Looking back to go forward: Do past management actions foreshadow management responses to climate change?

PICES

Laura J. Richards, Robin M. Brown,
James Christian and Jake Rice

Fisheries and Oceans Canada | Pêches et Océans Canada

Central Question:

How might fisheries management agencies respond to climate change impacts on local or regional resources?

Talk outline

- How are fish stocks assessed and fisheries managed?
  - Factors considered in fish stock assessment
  - Examples of past management actions to respond to changes in fish stock availability
- What lessons (learning opportunities) from past successes/failures might be applied to climate change?
- What tools might help adaptation to climate change?

Fisheries management:

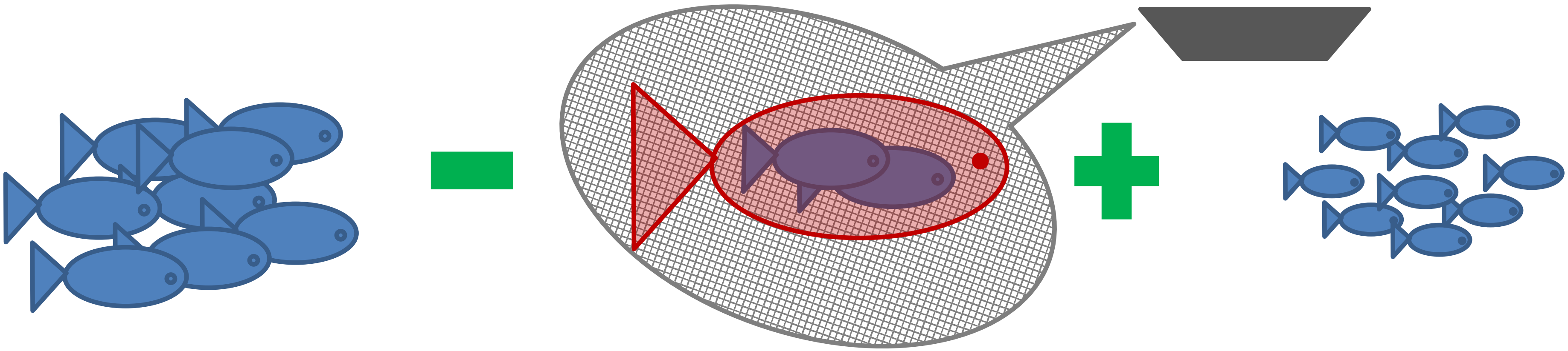
The integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities in order to ensure the continued productivity of the resources and accomplishment of other fisheries objectives.

FAO (1997) Technical guidelines for responsible fisheries

"… the fundamental purpose of fishery management is to ensure sustainable production over time from fish stocks, preferably through regulatory and enhancement actions that promote economic and social well-being of the fishermen and industries that use the production."

Hilborn and Walters, 1992, Quantitative Fisheries Stock Assessment Choice , Dynamics and Uncertainty.

Stock assessment basics



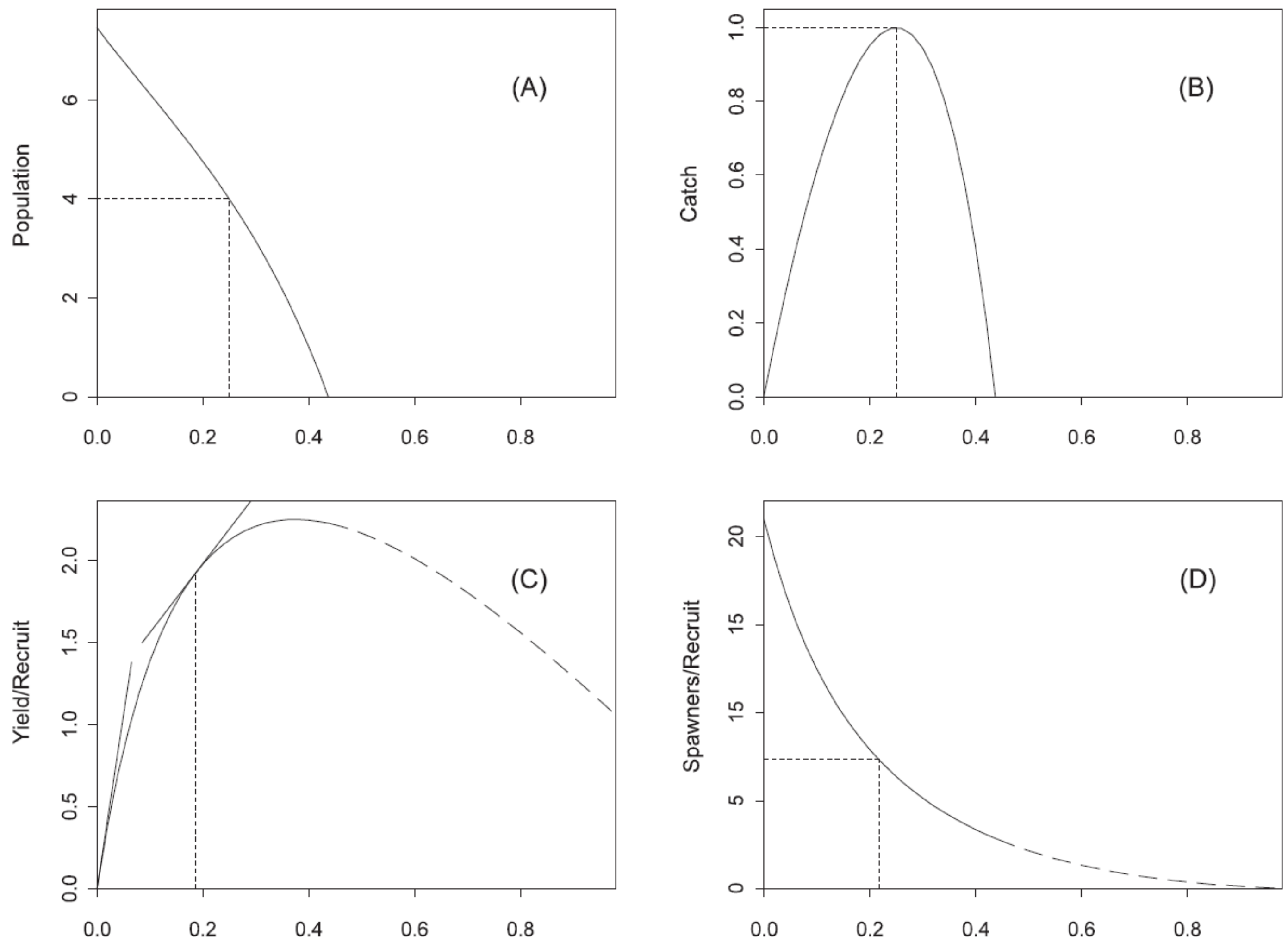
Population(t) = Population(t-1) – removals (natural mortality, fishing) + recruitment

Stock assessment aims to estimate

- Fish abundance
- How abundance has changed over time, particularly in response to fishing
- How abundance might change with alternative fishery management choices

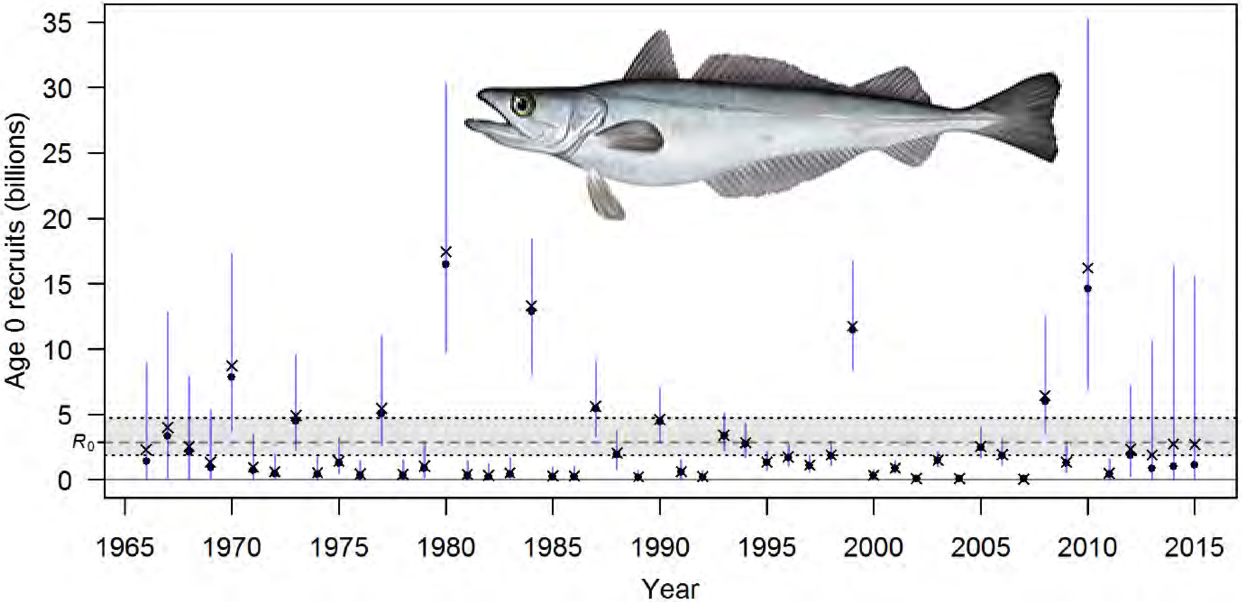
Model world: Stock assessment basics

under equilibrium conditions



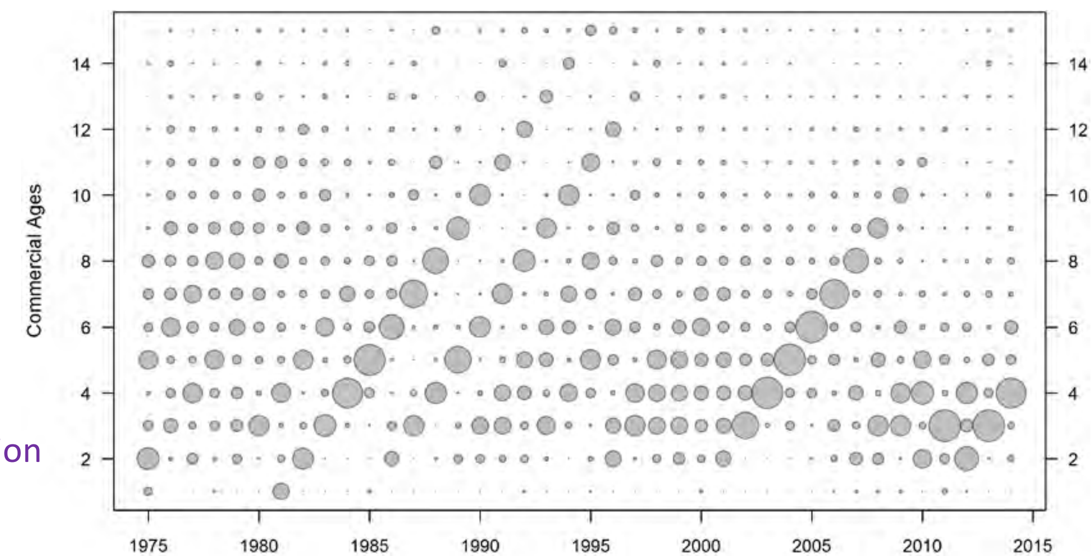
Schnute & Richards 1998 CJFAS 55

Real world: variation in recruitment



Pacific hake

Model estimates of age-0 recruits (top) and ages in the commercial fishery (bottom)



http://www.westcoast.fisheries.noaa.gov/publications/fishery_management/groundfish/whiting/2015-stock-assess.pdf

Fish abundance is expected to vary based on:

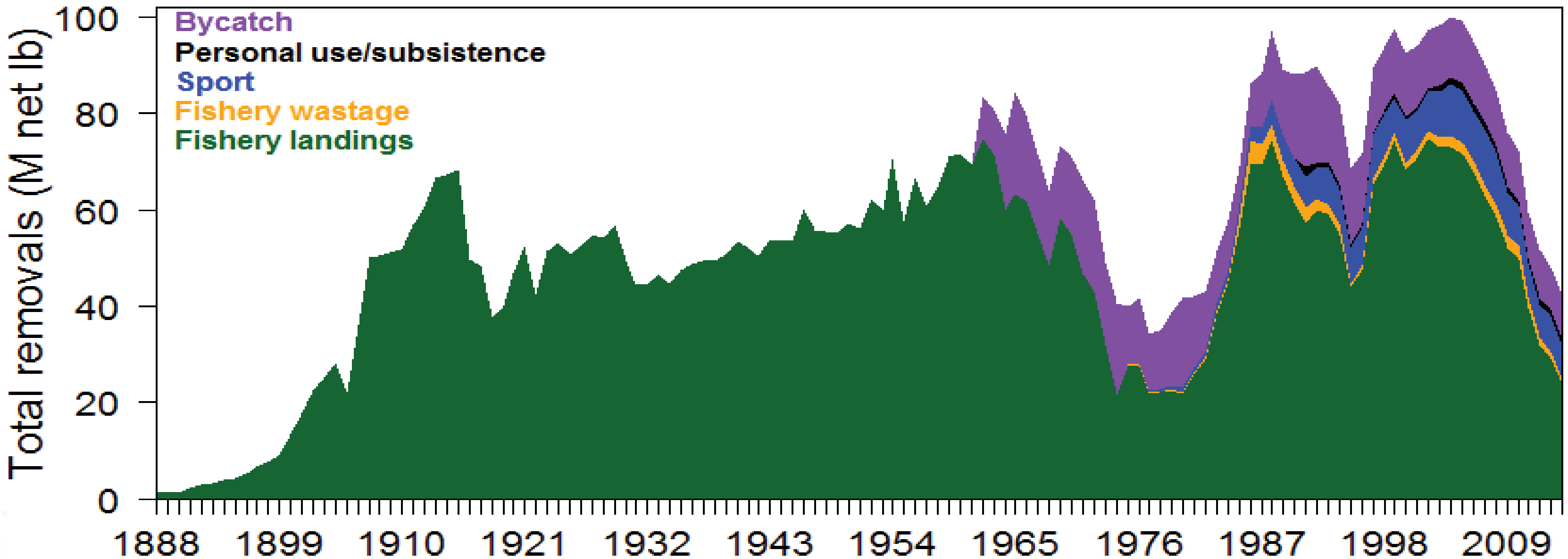
- current abundance and distribution
- catch history
- amount of recruitment
- fish biology (e.g. natural mortality)
- and many other factors

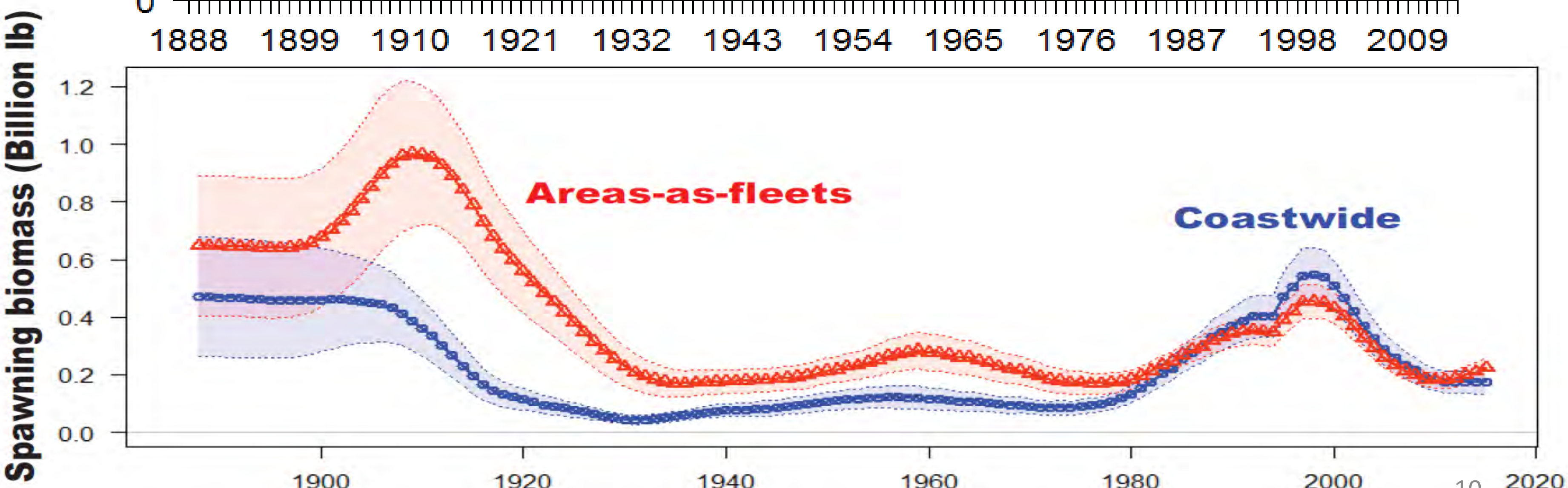
Fishing plans can be adjusted in response:

- e.g., reference points, targets, decision rules

… if variation is understood and the past is a reliable guide for the future.

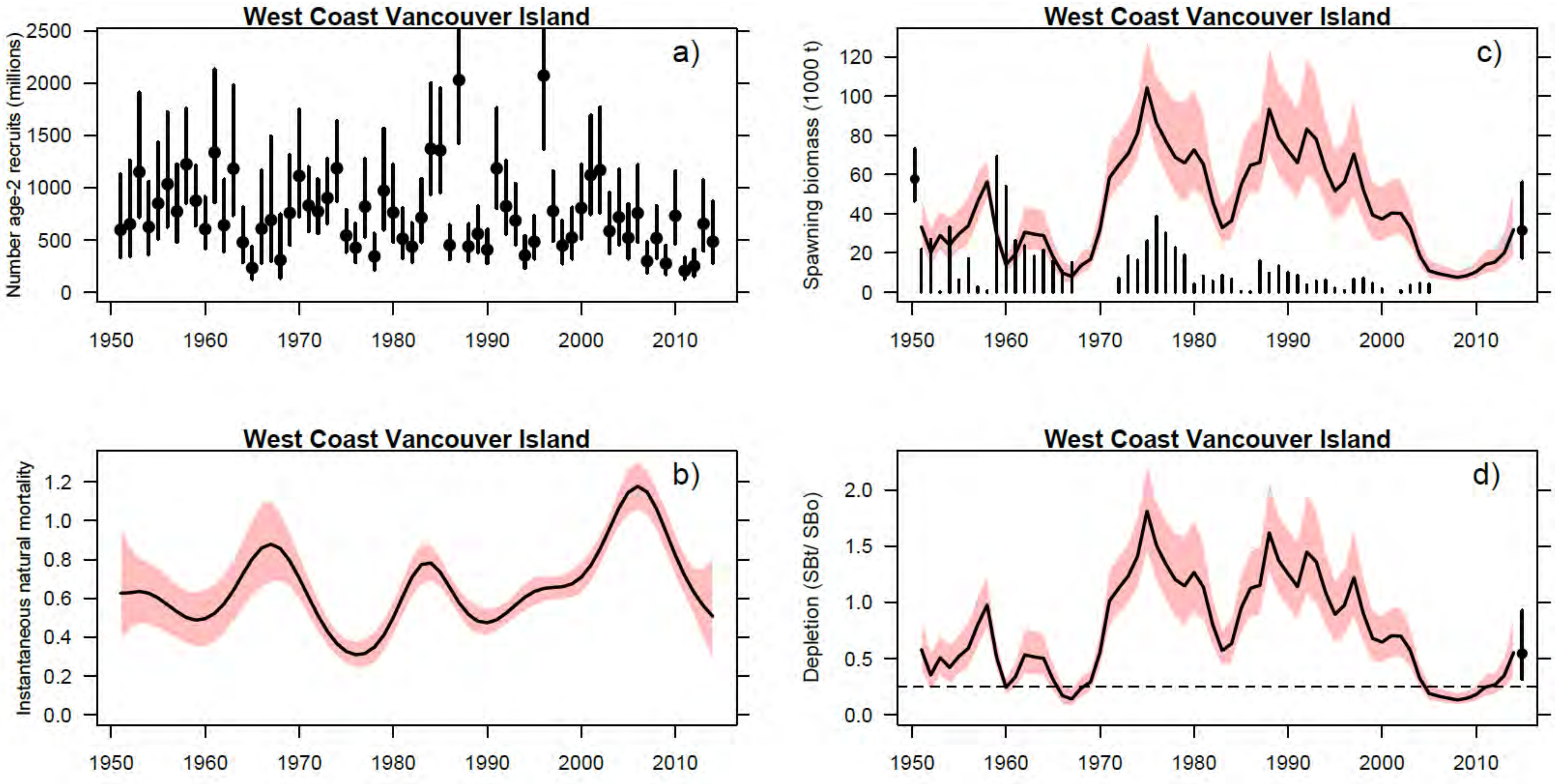
Pacific halibut managed by Canada and the US under treaty since 1923





IPHC 2015 bluebook; Photo NOAA

Pacific Herring management



DFO CSAS Sci Advis Rep 2014/060; Photo NOAA

Fish productivity can be affected by factors related to climate change through

- Change in spatial distribution
- Change in survival rates
- Change in recruitment of next generation
- Change in fish size
- … and others

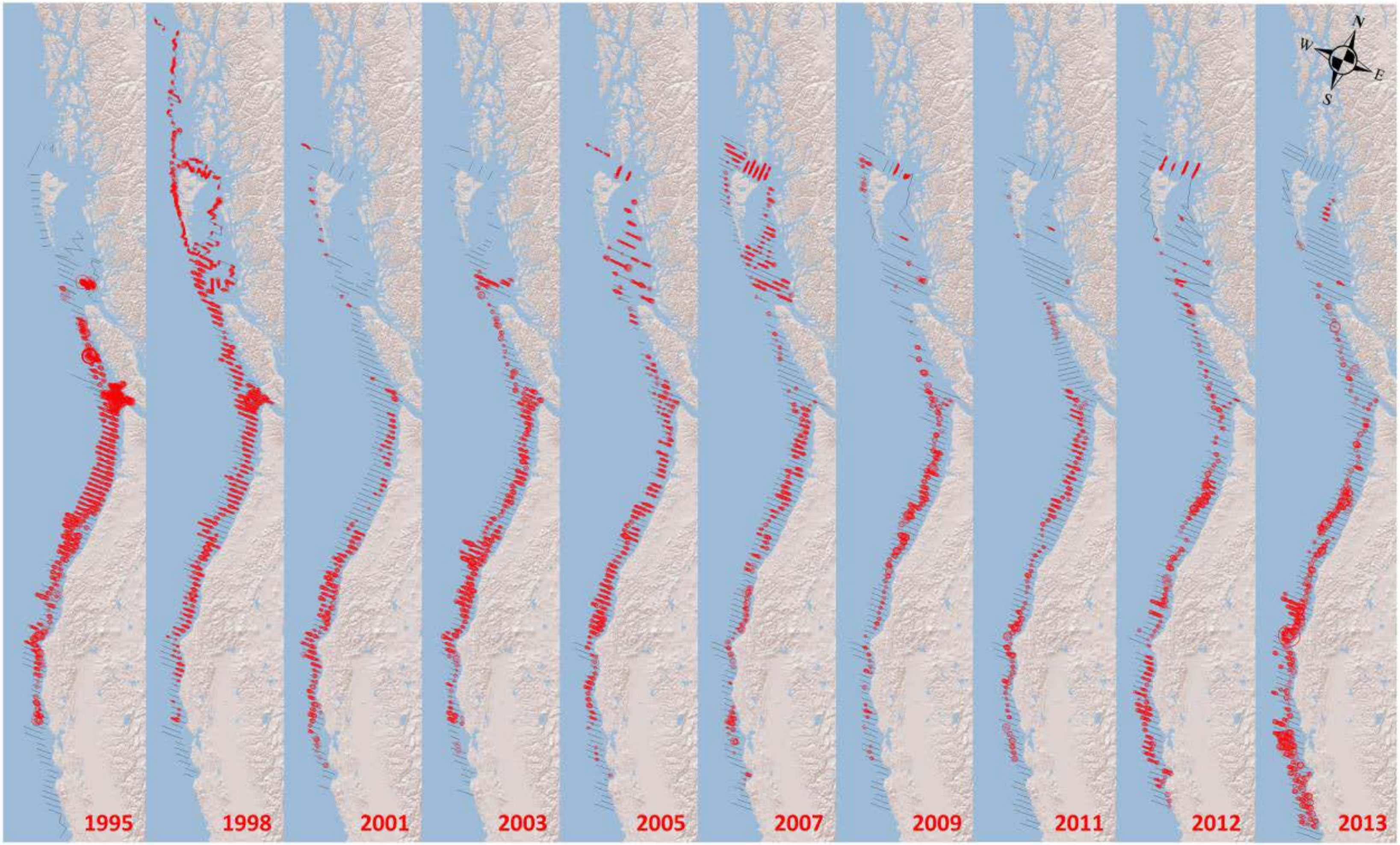
Impacts can be:

direct – e.g. temperature, currents

or indirect – e.g. through food supply, predators

All of these may impact the "safe" level of fish harvest

Change in distribution: Pacific Hake



http://www.westcoast.fisheries.noaa.gov/publications/fishery_
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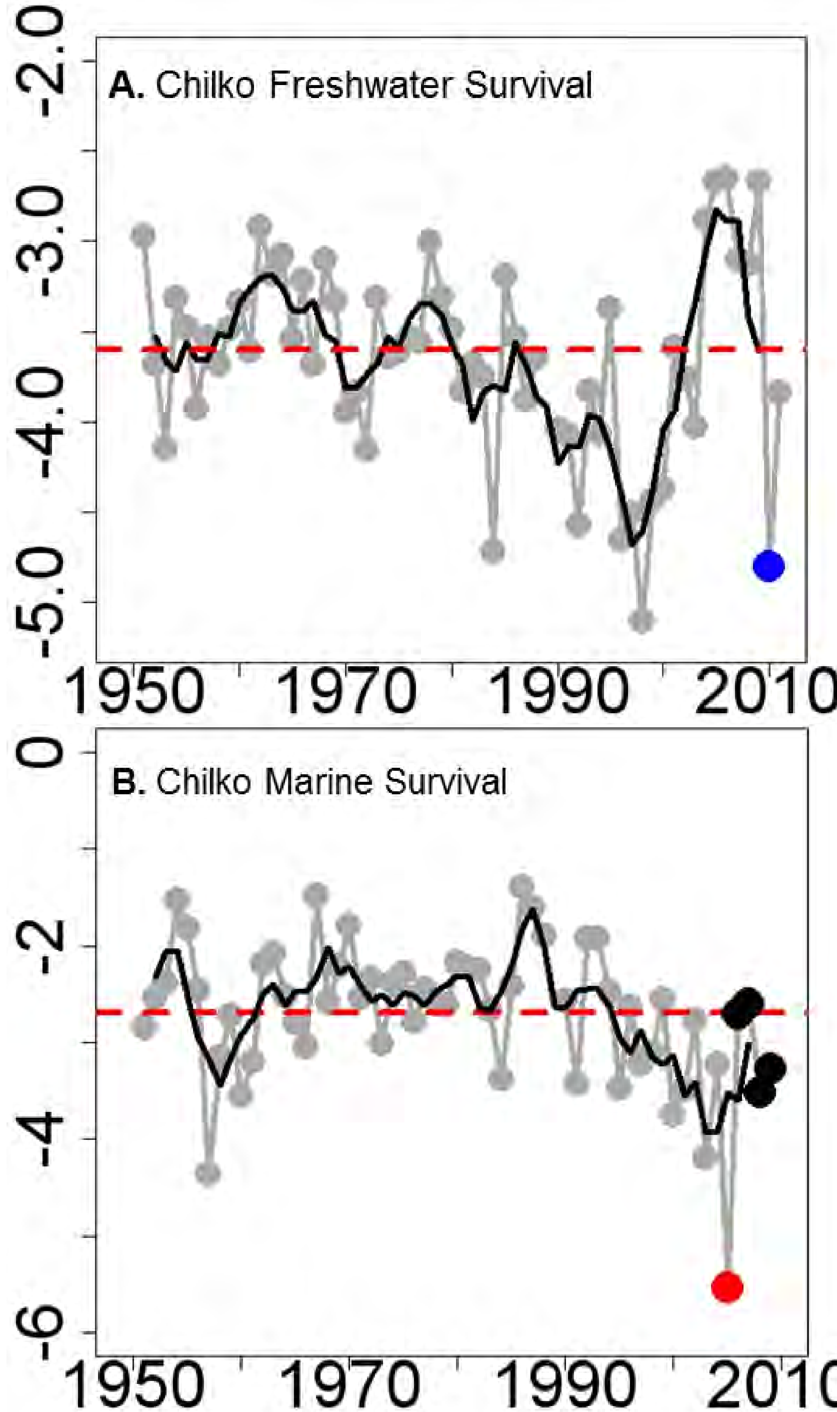
Change in survival rates for Sockeye salmon

Top: early freshwater survival ln(smolts/egg)

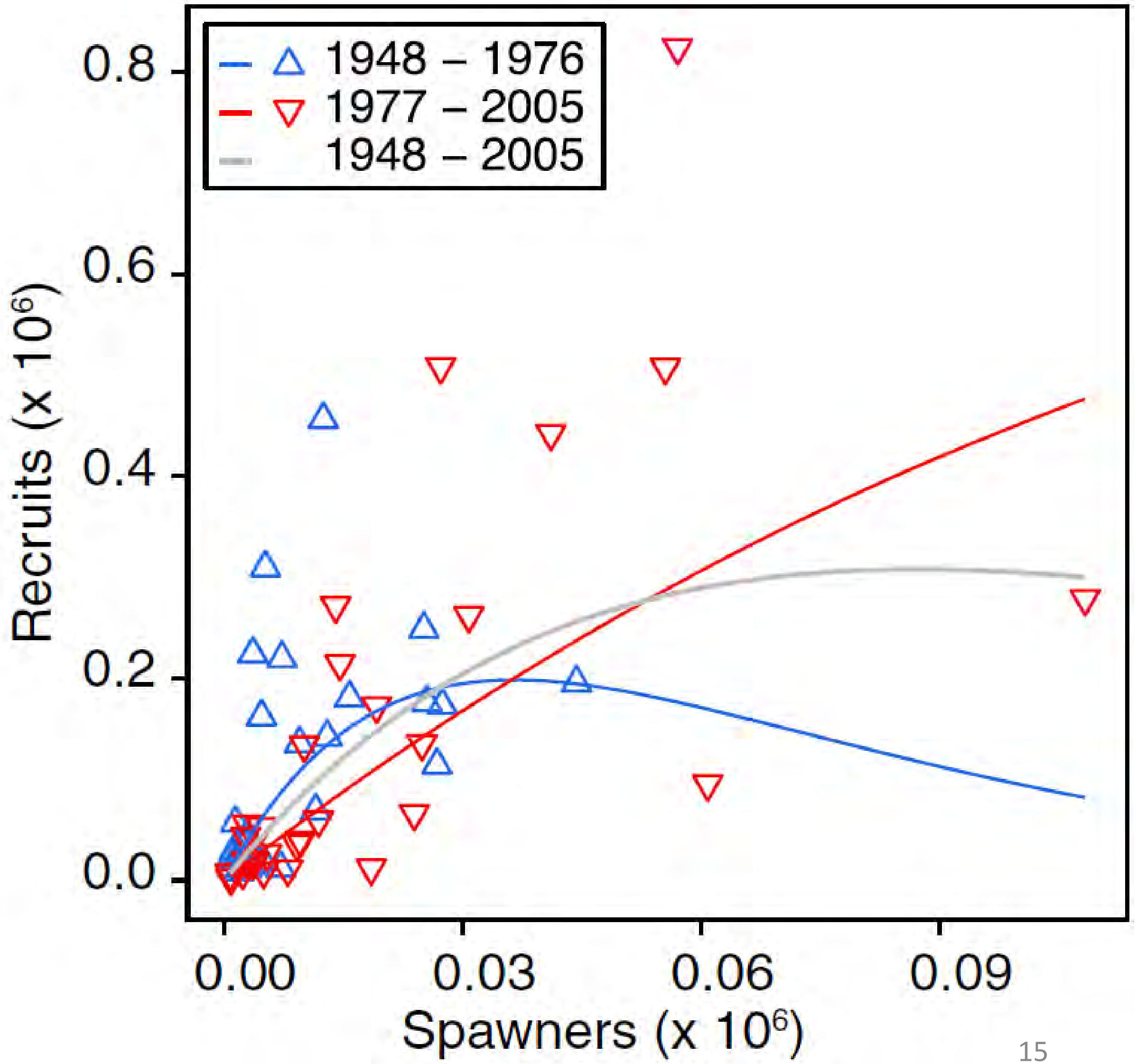
Bottom: marine survival ln(adults/smolt)

x axis: year of spawning

DFO CSAS Science Response 2014/041



Change in recruitment for Sockeye salmon

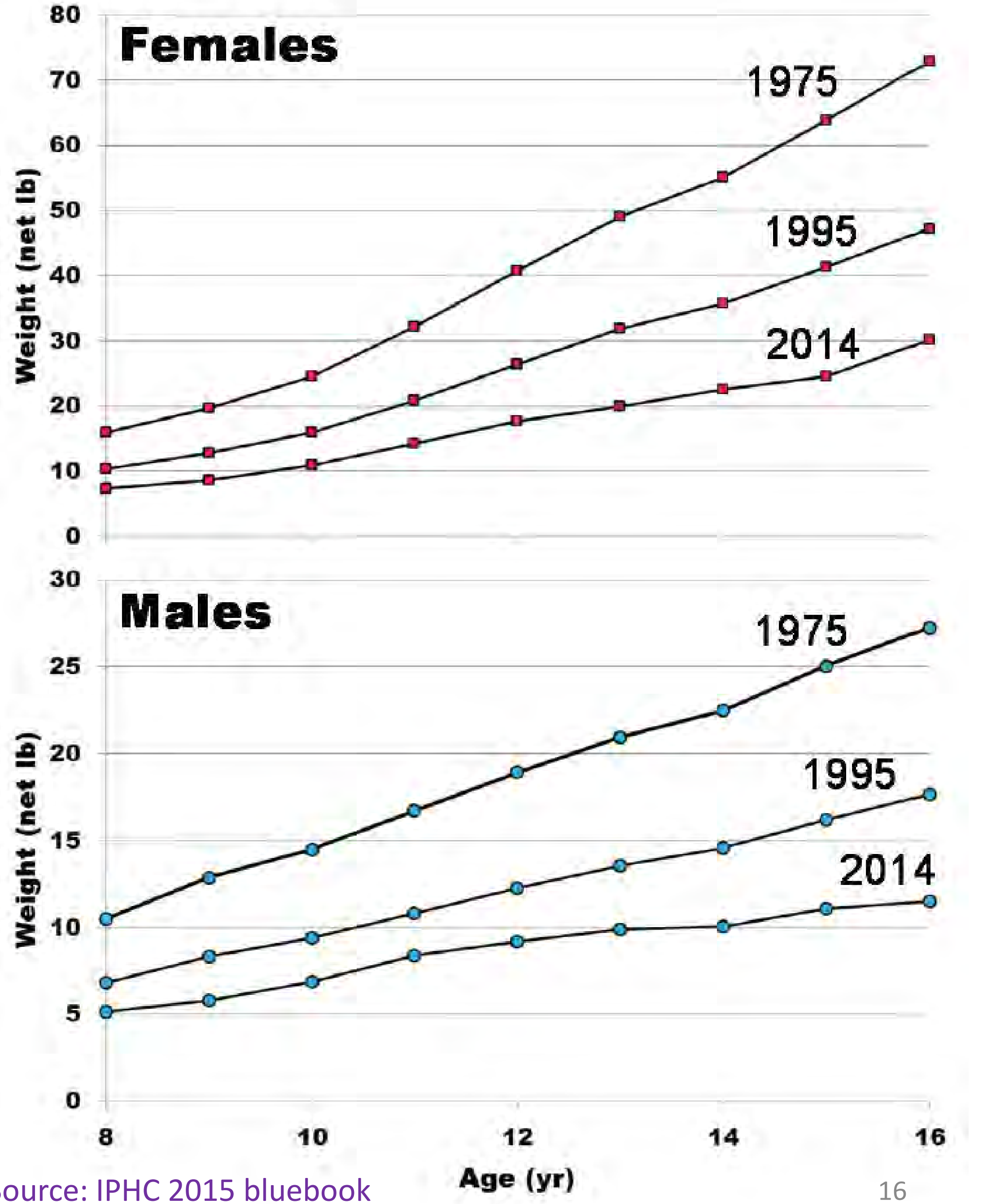


Ye et al. 2015 PNAS

Change in fish size: Pacific halibut

Photo: Orion McCarthy, IPHC

15-year old fish are smaller now than in 1975

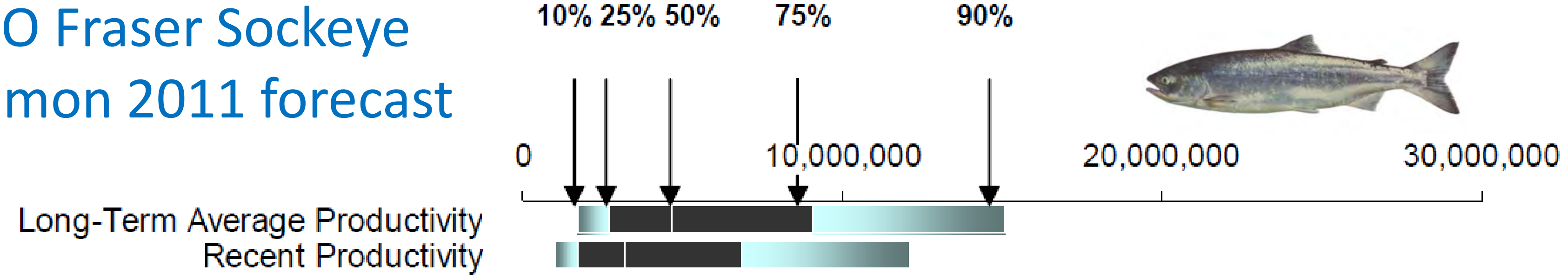


Source: IPHC 2015 bluebook

Going forward …

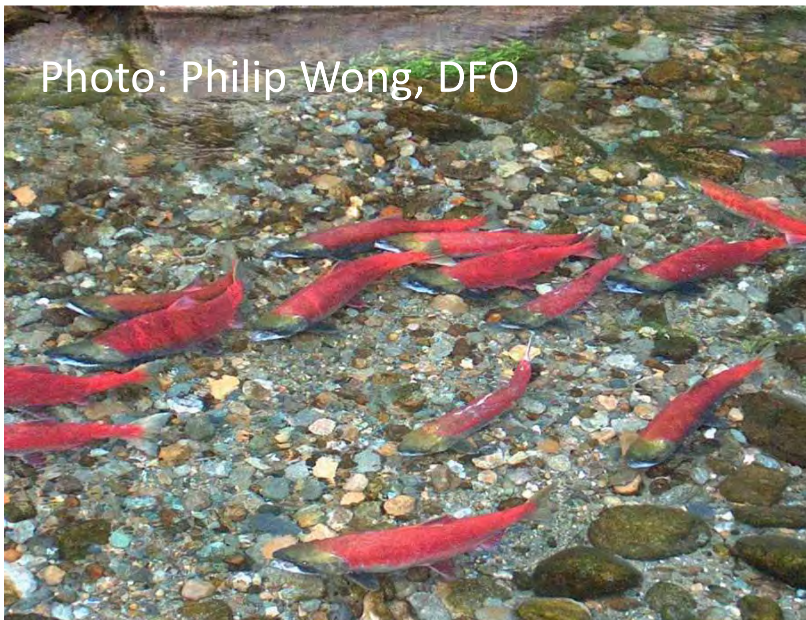
- Fishery management uses short term forecasts derived from past experience or history of the fishery
- Forecasts often have large uncertainty (e.g. large uncertainty in recruitment or survivorship)
- With changing climate, additional information will be required to provide an adequate basis to forecast
- With changing climate, weaker basis for forecast even for species with reasonable short term forecasts

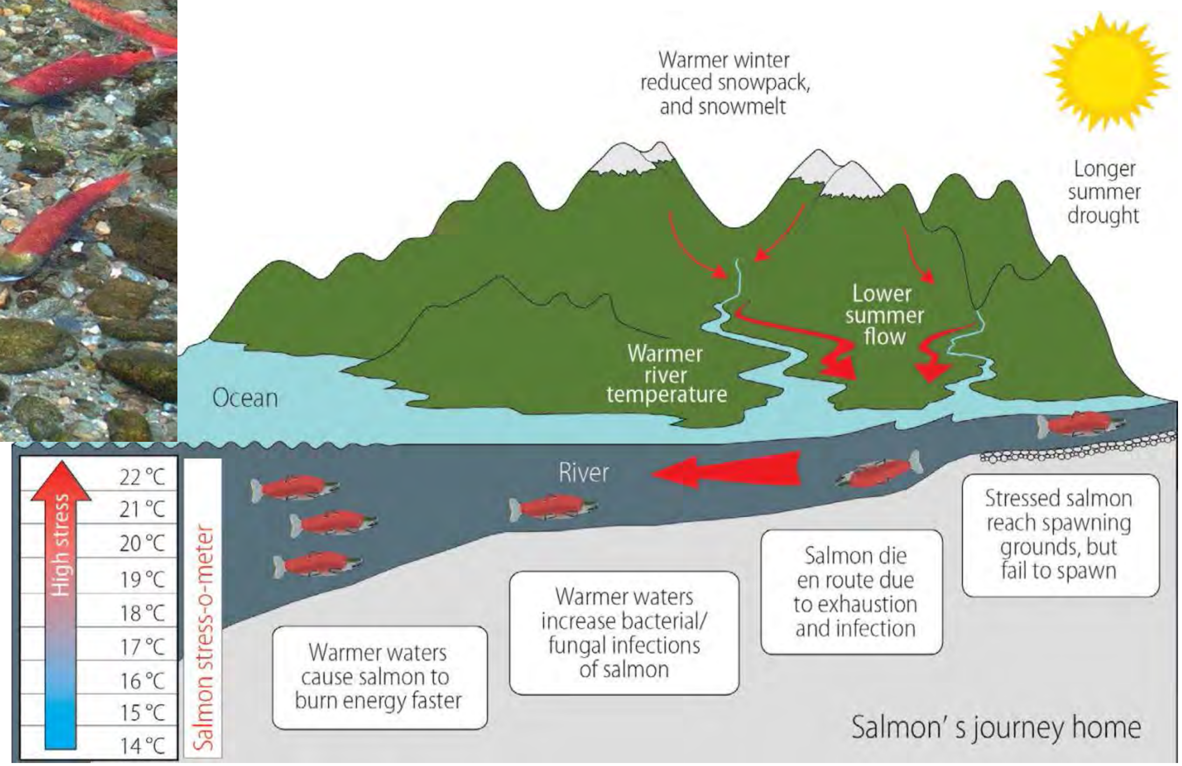
DFO Fraser Sockeye salmon 2011 forecast



DFO CSAS Res Doc 2011/134

Preparing for longer term climate change: Case study Fraser River Sockeye salmon





Case study Fraser River Sockeye salmon

- 2009: Meeting of experts under the Pacific Salmon Commission (PSC) concluded that:
  - Effects of temperature on in-river Fraser sockeye migration now understood
  - Marine mortality is still poorly understood
  - Climate change will impact Pacific Salmon Treaty stocks
  - Abundance and distribution of Fraser River salmon stocks could vary considerably over the next 10-year period
- Committee report prepared for the PSC

Case study Fraser River Sockeye salmon

Committee report recommendations included:

- Need for policies and procedures which anticipate ongoing changes in the abundance and distribution of key salmon stocks
- Need for a science plan including identification of salmon populations which have the greatest chance of long term persistence
  - Some Fraser sockeye stocks are more tolerant of high temperatures and/or acquire smaller thermal loads during up-river migration

PSC commissioners challenged the science and some were not prepared to consider the possible loss of salmon populations.

Case study Fraser River Sockeye salmon

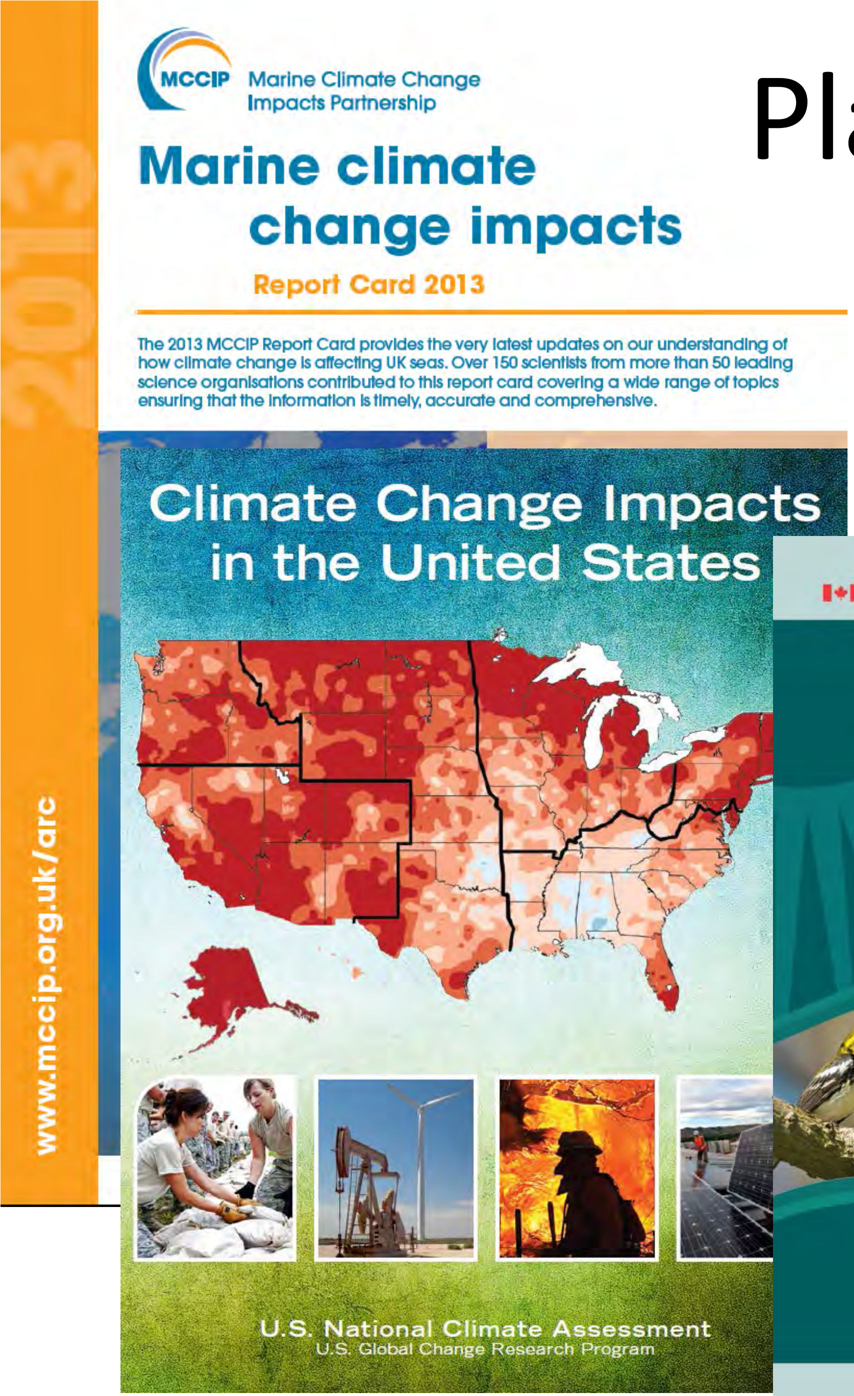
Why did our message fail?

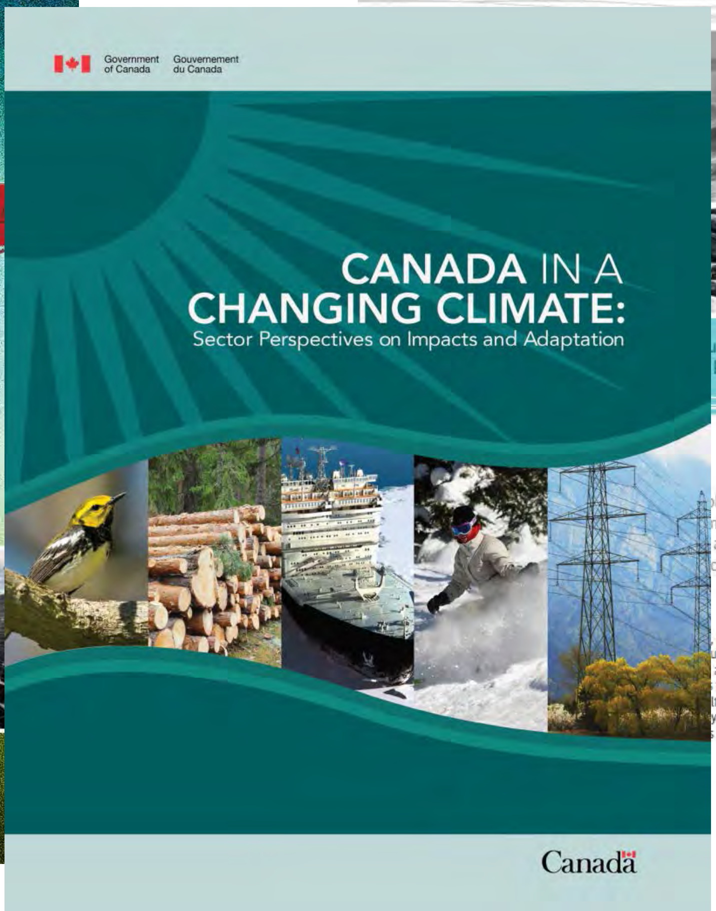
- Bad timing?
  - during heated Treaty re-negotiations
  - following the lowest return in 100 years
- Issues too long term for 10-year Treaty mandate?
- Recommendations not practical?
  - required different management units
- Not ready to contemplate a future world without some salmon stocks?

Conclusions so far …

- Many successes in responding to short term or cyclical change – especially when clear decision rules – basis of good fisheries management
- Conversely, many failures when short term science advice is not followed
- When stocks decline, easier to respond when decision rules previously negotiated/specified and actions expected
- Higher risks and thus less willingness to change when uncertainty is high or planning horizon is beyond next season
- Under climate change, clear messages and short term actions will be needed

Planning processes help prepare





Planning processes found

- Knowledge gaps
  - Need for climate change projection data at appropriate scale
  - Need for seasonal climate prediction capability
  - Need for information about risk, impacts and opportunities for key fish species
  - Need for more monitoring and assessment of cumulative and synergistic effects

- Management gaps
  - Need for more stakeholder awareness and communication
  - Need for institutional support, capacity and mandate
  - Need for tools to support management actions

Knowledge gaps - opportunities:
Canadian Pacific example

- Possible increases in yield of some important commercial species (e.g. crab, prawn, geoduck, salmon)
  - But potential for user group conflicts
- Possible increase in the commercial availability of migratory hake, Pacific mackerel, sardine and albacore tuna
  - But may require Treaty re-negotiations (where fixed shares)
- Possible improved cultured shellfish growth through enhanced food supply
  - If potential acidification impacts can be minimized
- Invasive species could become commercial or recreational species.

DFO CSAS Science Response 2013/016

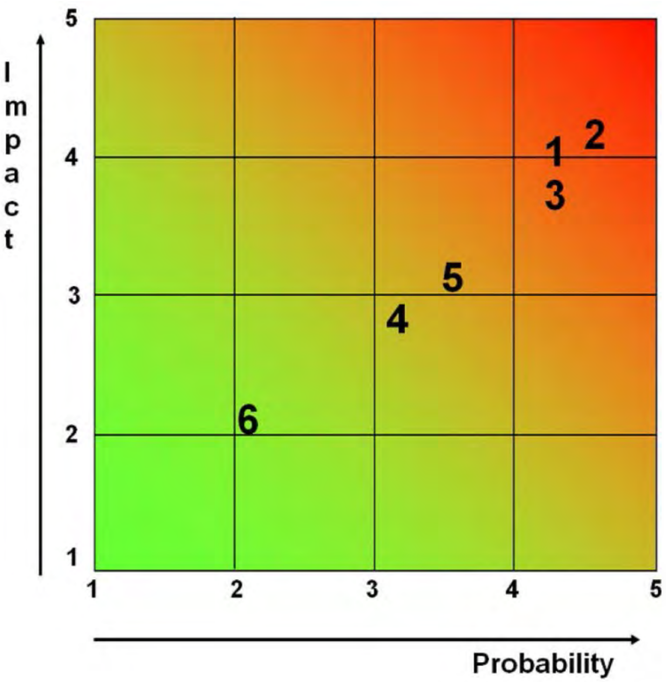
Management gaps - Stakeholder awareness and communication

- Industry groups generally eager to hear about climate change impacts – can be challenging to make time for this during discussions on current fishing plans
- Typical "hard" questions posed by stakeholders questions include
  - Why more precaution is needed in an increasingly uncertain world?
  - Why sequences of "good years" might be part of a long term decline?
  - Why not "catch it all" if it will be lost anyway?
  - Can government help with adaptation costs?

Management gaps - Institutional support: Pacific Ocean area heat maps

50 year horizon

Not scientifically defensible, **but** meaningful communication tool for agency policy makers



1) Ecosystem and Fisheries Degradation and Damage
2) Changes in Biological Resources
3) Species Reorganization and Displacement
4) Increased demand to provide Emergency Response
5) Infrastructure Damage
6) Changes in Access and Navigability of Waterways

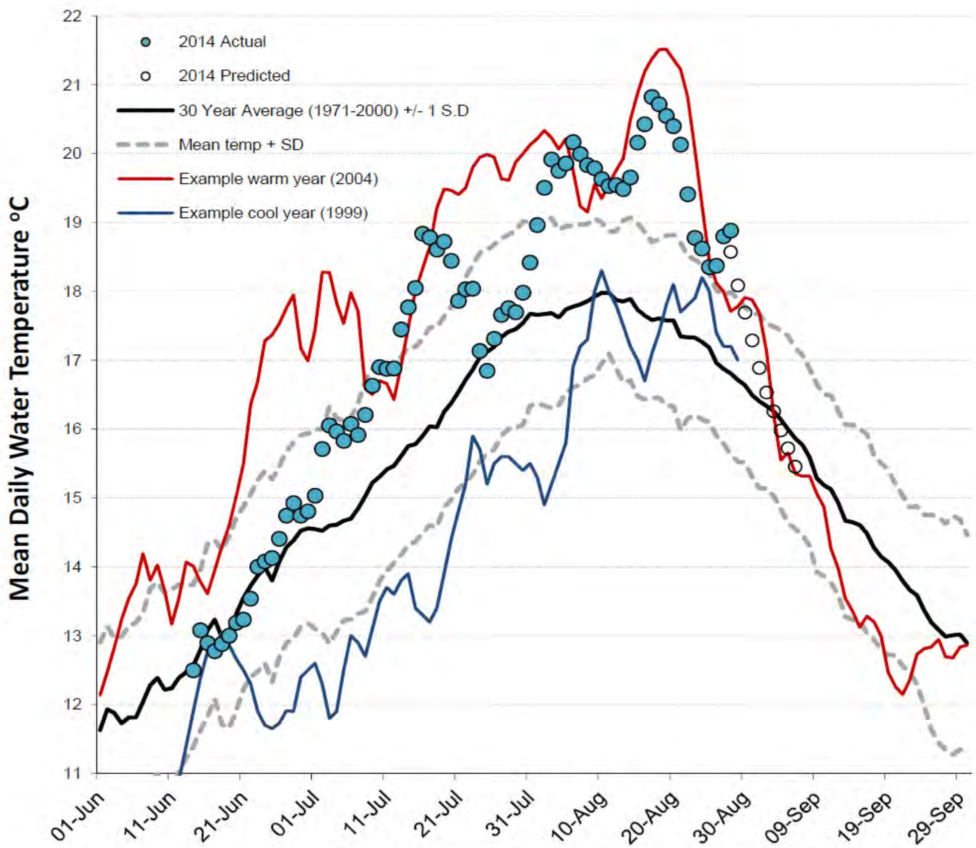
DFO CSAS Science Response 2013/016

Management gaps - Adaptation tools

- NatureServe Climate Change Vulnerability Index
  - can help identify plant and animal species vulnerable to climate change
- Anticipatory Zoning (North Pacific Fishery Management Council, National Marine Fisheries Service; U.S.)
  - Arctic Ocean off Alaska closed to commercial fishing to protect unexploited ecosystems while fisheries management plans are developed
- U.S. EPA relative vulnerability of threatened and endangered species (U.S. Environmental Protection Agency; U.S.)
- Fish Invasiveness Scoring Kit (FISK) (CEFAS; UK)
- Spatial Ecosystem and Population Dynamics Model (SEAPODYM) (Secretariat to the Pacific Community; Western and Central Pacific)
  - Used by the Pacific Community Secretariat to assess vulnerability of skipjack and bigeye tuna to changes in Western and Central Pacific (2050-2100 horizon)
- Incorporating alternative climate forecasts into fisheries management determination of catch limits (University of Washington; Alaska)
  - A'mar, Punt, Dorn. 2009. ICES JMS, 66: 1614–1632

Adaptation Tools: Canadian example - Sockeye

18°C – decreased swimming performance
19°C – signs of physiological stress & slow migration
20°C – high pre-spawning mortality & disease
21°C – severe stress & early mortality exposure



- Numerical model predicts Fraser River flow and temperature
- Predictions drive a biological effects model to estimate salmon in-river mortality
- Harvest levels are reduced to compensate for excessive in-river mortality

http://www.pac.dfo-mpo.gc.ca/science/habitat/frw-rfo/index-eng.html

Industry can generally adapt if …

- Climate change projections can be provided at the right scale
  - (different requirements for local versus capital intense fisheries)
- Analyses give adequate advance notice of changes to the fish community
  - (e.g., change in spatial distribution, survival rates, recruitment, fish size, and fish abundance)
- Regulatory frameworks are flexible

Industry may not be able to adapt if …

- Allocated fixed amount of resource
  - (e.g., some BC First Nation agreements)
- Allocated non-transferable share
- Restricted to fishing zone
  - (e.g., Atlantic inshore fleet, Pacific gillnet fleet)
- Restricted to gear type
  - (e.g., Pacific license conditions)
- … Or restricted by other allocation mechanisms generally aimed preserving current rights and at reducing overcapacity

Final Remarks

- Many well managed fisheries with a history of success in responding to short term or cyclical change
  - Based on clear decision rules previously negotiated/specified so that actions expected when change occurs
- Climate change can provide some opportunities (in addition to the challenges)
- Tools are available and can be developed to assist with adaptation
- To plan for longer term change,
  - need to address knowledge gaps, particularly climate change projection data at appropriate scale
  - need continued communication among resource users, managers and scientists
- Industry can generally adapt if regulatory frameworks are flexible
- Successes to date give reasons to be optimistic for future fisheries