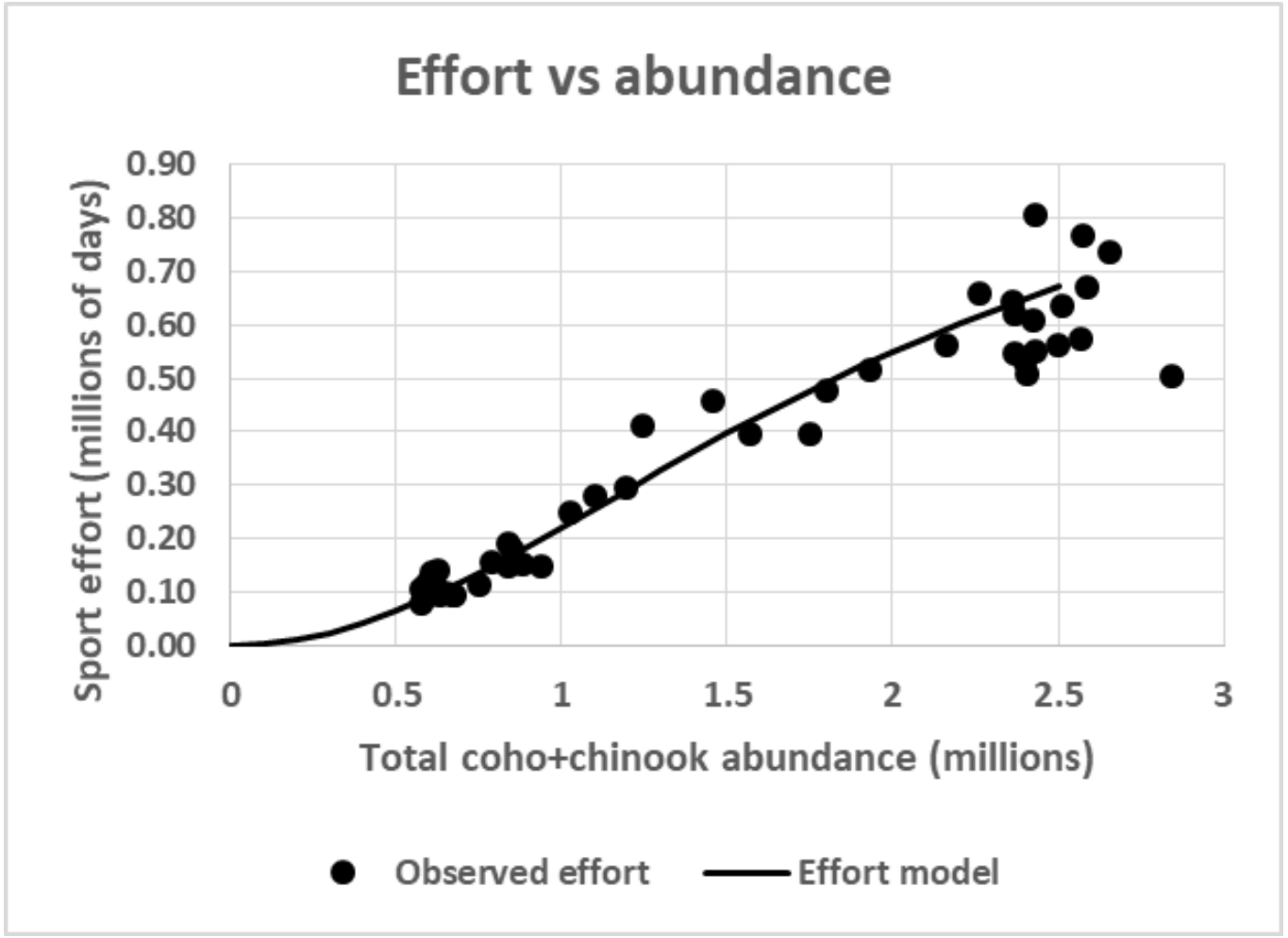
Argue and Shepard (1958) commented on low chinook and coho catches by the early fisheries

Georgia Strait chinook and coho salmon: fishery collapse was due to declines in juvenile survival rates, first ocean year: this was one of B.C.'s most valuable fisheries!

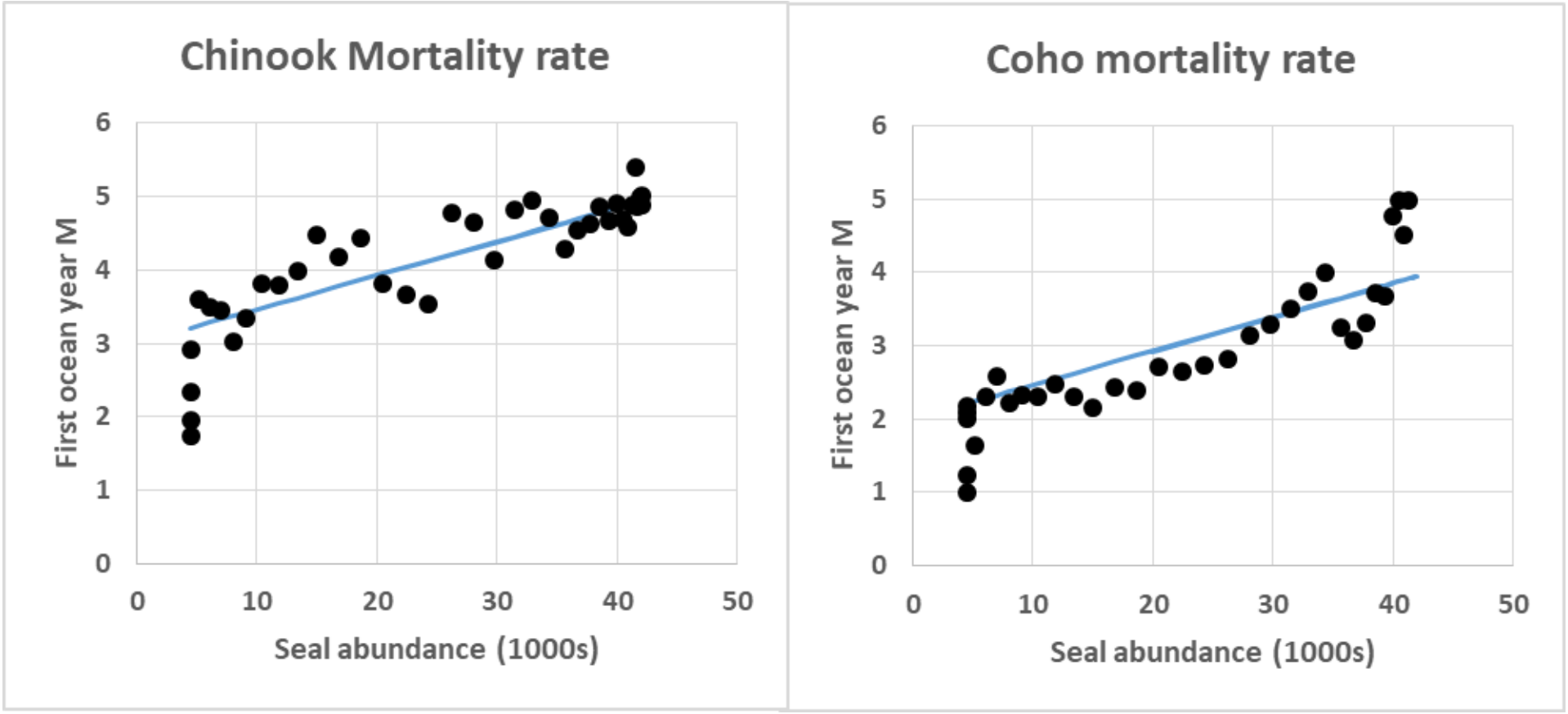




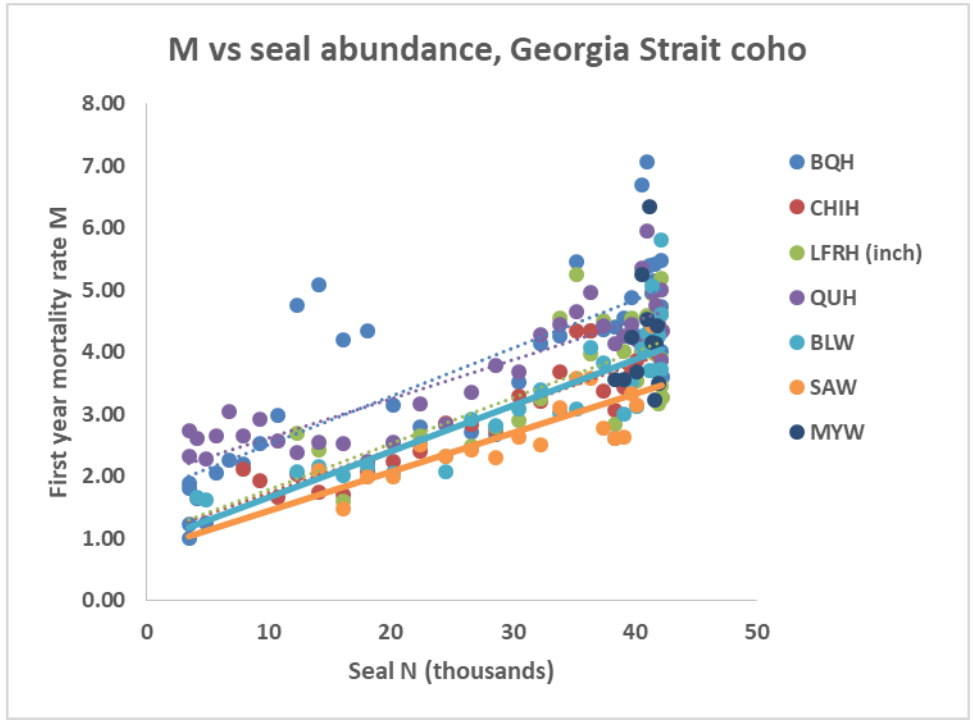
Sport fishing effort in the Georgia Strait has responded very strongly to changes in chinook and coho abundance, as is typical for sport fisheries

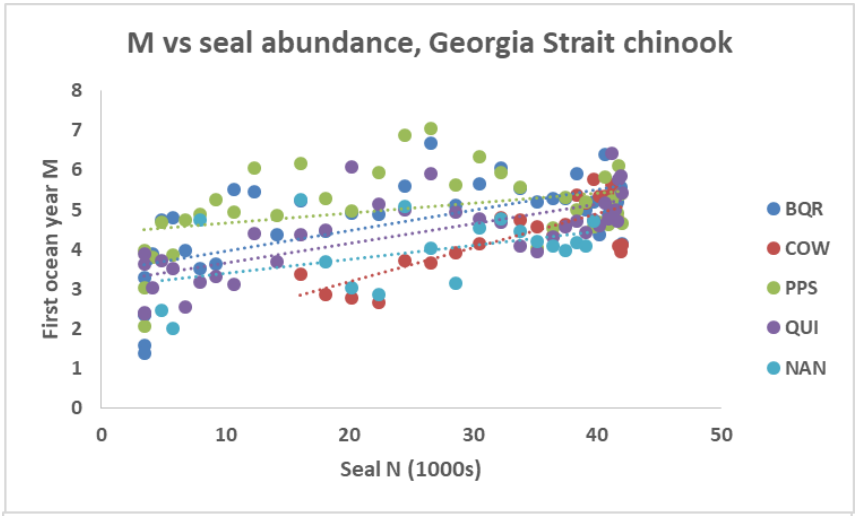


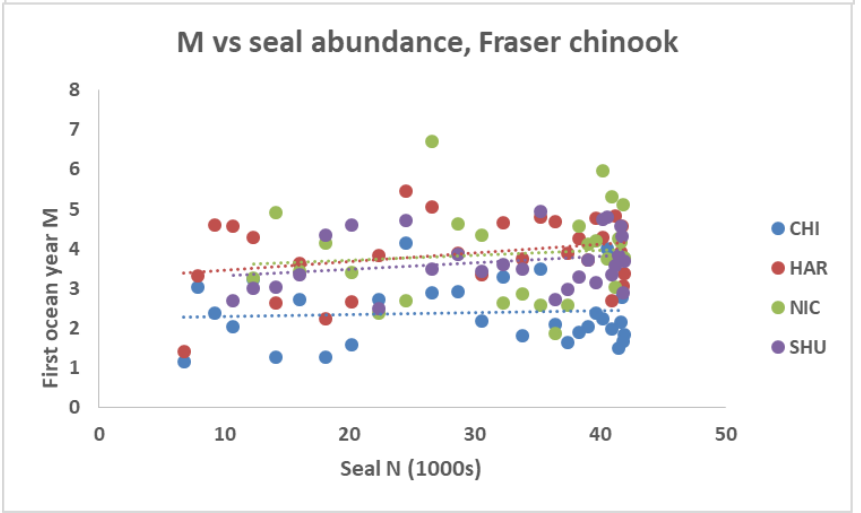
Chinook and coho first ocean year mortality rates from tagging (CWT) data: strongly correlated with seal abundance, regression slope predicted correctly from consumption estimates based on seal diet data



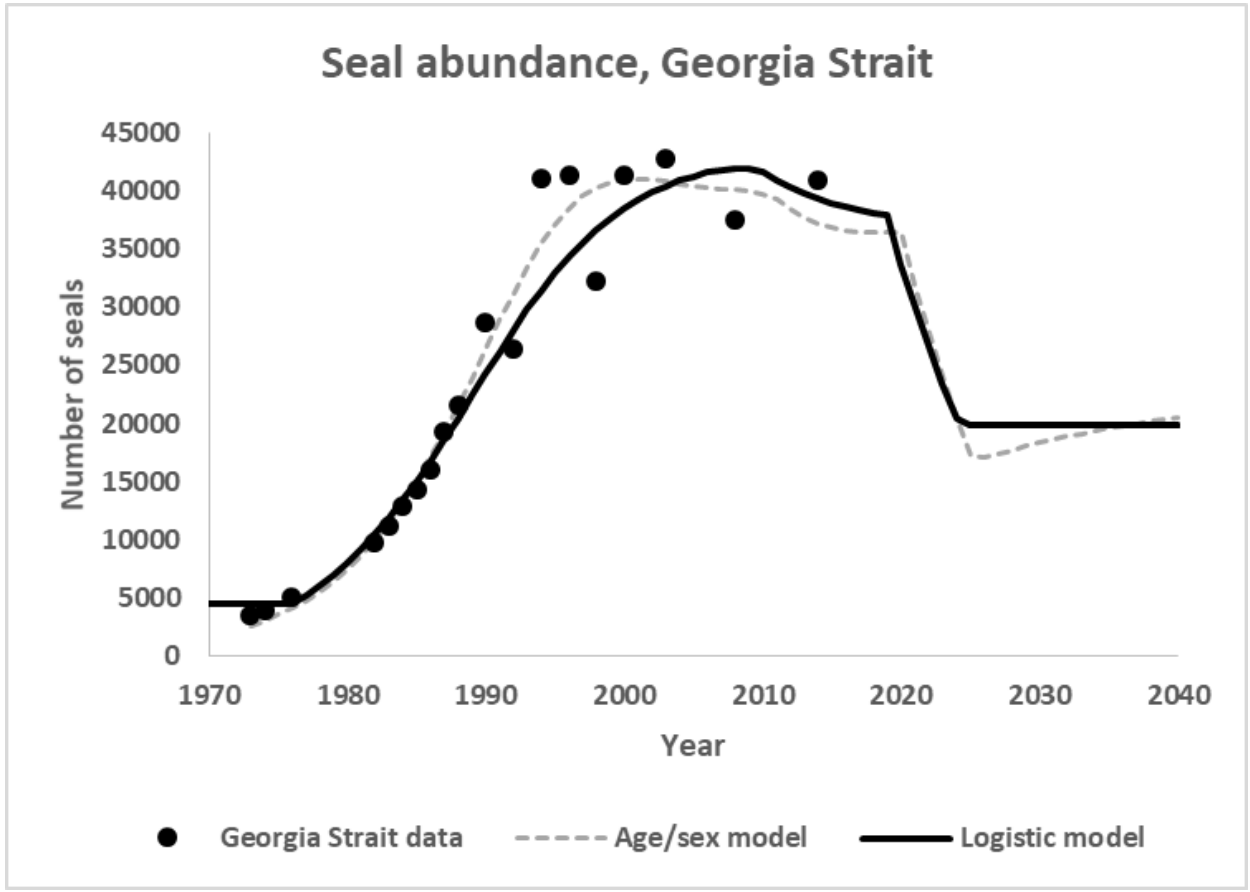
A source of concern has been that the correlation pattern is much weaker and more variable for chinook than coho (as are chinook life histories)





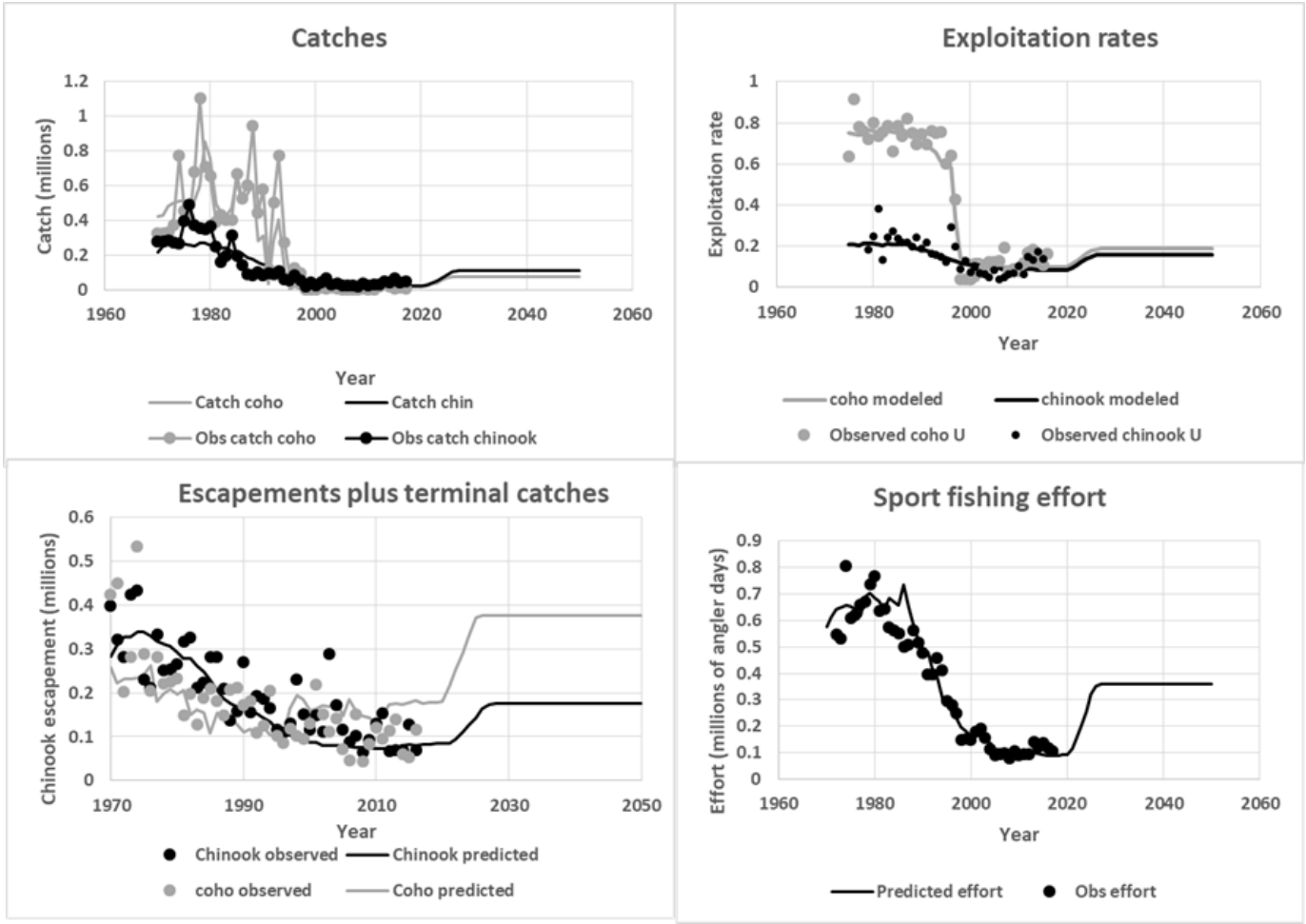


Proposed harvest of seals would reduce the Georgia Strait population by about 50%, then hold it at that (productive) level



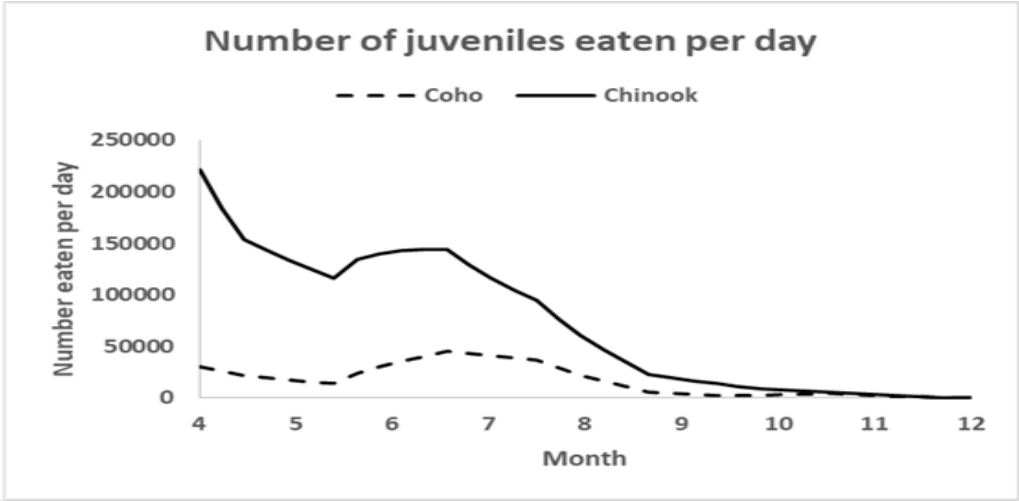
How much would the Georgia Strait fishery rebuild if seal abundance were reduced by 50%?

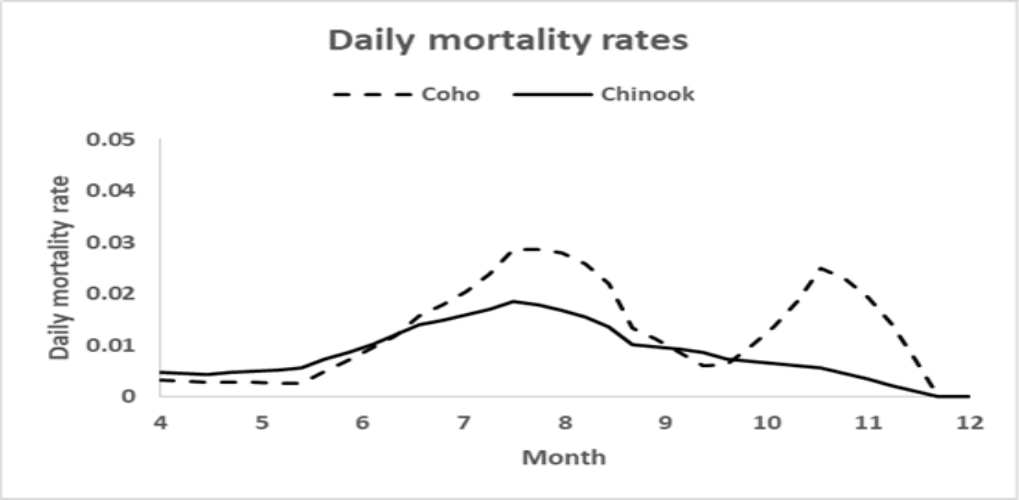
- Fit a production model to historical data, then projected forward
- Prediction is for modest recovery in catches, substantial recovery in fishing effort



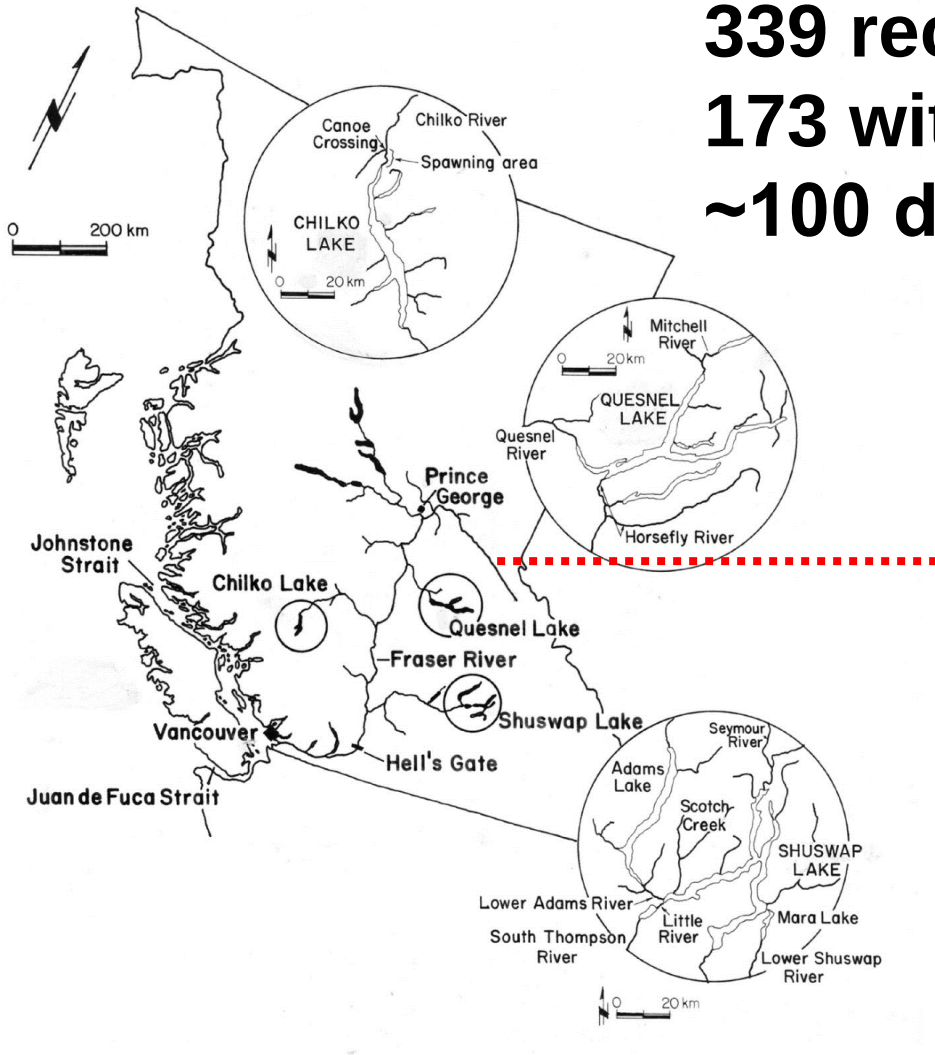
Would it help to just cull “problem seals” in estuaries?

- NO WAY. Diet data and survival analysis indicate that the mortality is spread over several months of the chinook and coho first ocean year
- This is a “lose-lose” policy option: it would be hugely unpopular, and would not solve the problem





Fraser Sockeye: a wonderfully diverse production system



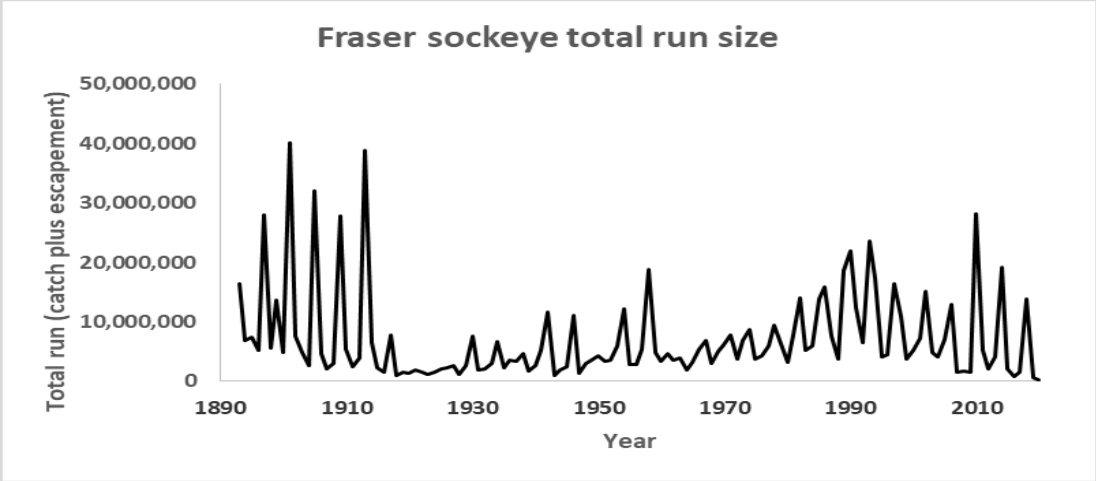
339 recognized spawning areas
173 with 10+ yrs data
~100 distinct “stocks”

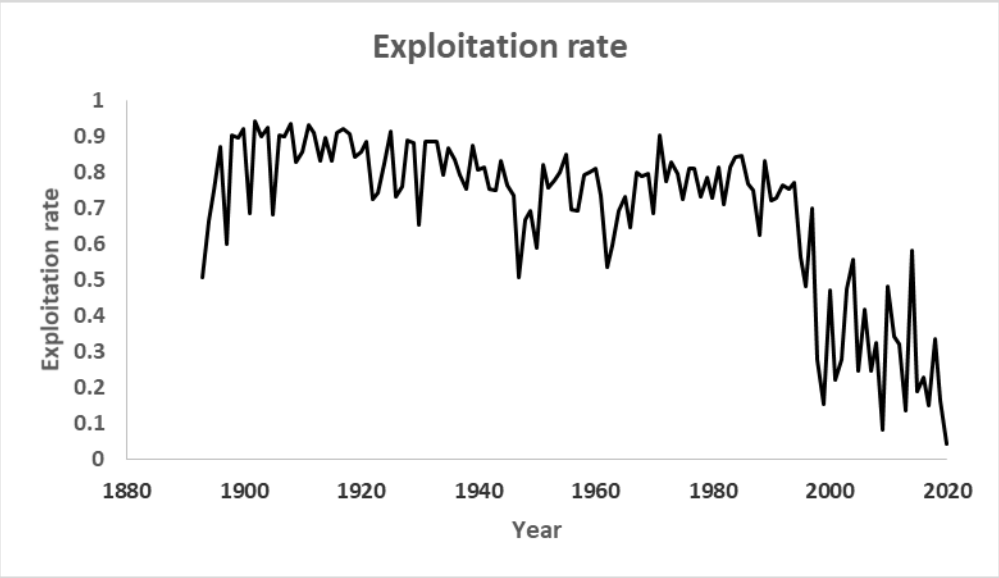
September spawning

October spawning

Decline in stocks vs decline in the fishery: DFO has cut harvest rates severely since 1995, due to concerns about pre-spawning mortality and protection of weak stocks

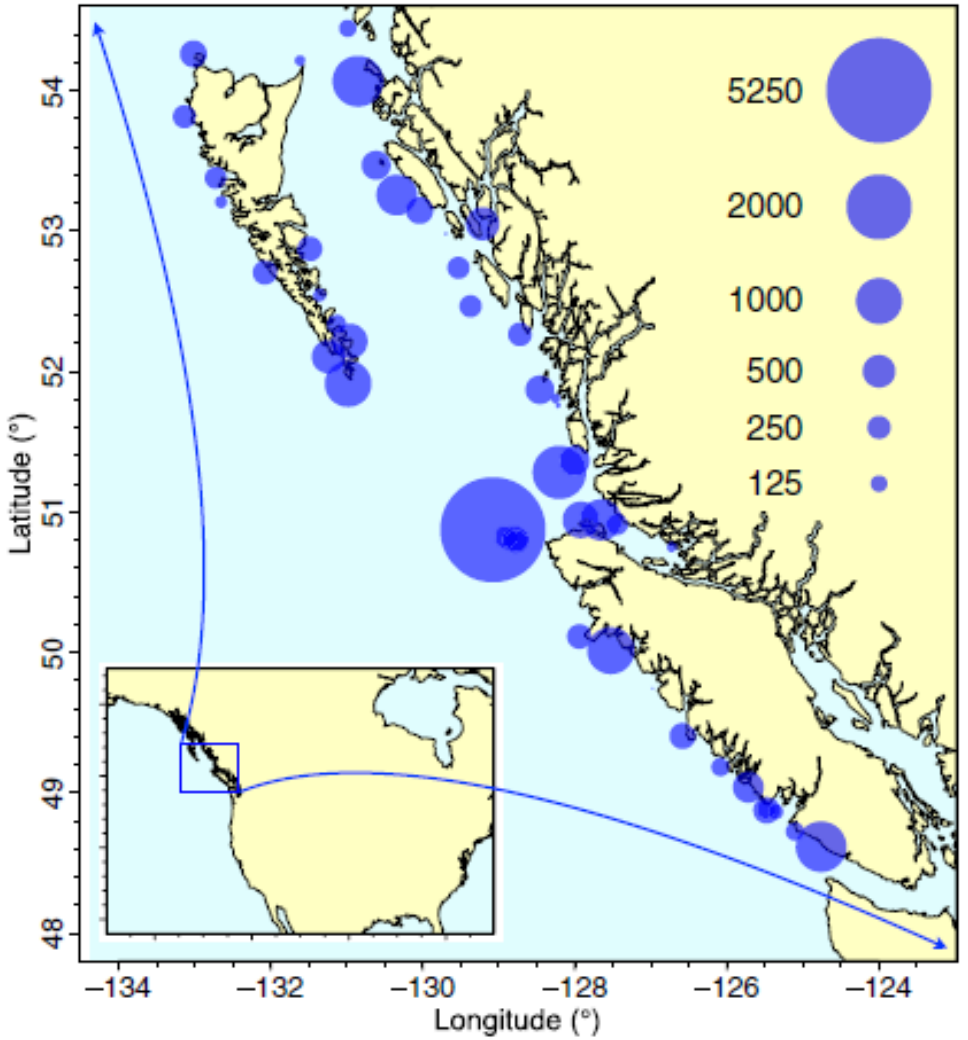
- System has returned to historical pattern of only one big year every four years
- Low years are getting progressively lower relative to big years, i.e. survival rate is getting lower for years of low spawner abundance, despite fishery closures



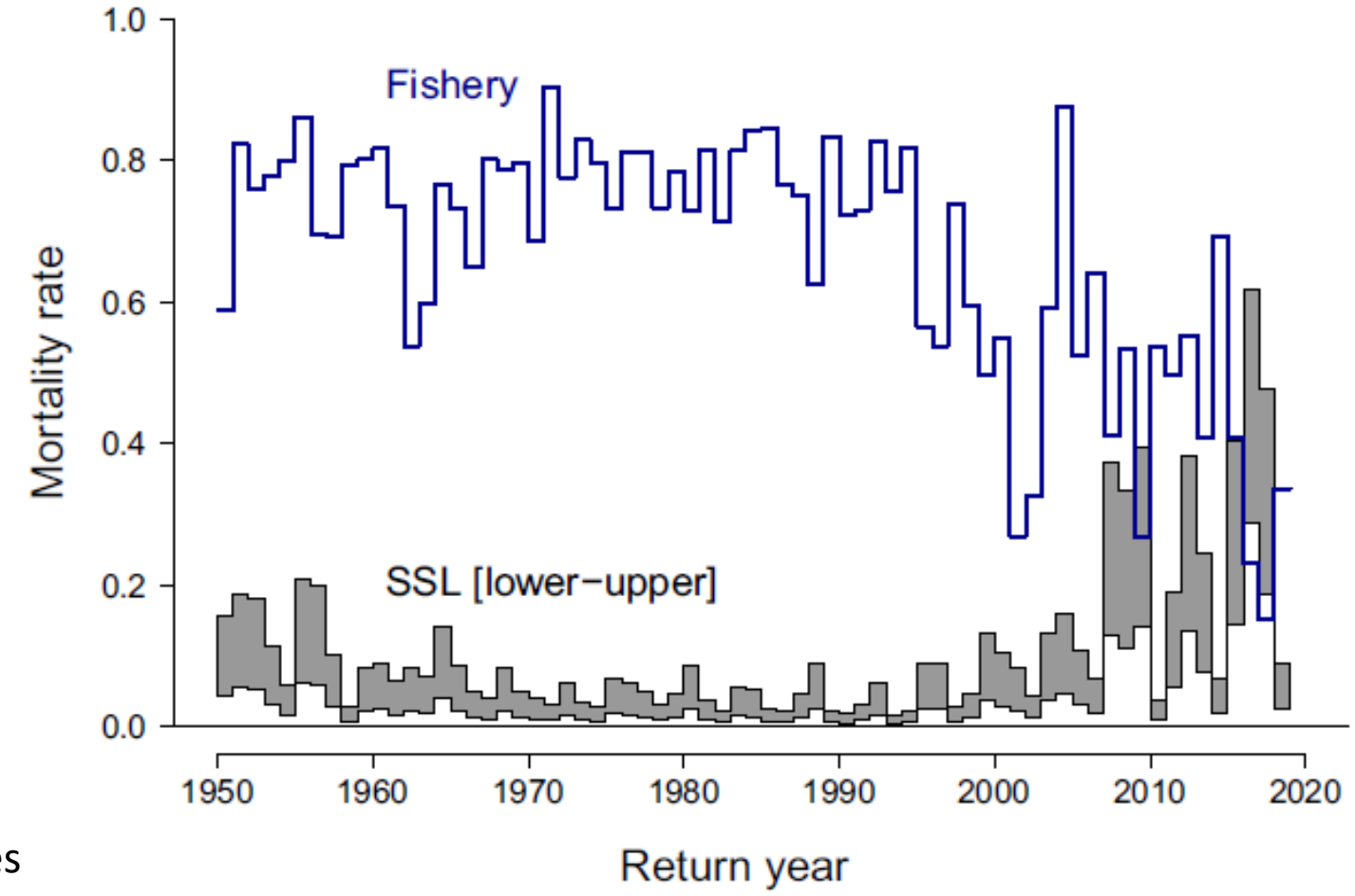


134 years of data on catches and 80 years of data on spawning runs

Returning adult sockeye pass near the largest Steller sea lion concentrations in B.C.



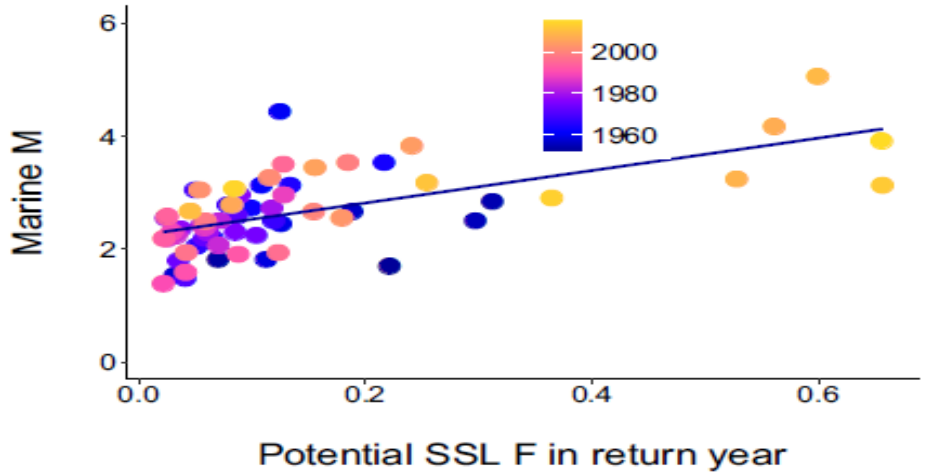
Direct estimates of potential sockeye consumption by sea lions now imply predation mortality rates as high or higher than the fishing mortality rate

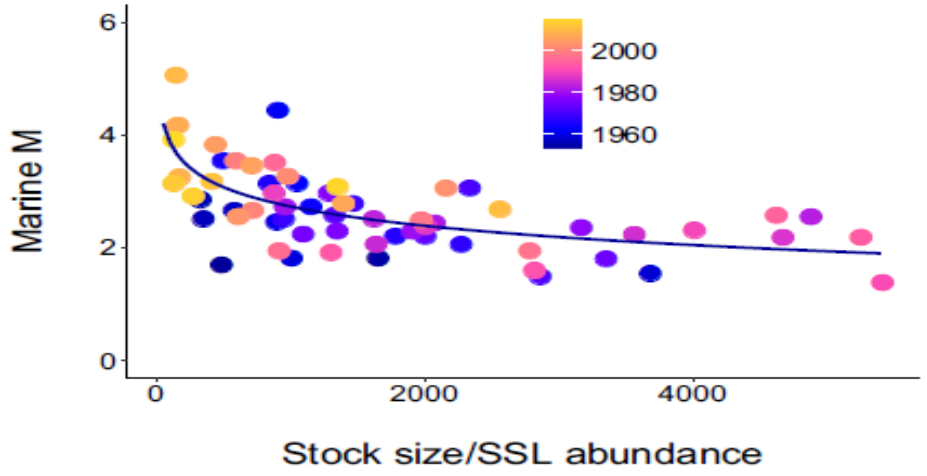


Walters et al 2020 Fisheries

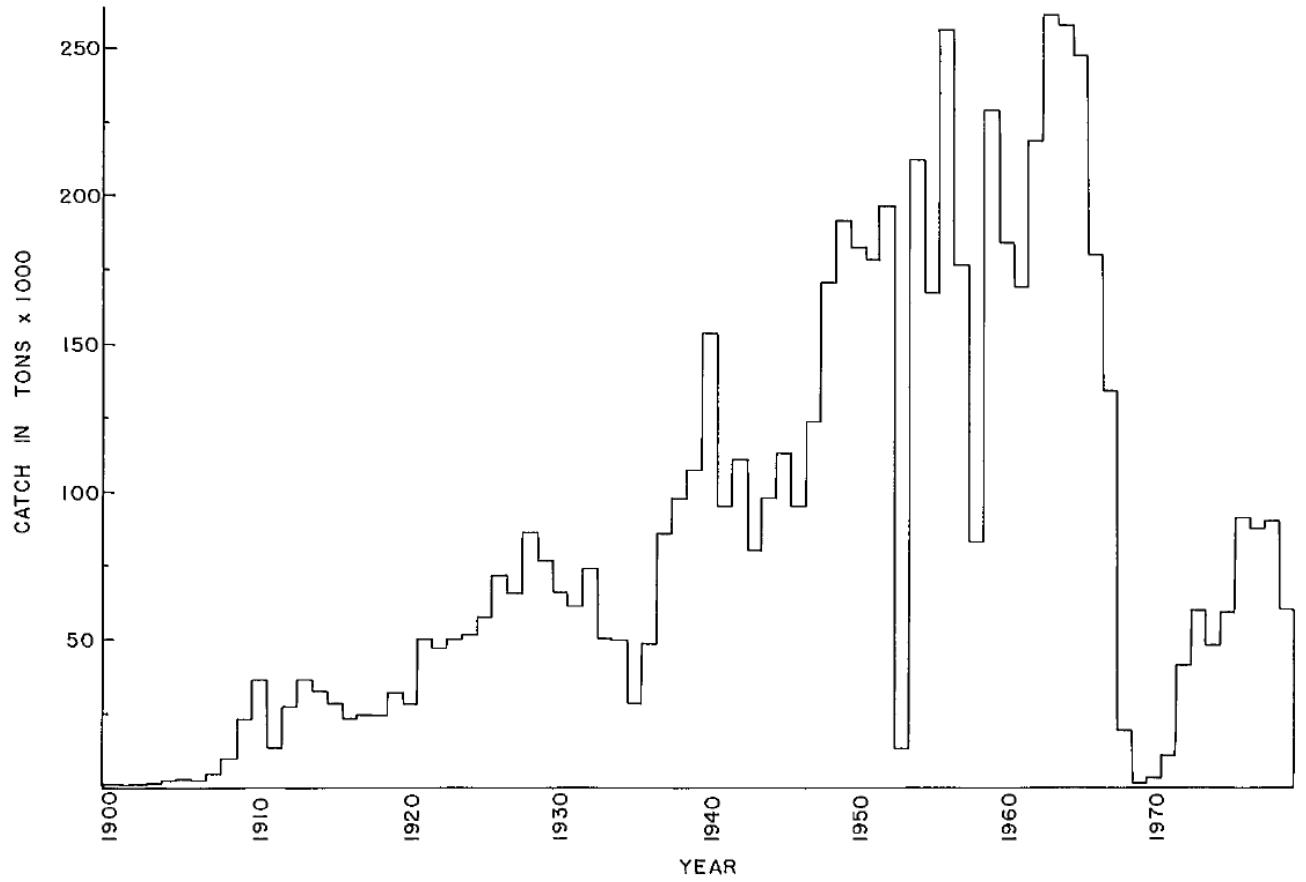
For Chilko sockeye, there is direct evidence of "depensatory" increase in marine mortality rate (M) for years of low smolt abundance

Warning: these mortality rate (M) estimates include high mortality rates during downstream migration in the Fraser River





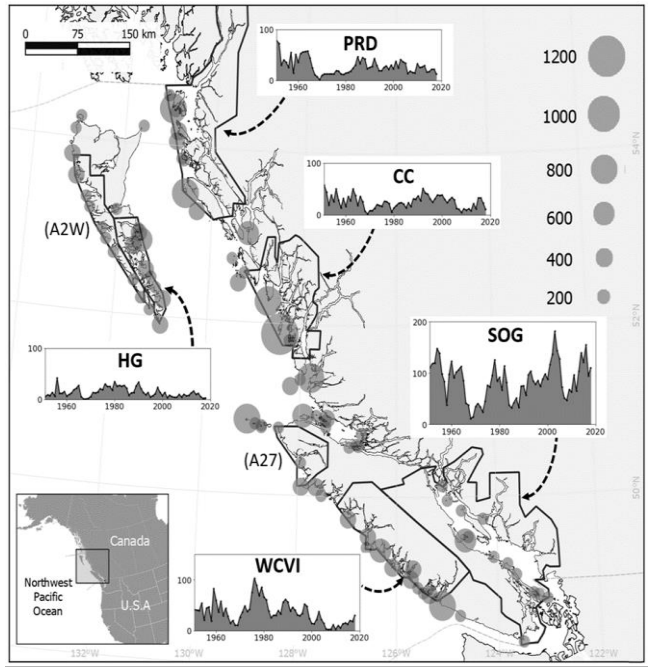
B.C. Herring fishery history: overfishing by 1960s led to collapse, then rapid recovery after closure

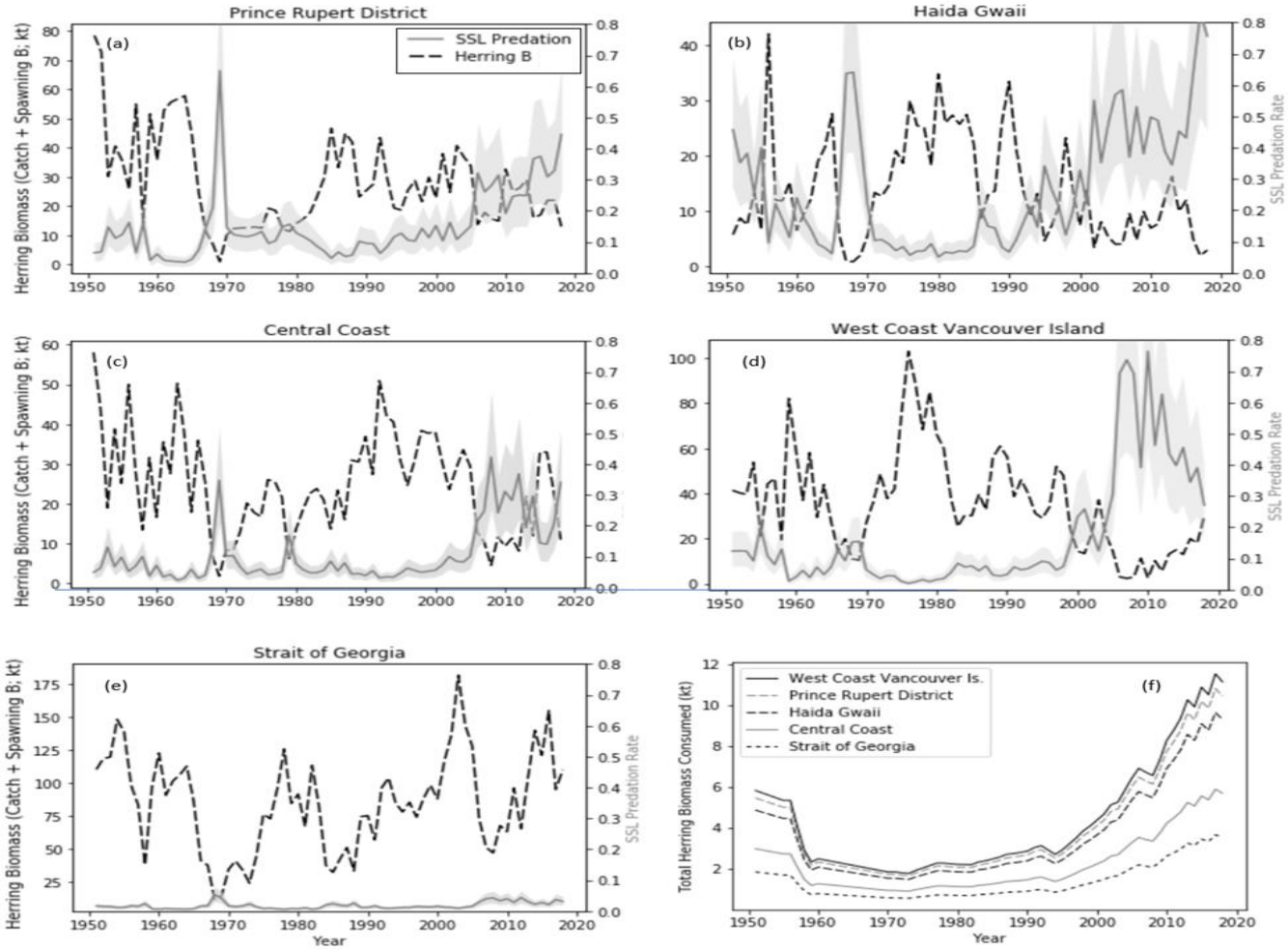


Things were looking good as of 1980 when Hourston published this graph

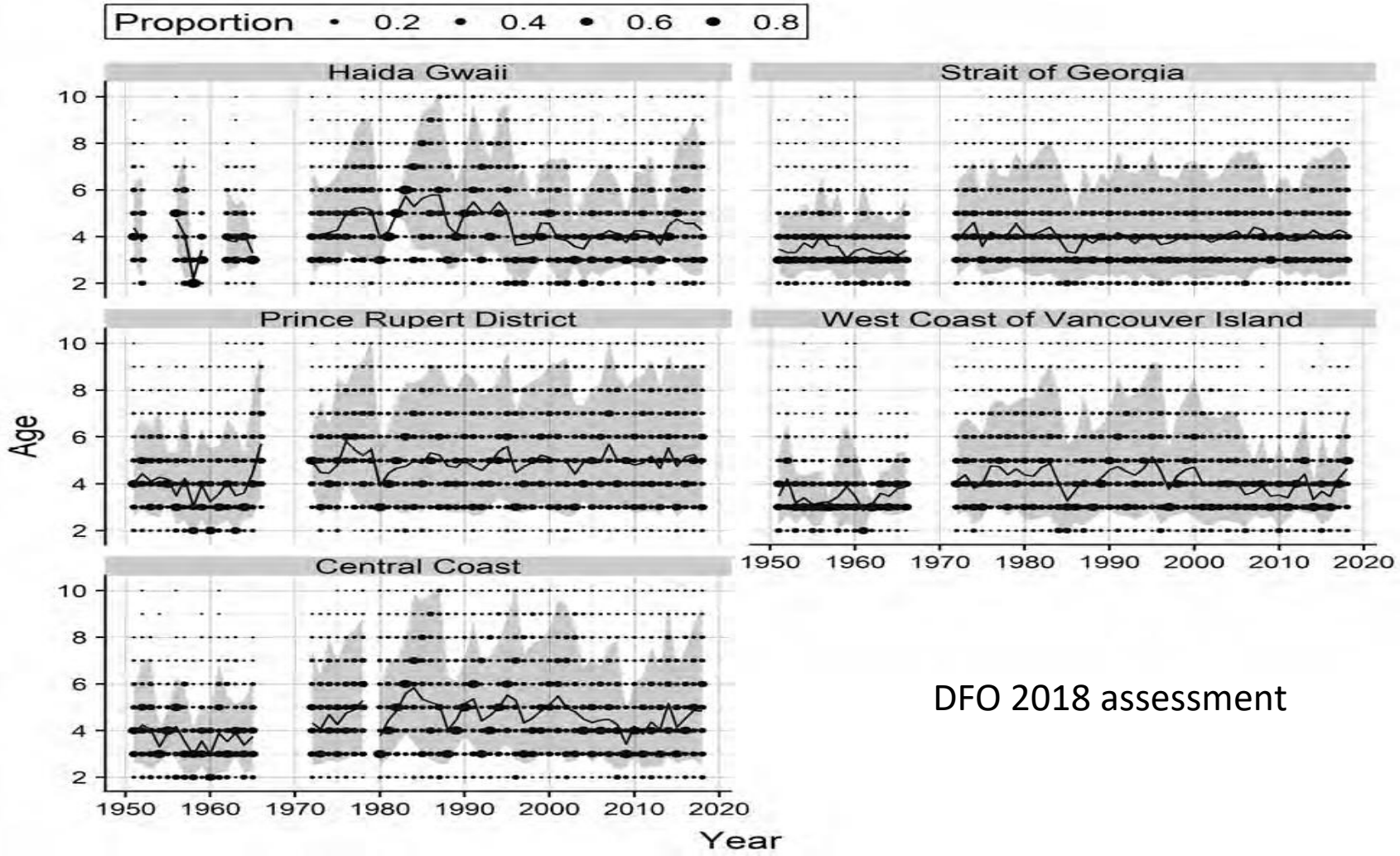
Hourston and Haegele. 1980. herring on Canada's Pacific Coast

Herring collapses after 1990: due to increasing natural mortality rate in three areas of highest sea lion winter abundance





Changes in herring natural mortality rates are obvious in age composition data: loss of older fish even after fisheries have been closed



DFO 2018 assessment

Conclusions

- There are three basic policy options
  1. Adopt radically precautionary harvest policies
  2. Include regulation of marine mammal abundances as we would any fishery
  3. Restore the traditional First Nations mammal harvesting system
- DFO has adopted the first strategy, blaming stock declines on factors like climate change
- The second strategy could involve culling, an extremely unpopular and unnecessary choice
- There are active proposals for the third strategy, which DFO has now been sitting on for almost two years
- What we need now for the Georgia Strait is NOT more data, it is a bold management experiment

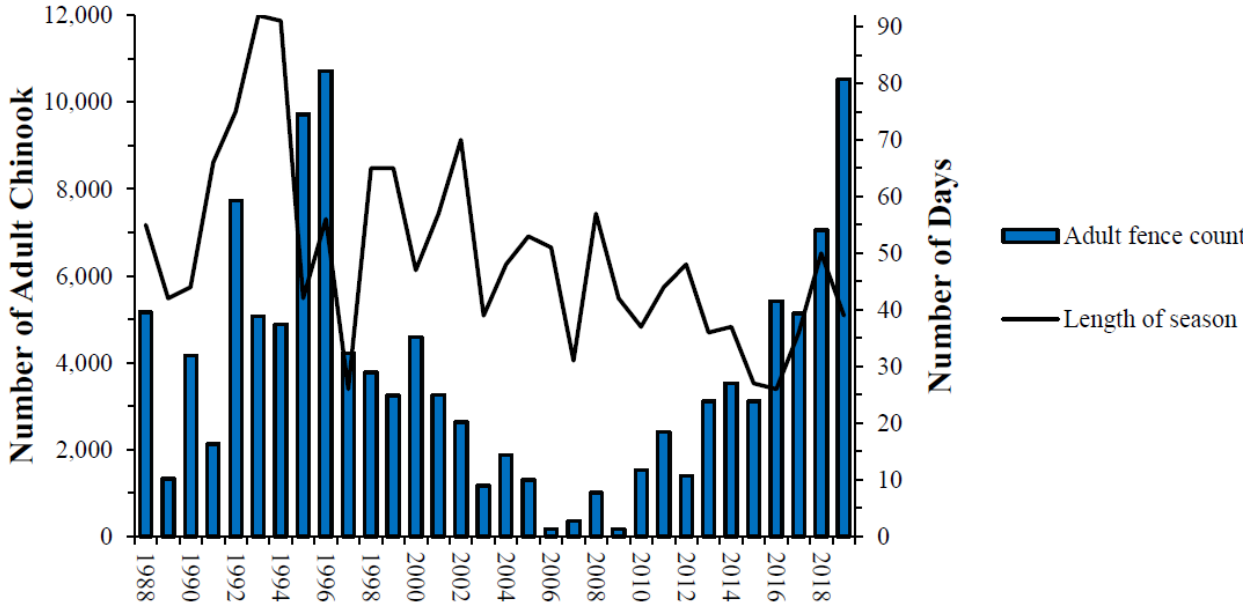
A question for the public fishery: would fishermen be willing to provide financial assistance to First Nations hunters during the first few years of pinniped harvesting?

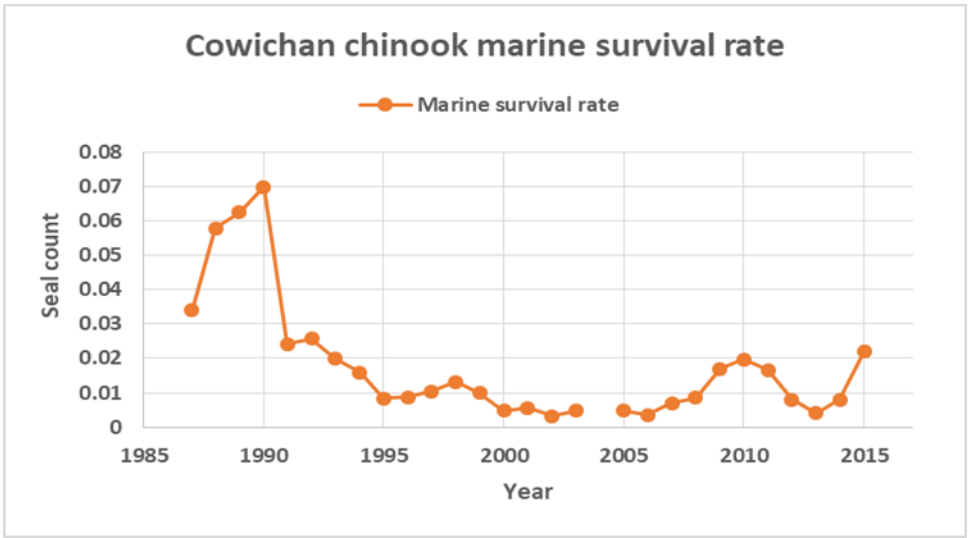
- The pinniped fishery may initially be unprofitable due to limited development of markets for seal products
- It may be necessary to initially provide an economic incentive of around $50/seal to cover harvesting costs, totaling $500,000/year for a few years
- This incentive or subsidy could easily be paid through a voluntary sport license price add-on of around $5.00 per license holder, if half of tidal license buyers (100,000) were willing to contribute.

A few extra bits of information

What about Cowichan chinook?

- Escapements have increased dramatically since 2008
- Marine survival rates have also improved, but apparently not enough to explain such a big increase in escapement
- Smolt numbers may have increased also: habitat improvement effect?

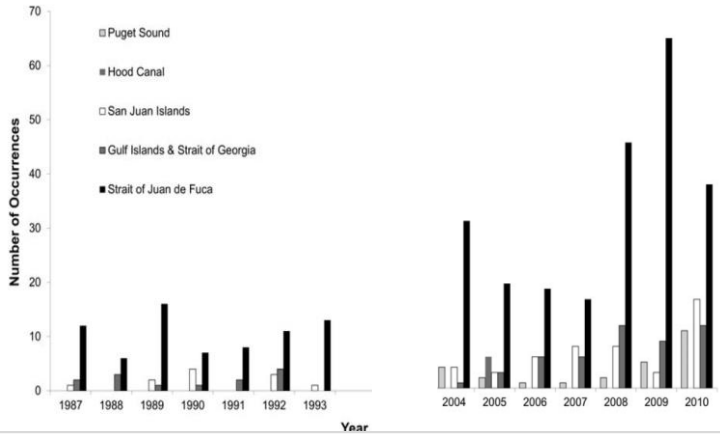


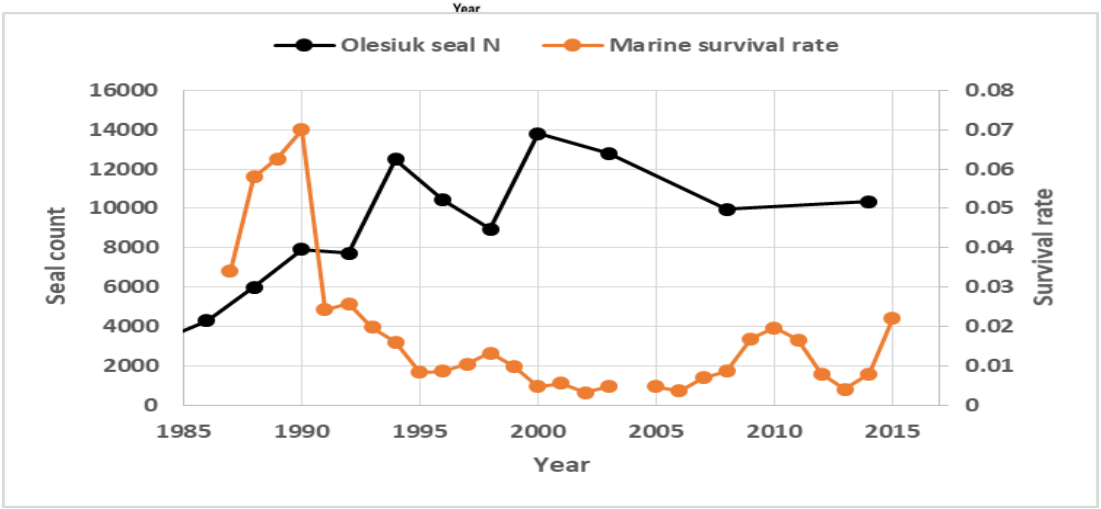


What about Cowichan chinook?

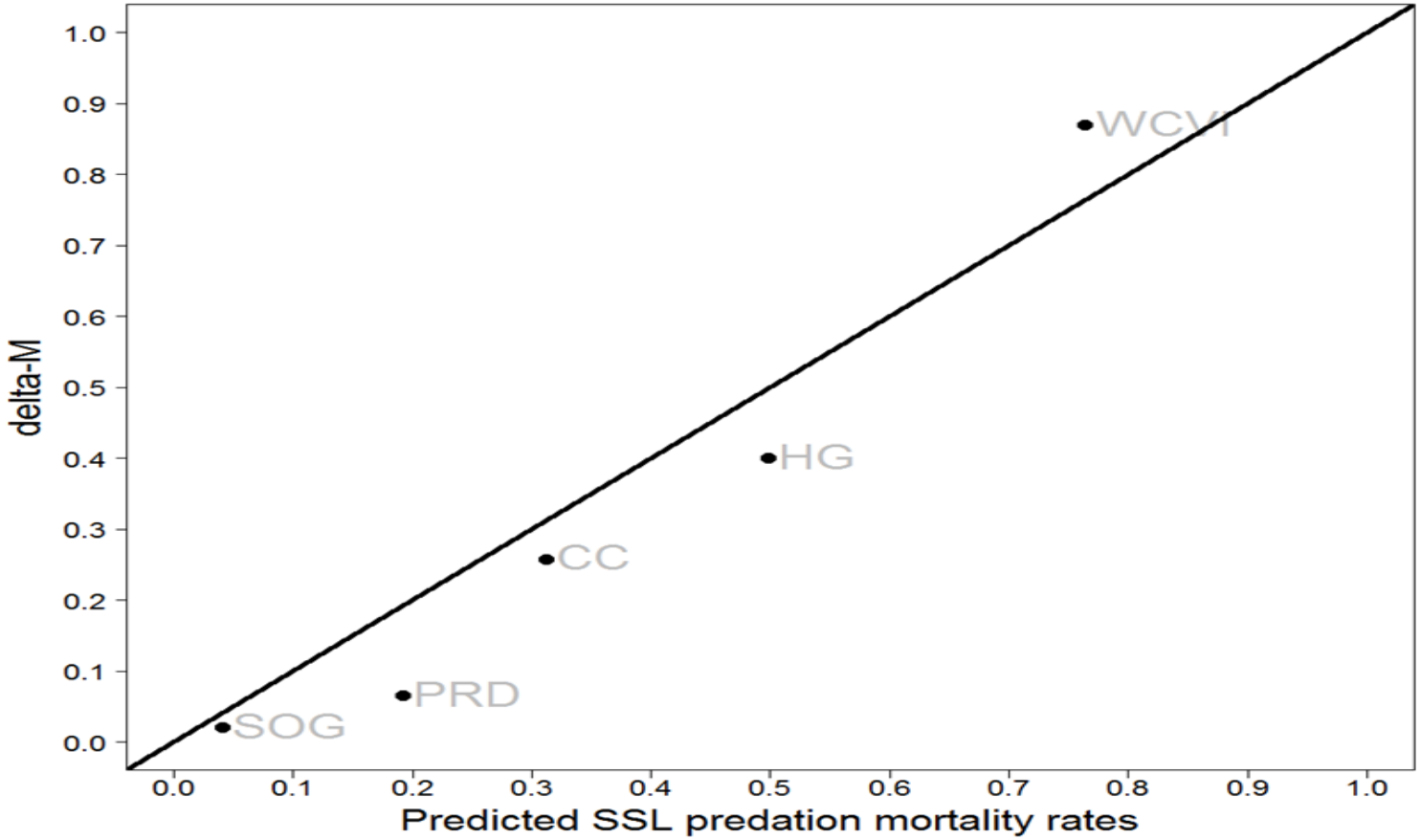
- Transient killer whale sightings increased dramatically around 2008, coincident with survival rate improvements
- Transients sometimes search along the shore, specifically targeting seals
- There was a large drop in seal haulout counts (2004-2014) within the Gulf Islands, where Cowichan chinook juveniles are concentrated
- This suggests that the whales have “protected Cowichan chinook juveniles from seal predation

Transient killer whale sightings (from Houghton et al 2015)

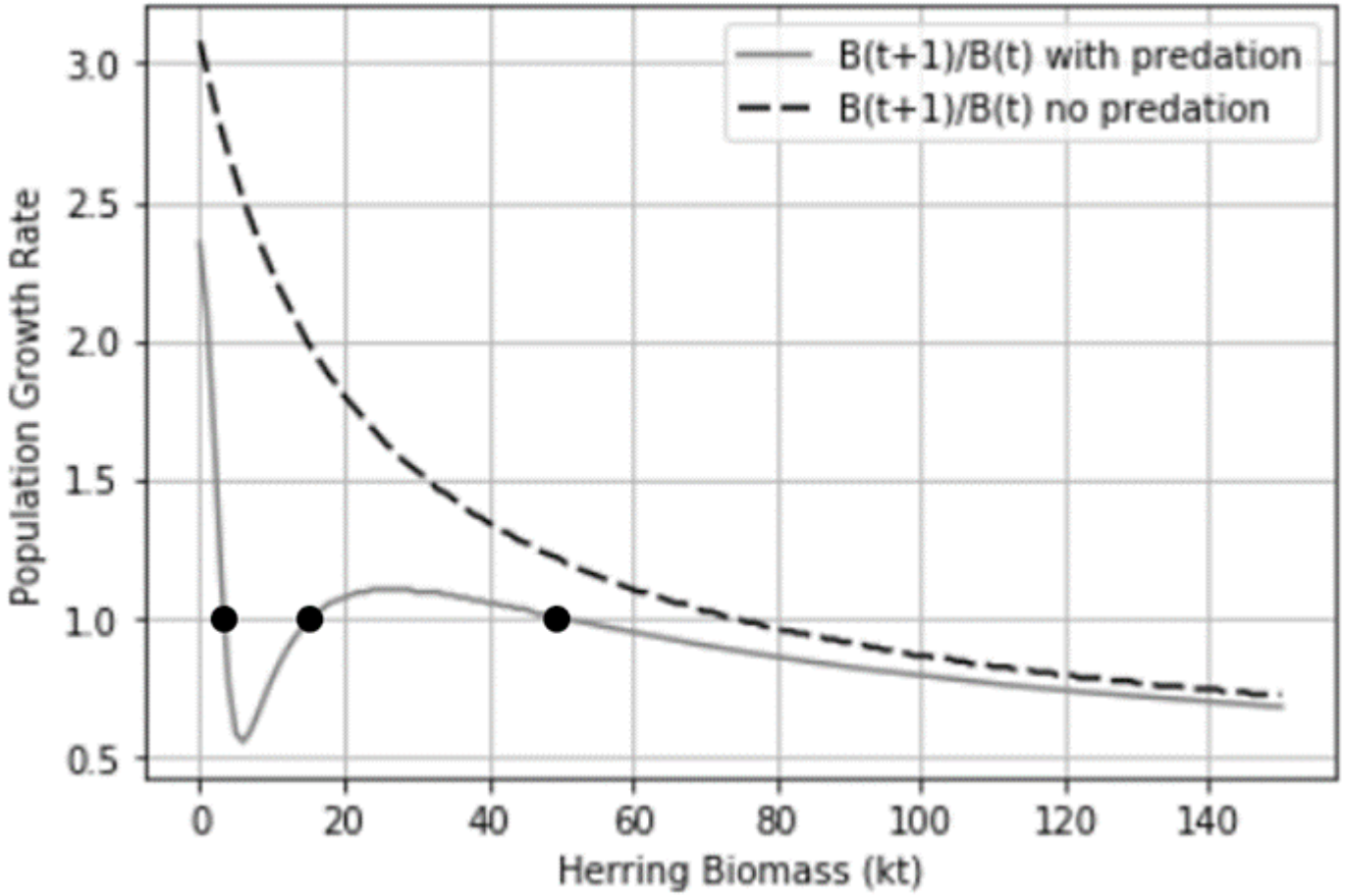




Regional changes in herring natural mortality rate estimated from the age composition data are close to those predicted from Steller sea lion abundance and consumption estimates



Depensatory predation on herring can cause fundamental changes in the production-biomass relationship for exploited populations



Depensatory predation can cause fundamental changes in the production-biomass relationship for exploited populations, creating a “cusp catastrophe” structure in the dynamics