Abrupt changes in migatory behaviour of Pacific hake in Canadian waters

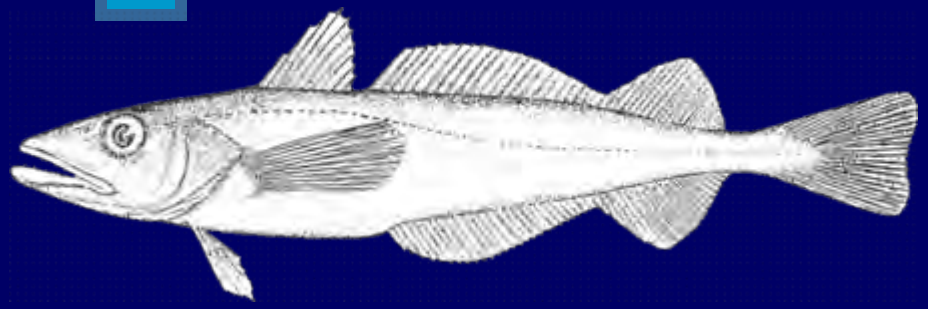
Jacquelynne R. King, Gordon A. McFarlane, Simon R. M. Jones, Scott R.Gilmore and Cathryn L. Abbott

Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, British Columbia, Canada, V9T 6N7

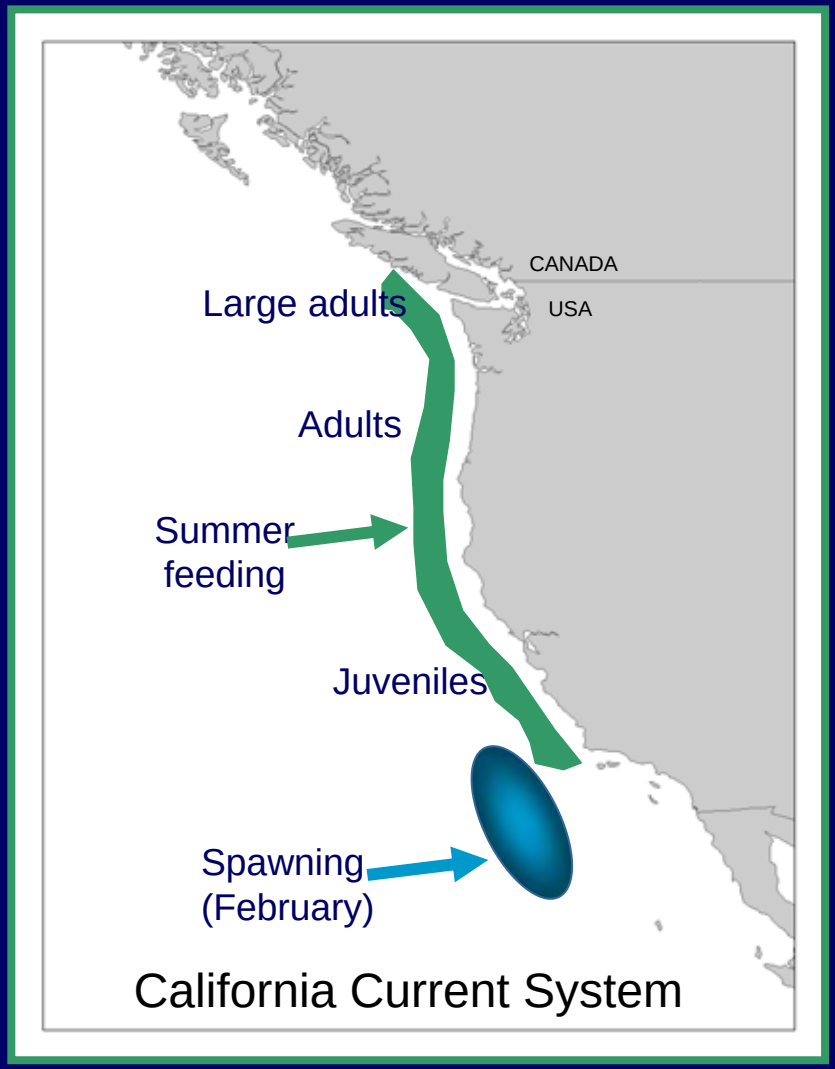
Overview

- Pacific hake – why you should care
- Why has hake changed its migration?
  - Potential mechanisms
    - Extrinsic and Intrinsic
    - King et al. 2011. ICESJMS.
- Ecosystem Reorganization
  - Impact on Competitors
  - Stock delineation of Pacific hake
    - King et al. Fisheries Research. *In press.* doi:10.1016/j.fishres.2010.12.024

Pacific hake (*Merluccius productus*)

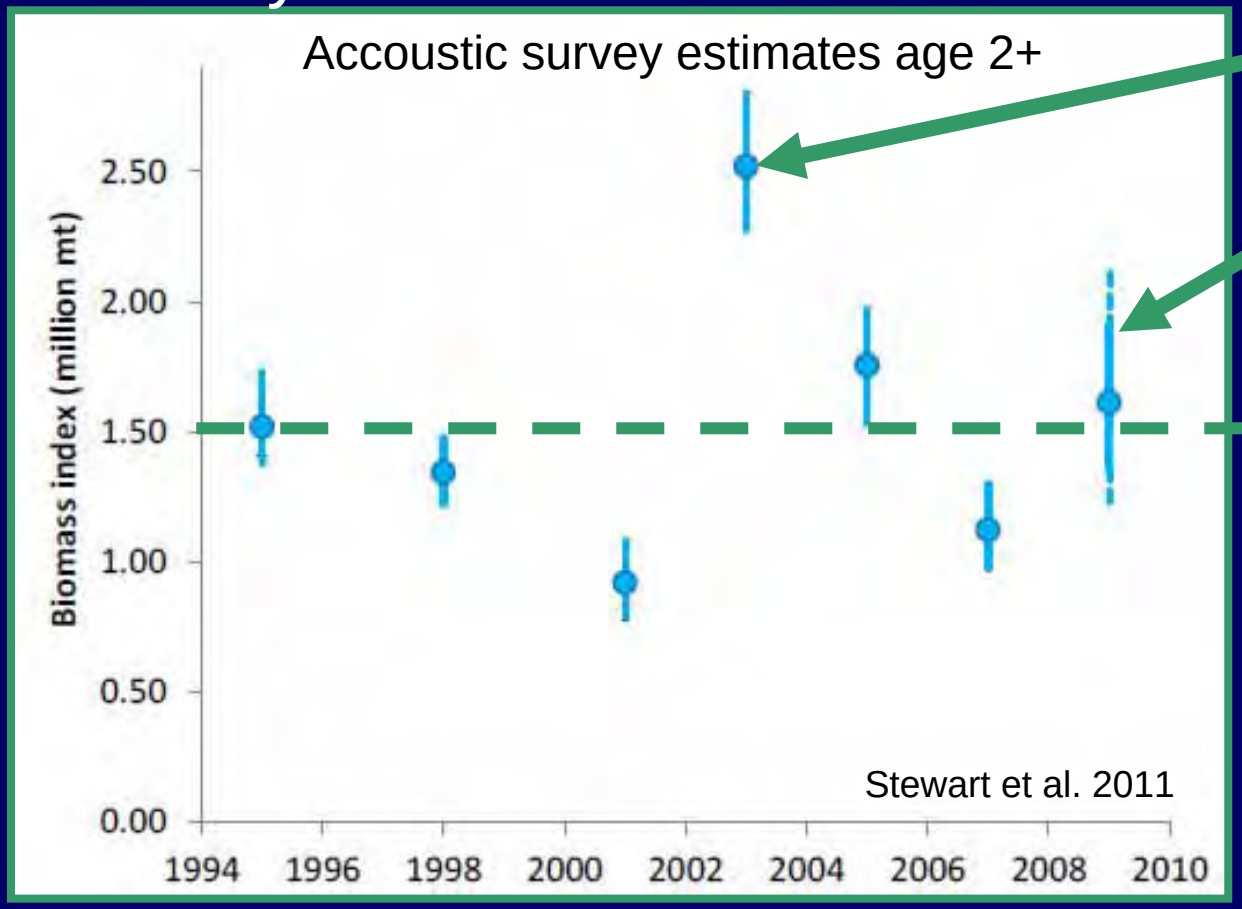


- maximum age: 16
- age of maturity: 3+
- age of recruitment: 2-5
- bathypelagic (up to 500 m)
- highly migratory throughout the California Current System
  - straddling stock between Canada and the US
  - 25-40% enter Canadian waters for summer feeding



Pacific hake biomass

- Most abundant groundfish population in the California Current system



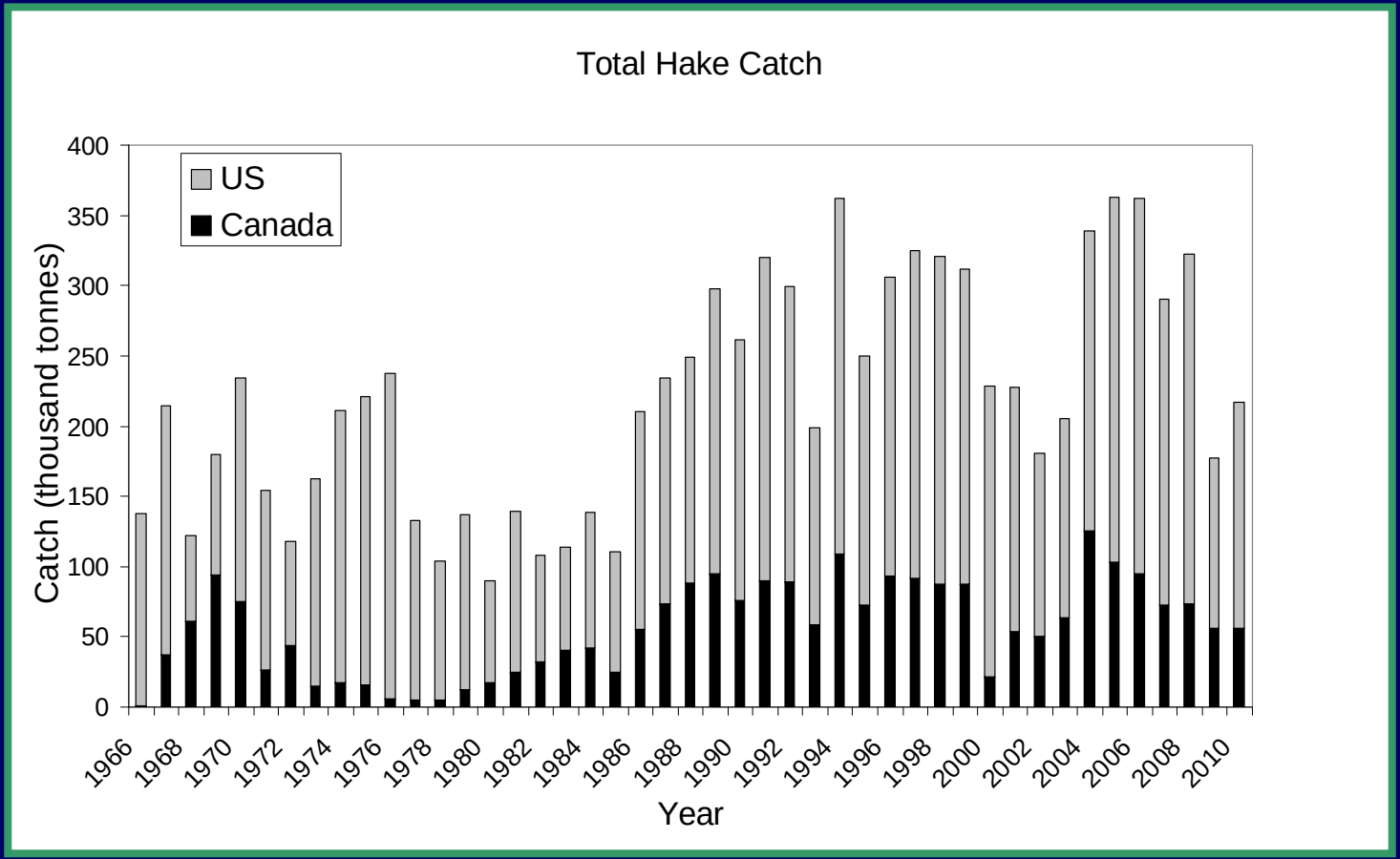
1999 yearclass

Humboldt squid

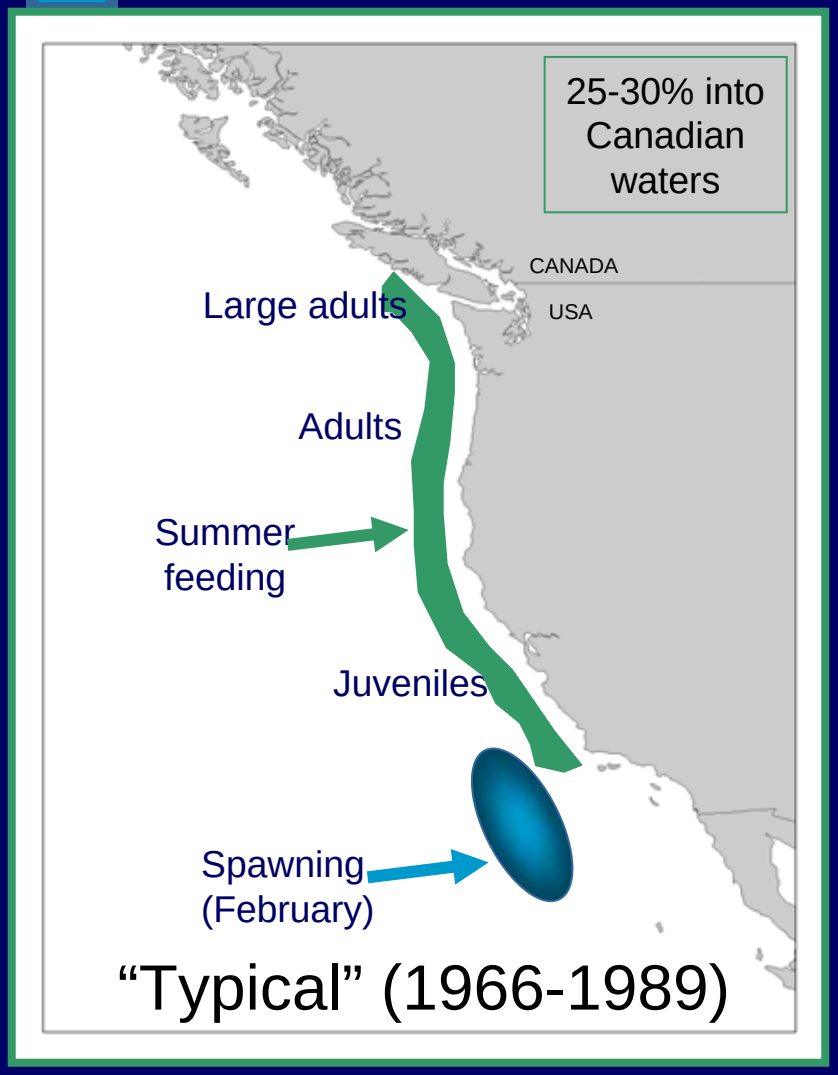
1.5 million tonnes

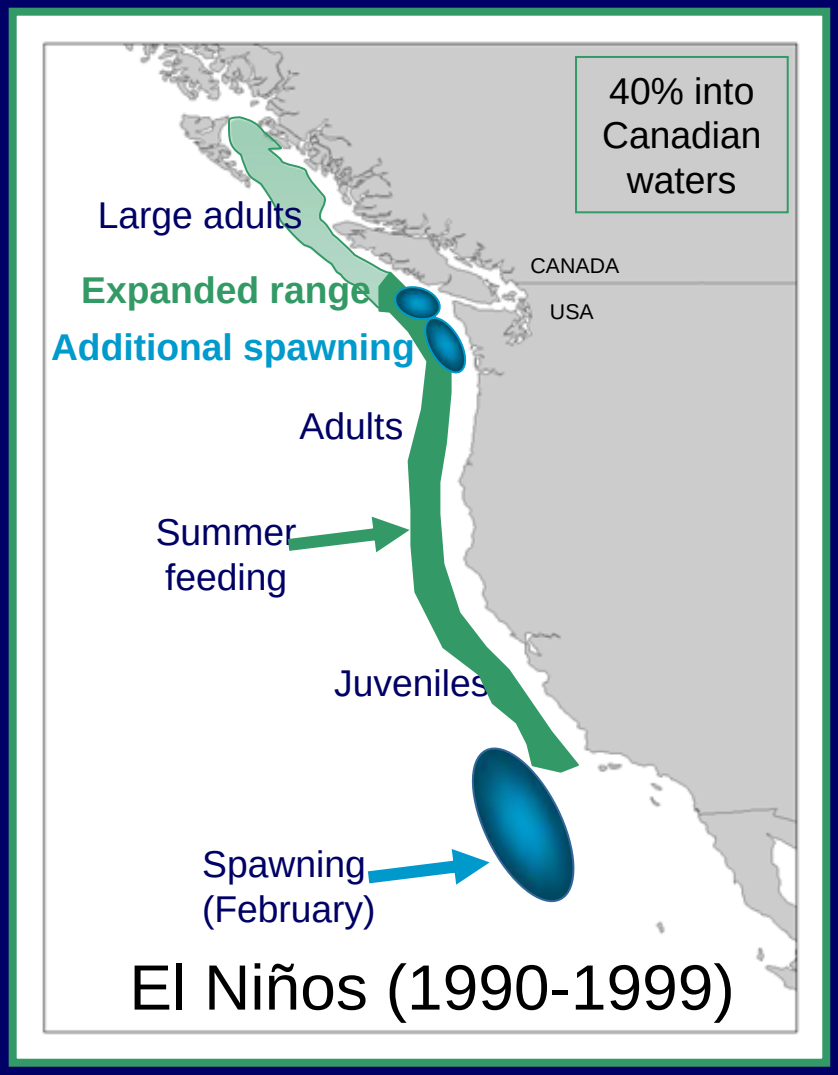
Pacific hake fishery

- Important fishery; more hake caught than all other groundfish species combined



Pacific hake migration





Pacific hake migration mechanism

- in warm (El Niño) years (1990s), Pacific hake migration is more northward:

Extrinsic

- poleward flow of California Undercurrent is stronger
  - equatorward flow of surface California Current is weaker
- upwelling intensity is reduced in southern waters and increased in northern waters

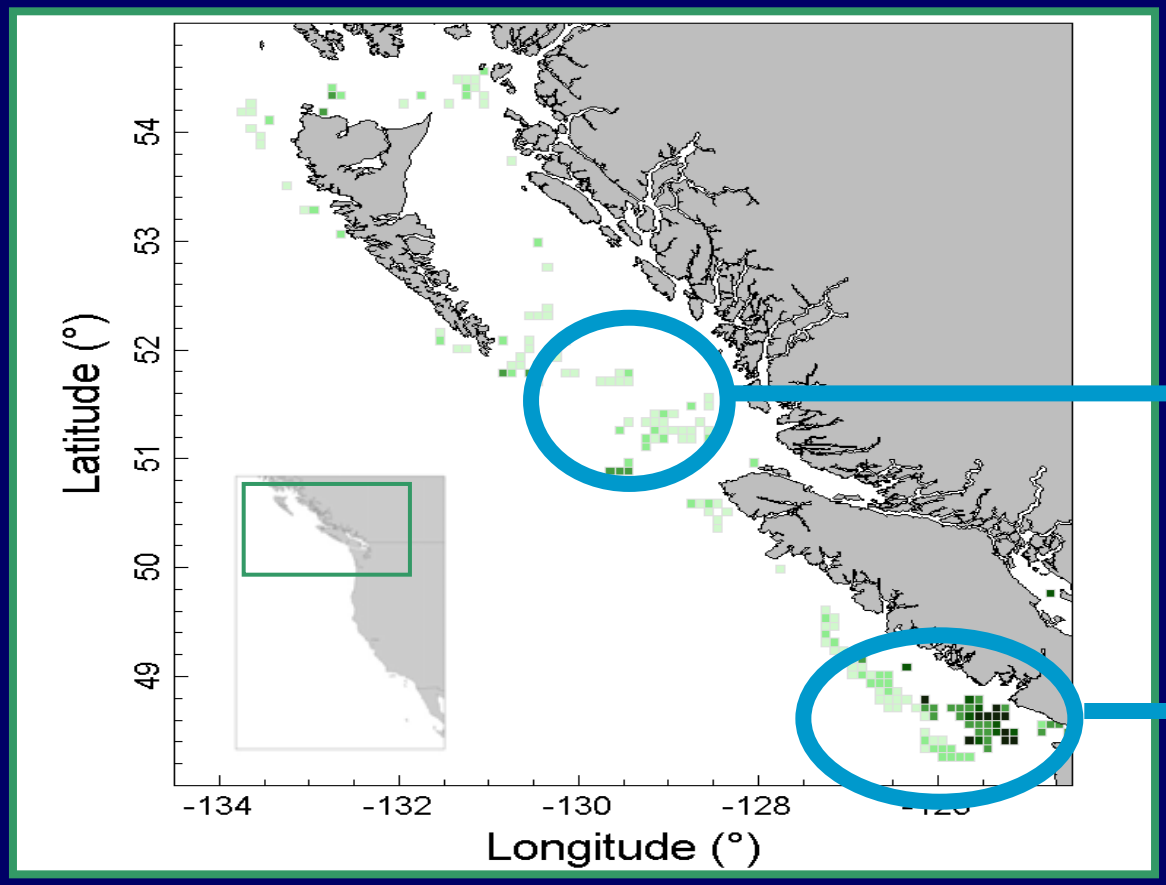
Intrinsic

- less productivity and prey availability in south;
- adult hake forage more northerly
- Prey availability improved northward

Hollowed 1992; Horne and Smith 1997; Agostini et al. 2006; King et al. 2011. *ICESJMS*.

Canadian fishery

- propagated on the migratory summer feeders
  - July - September

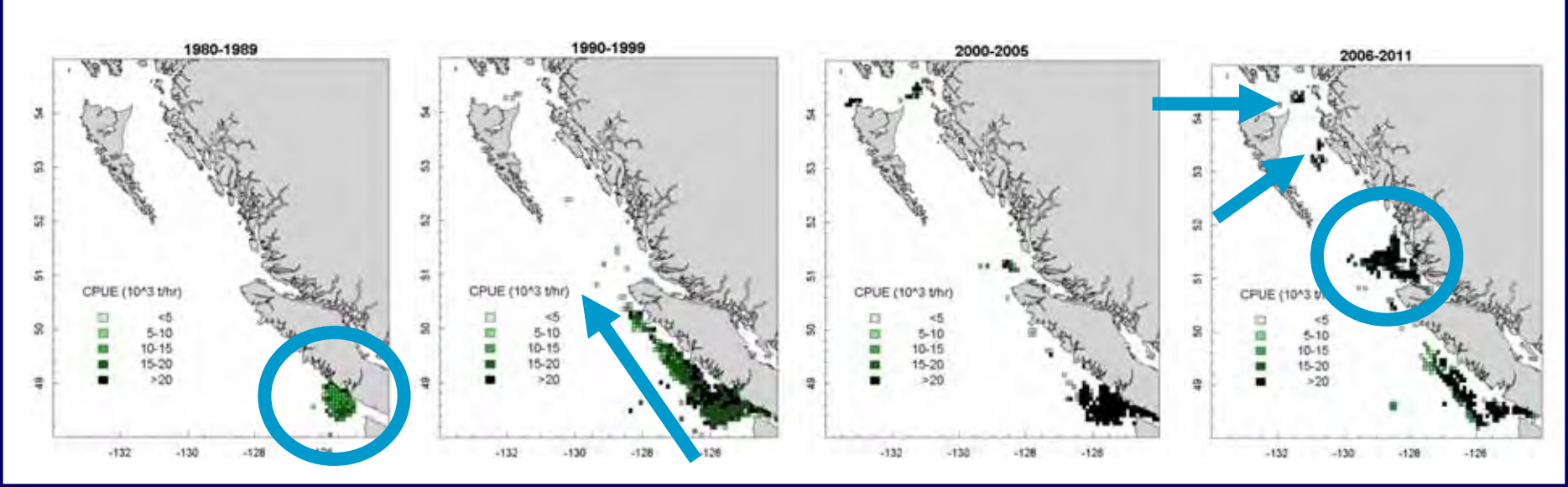


Queen
Charlotte
Sound

West
Coast
Vancouver
Island

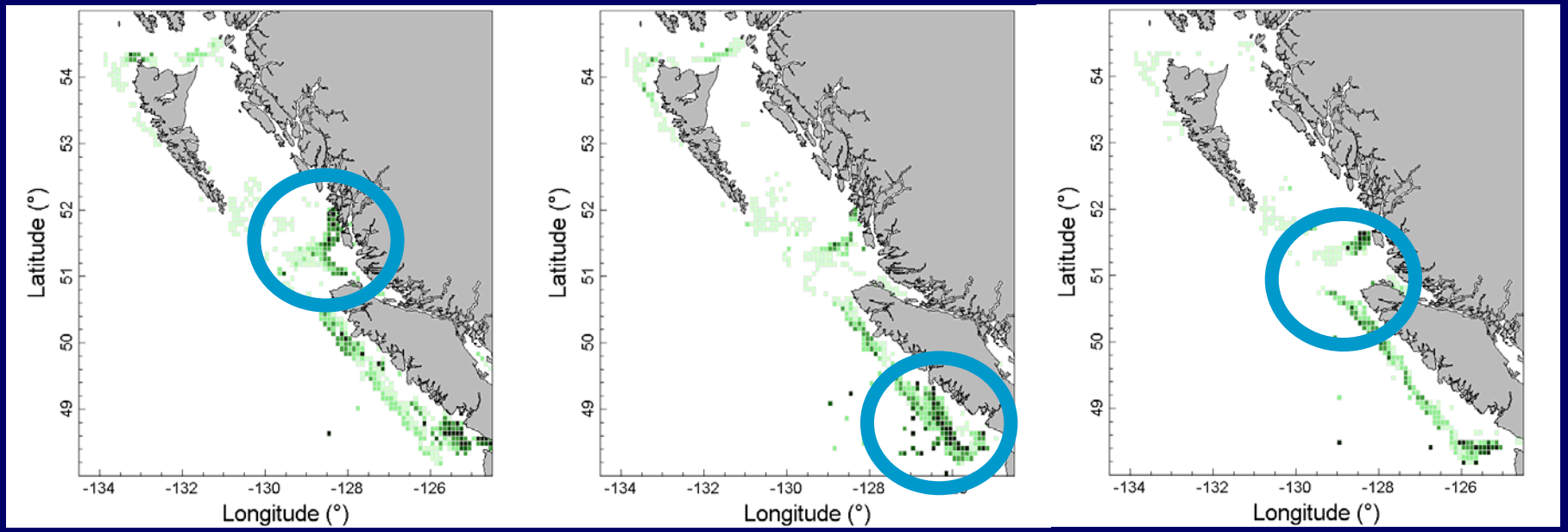
Canadian summer fishery

- dramatic changes in hake fishing grounds in 2006



- WCVI only
- northward expansion
- El Niño years
- back to more ‘typical’ distribution
- intense in the north
- decline off WCVI

What happened in 2010?



2009

- intense in the north

2010

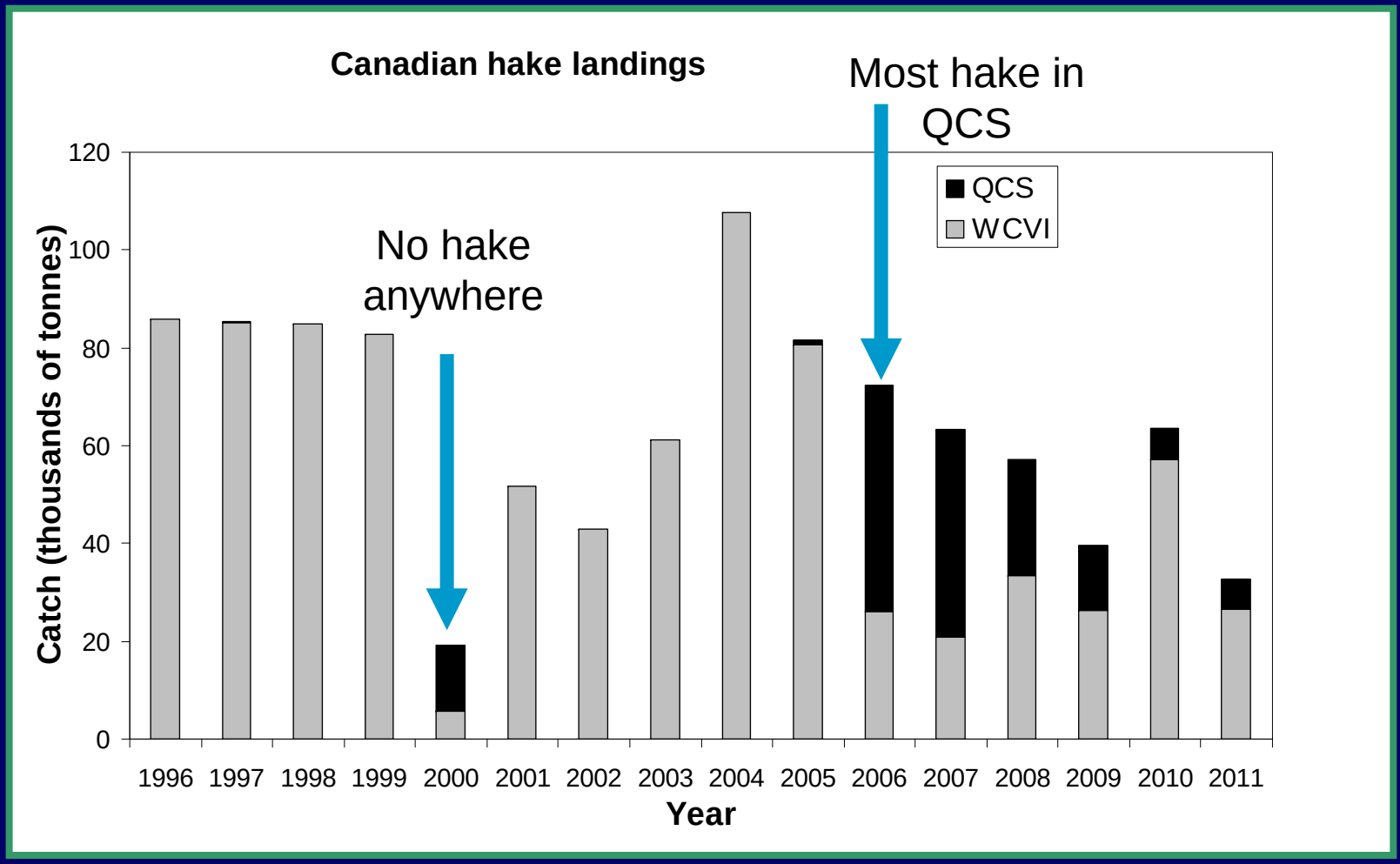
- focused back on WCVI

2011

- preliminary
- return to the north

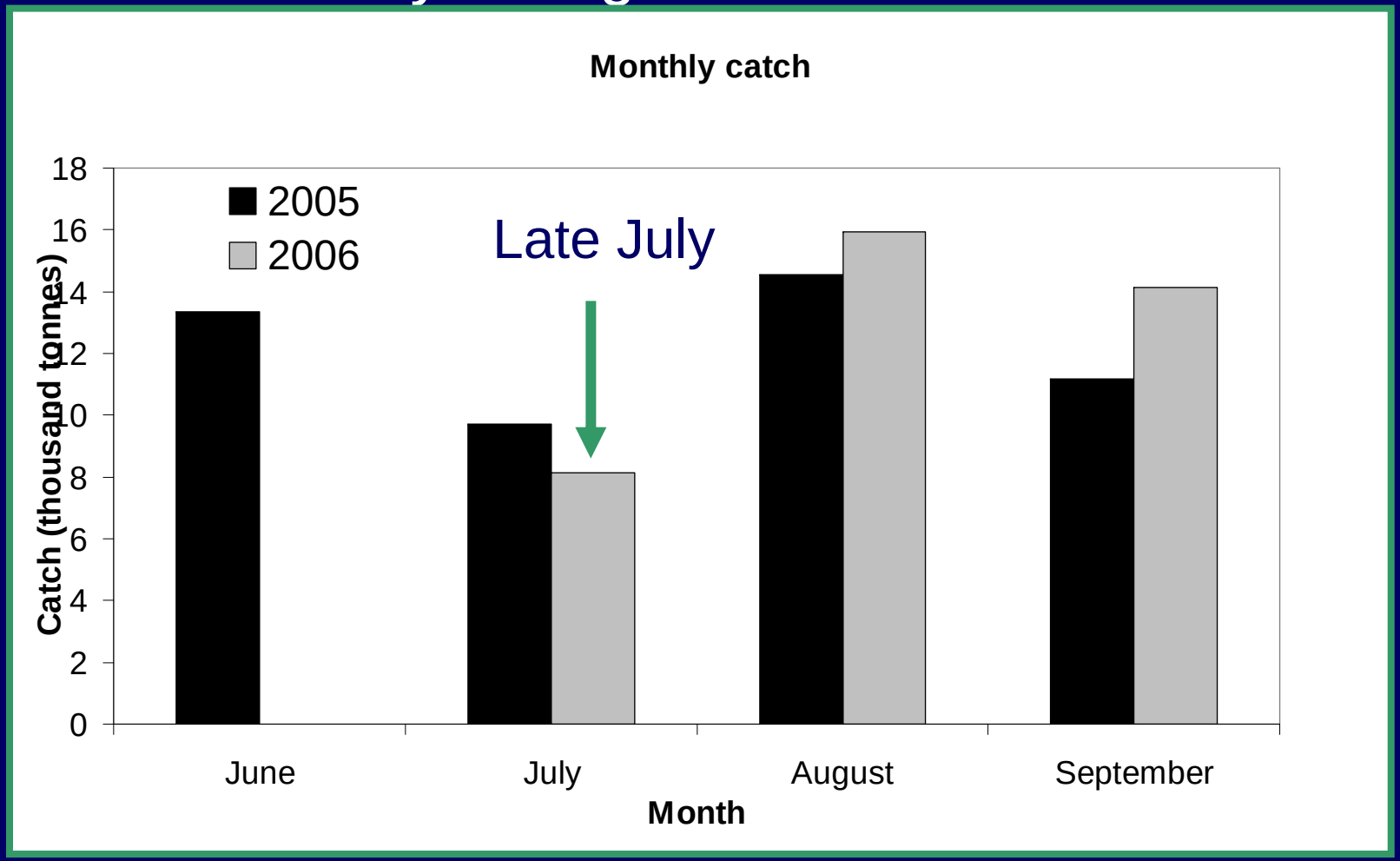
Canadian fishery

- 2006 changes were dramatic and unprecedented



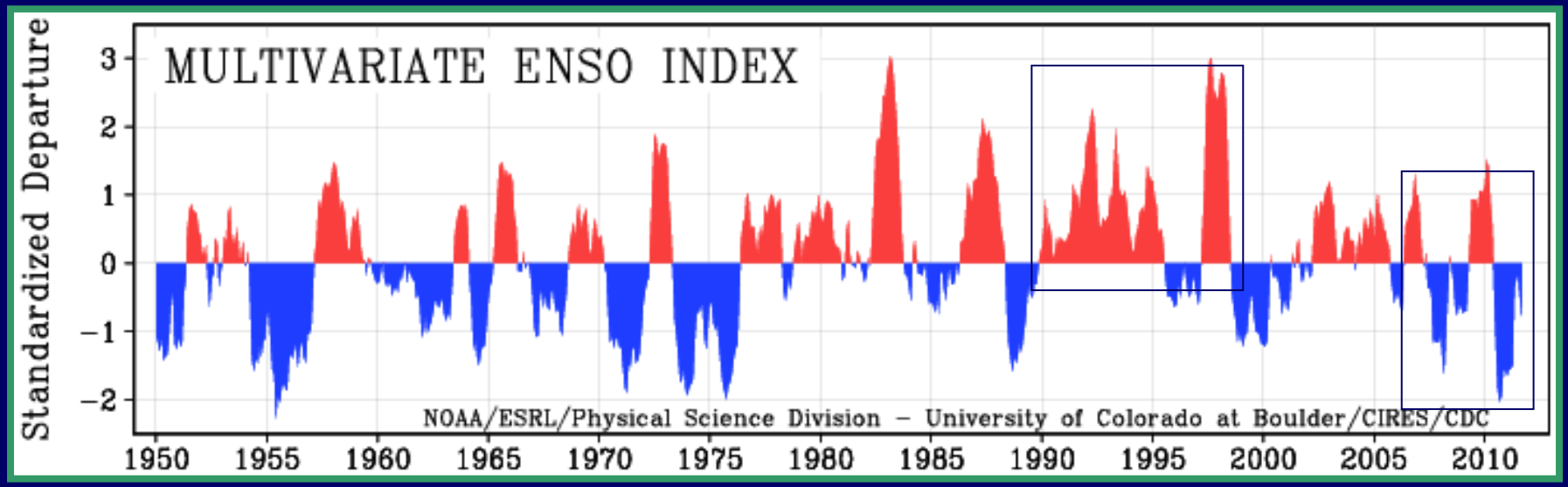
Canadian summer fishery

- distinct monthly changes in distribution after 2006

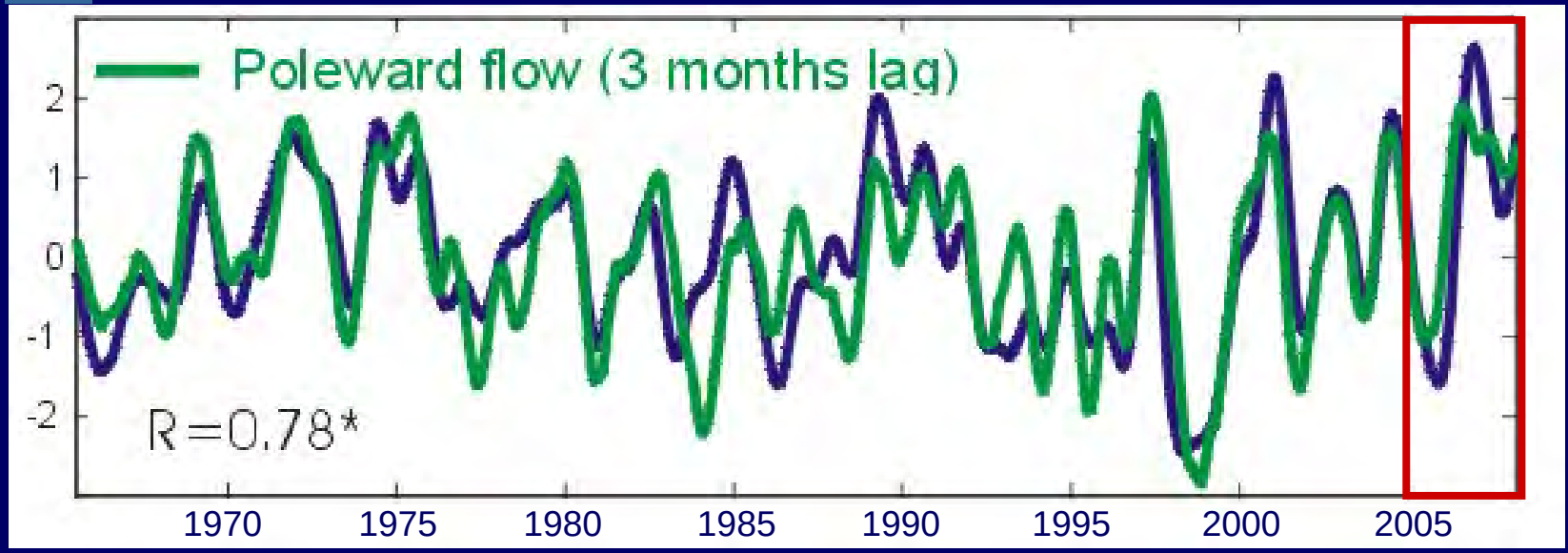


ENSO events 2000-2010

- Unlike the 1990s, when hake expanded northwards, there has not been strong, prolonged ElNiño events from 2006-2011

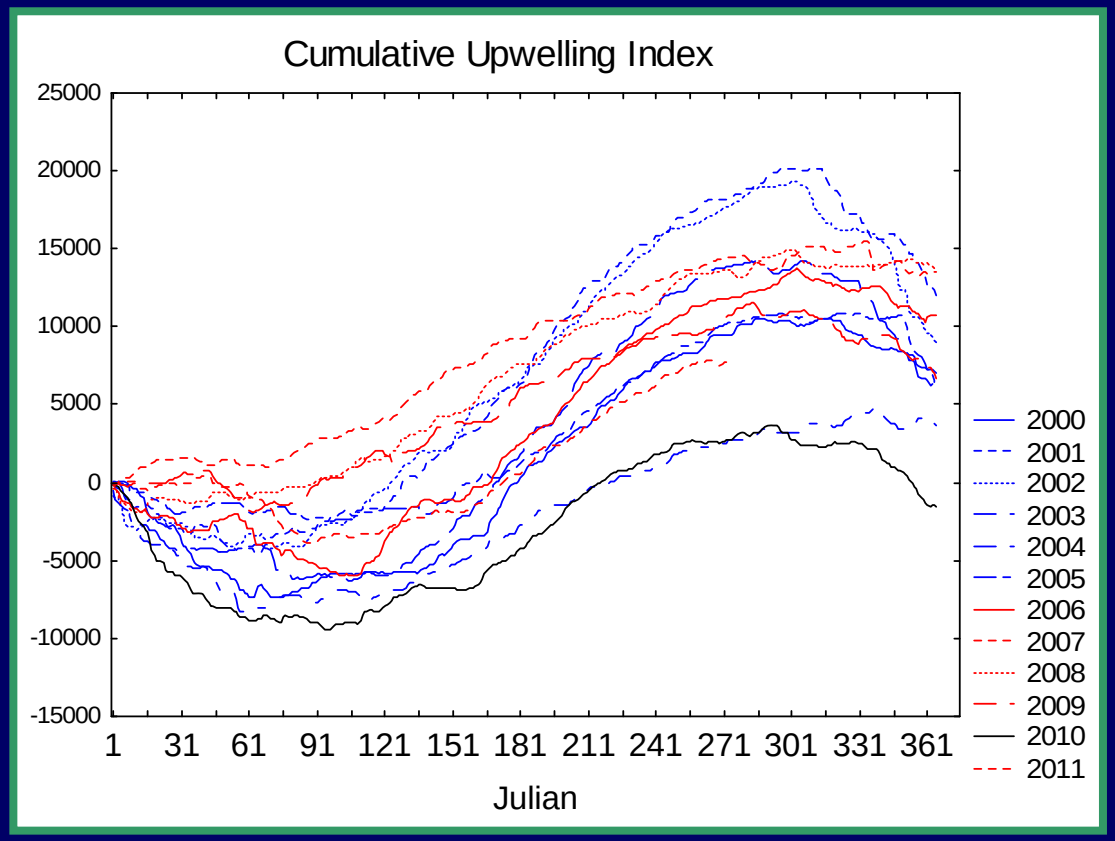


California Undercurrent mechanism



- difficult to measure
  - ROMS model results (DiLorenzo pers. comm.)
- 2006 not exceptionally different from 2000-2005

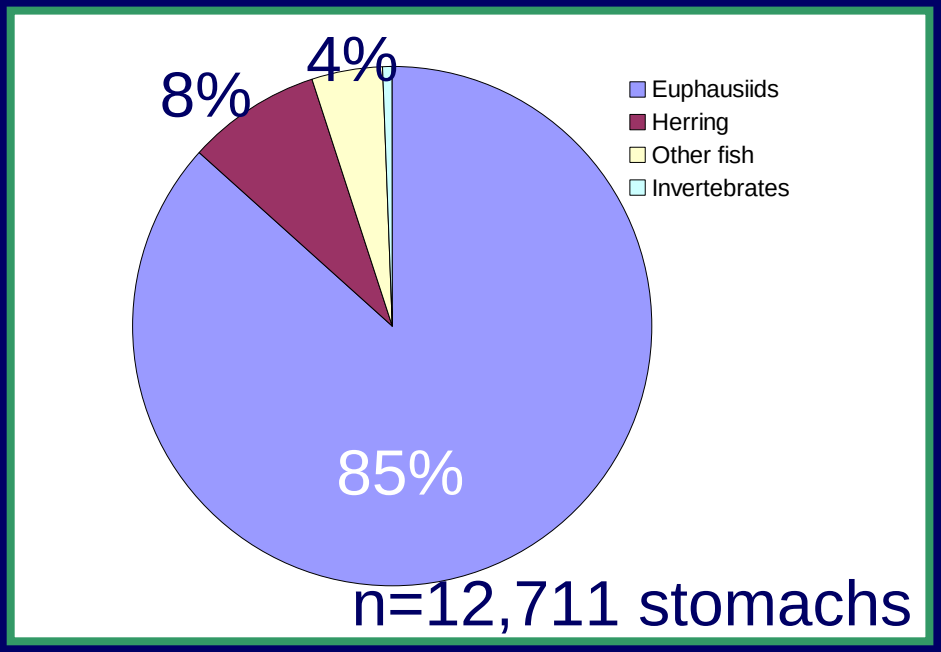
Upwelling mechanism - south



- 2000-2005 was actually weaker in intensity
- no difference in spring transition
- 2010 was remarkably weak – but not a year of high northward extension

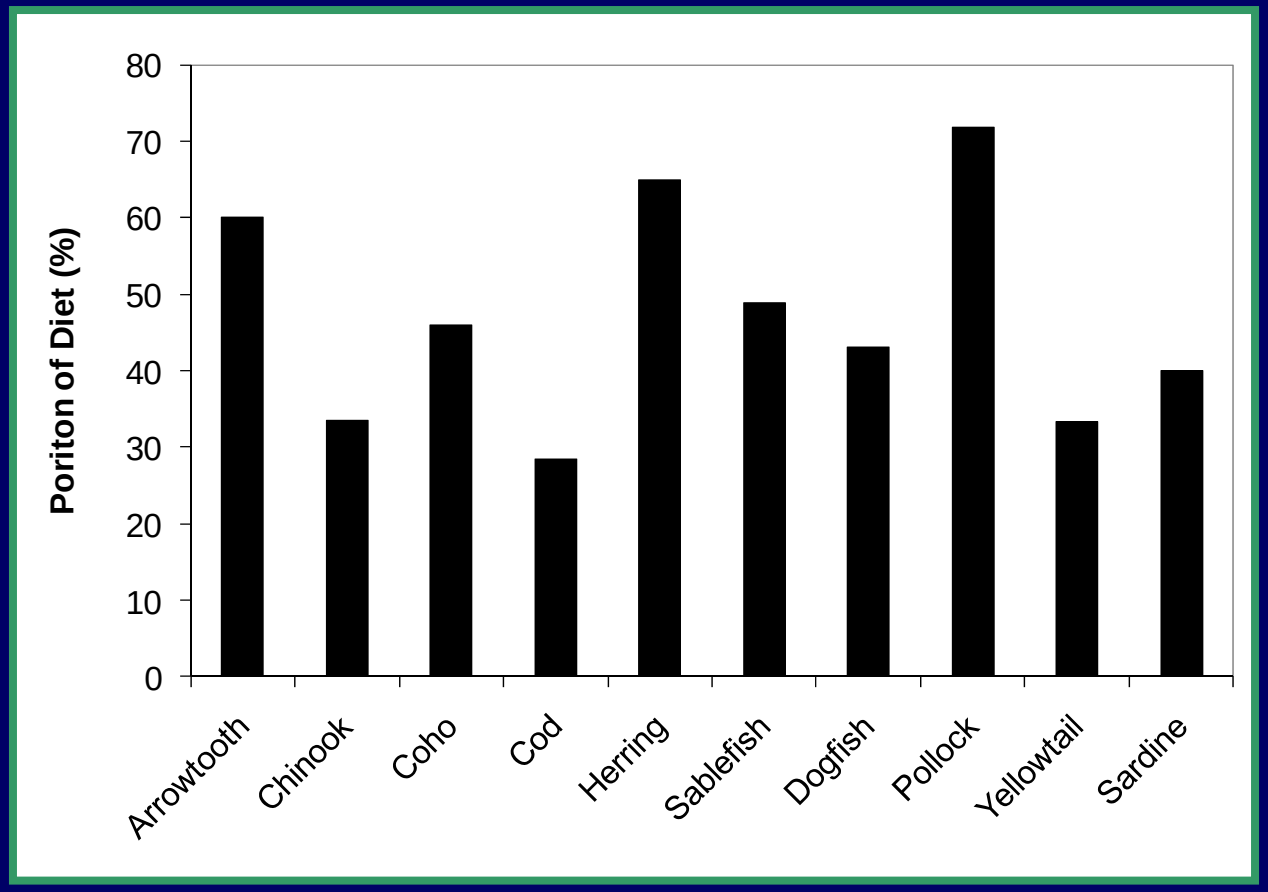
Prey availability mechanism

- Pacific hake diet:
  - euphausiids; small fish (Pacific herring); shrimp

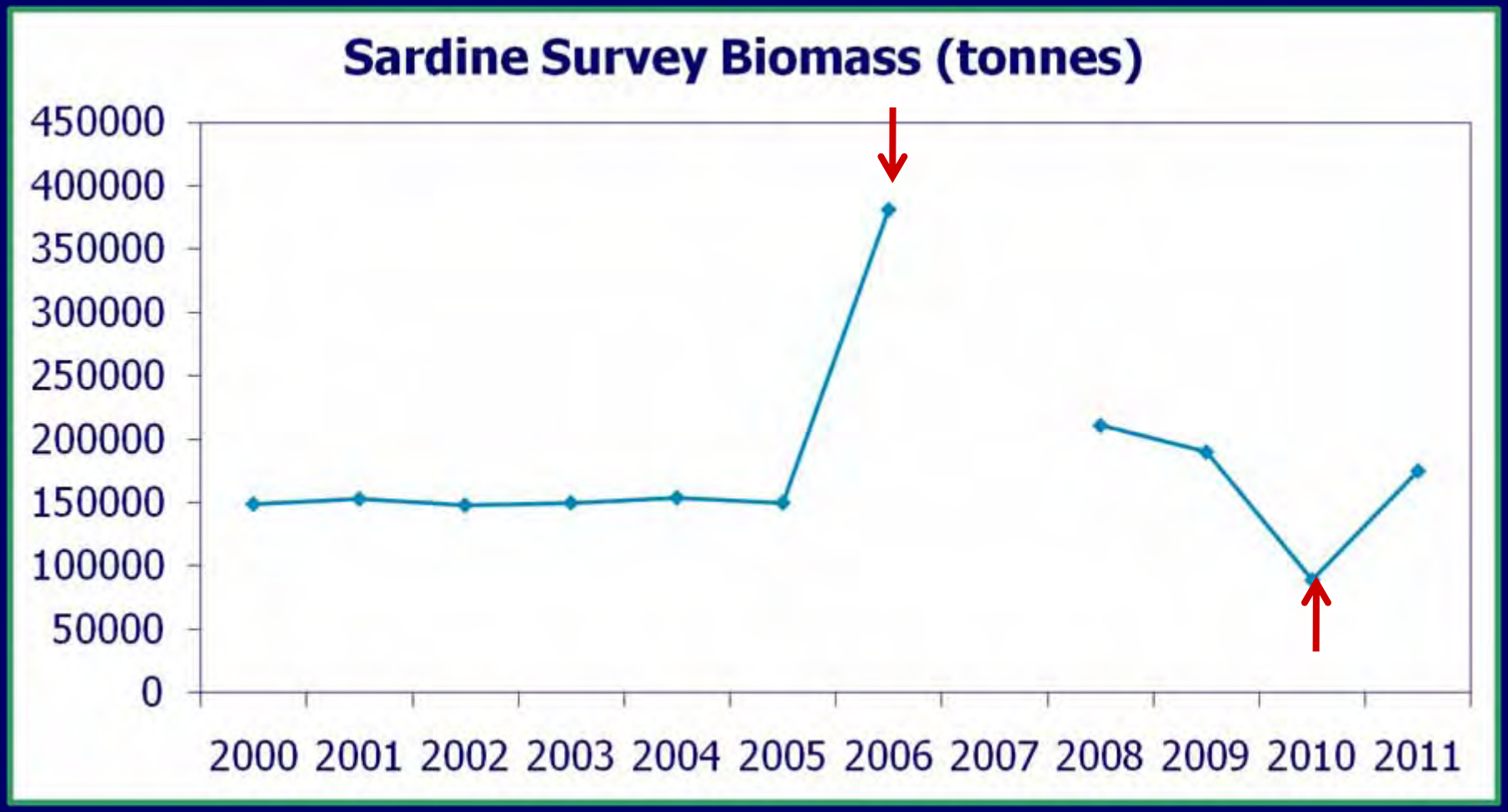


Competitors

- who else eats lots of euphausiids?



Competitor with biomass dynamics



Mechanism of hake redistribution

- Intrinsic mechanism due to:
  - Bottom-up prey availability (previous conceptual mechanisms during ElNino years)
  - Top-down prey availabilty i.e. Impact of competition with ‘new’ competitor of sardines in WCVI
  - ➢ different Extrinsic Mechanisms for each direction which requires flexibility in our search

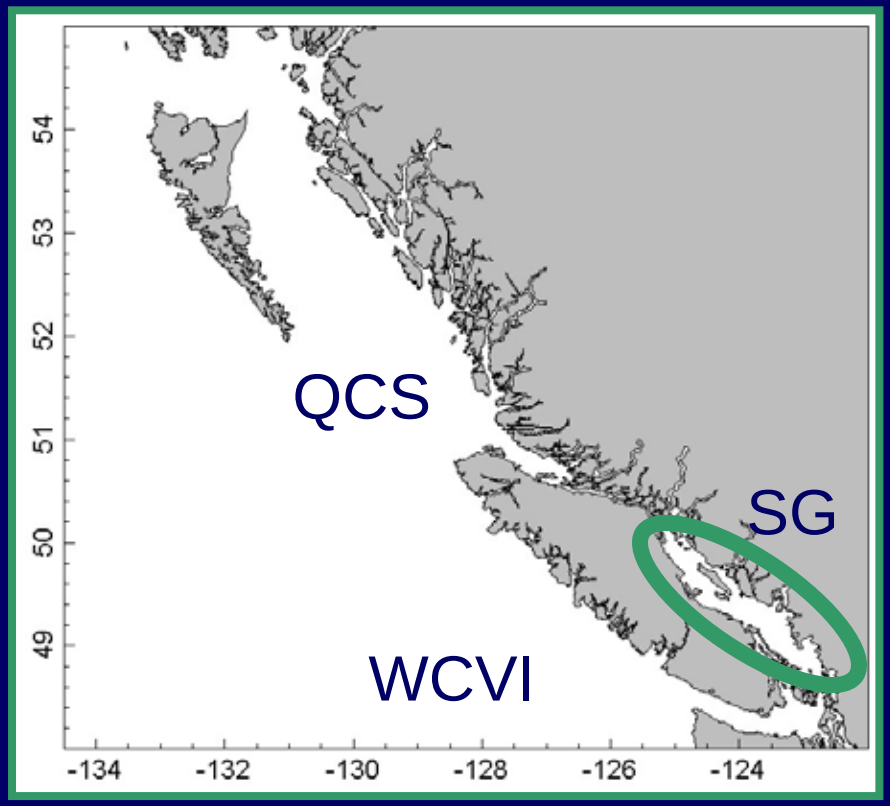
Ecosystem reorganization

- large biomass of Pacific hake redistributed (by 2010)
  - no longer dominate the highly productive LaPerouse Bank of the WCVI
  - major component Queen Charlotte SoundI

Impacts on other competitors in Queen Charlotte Sound?

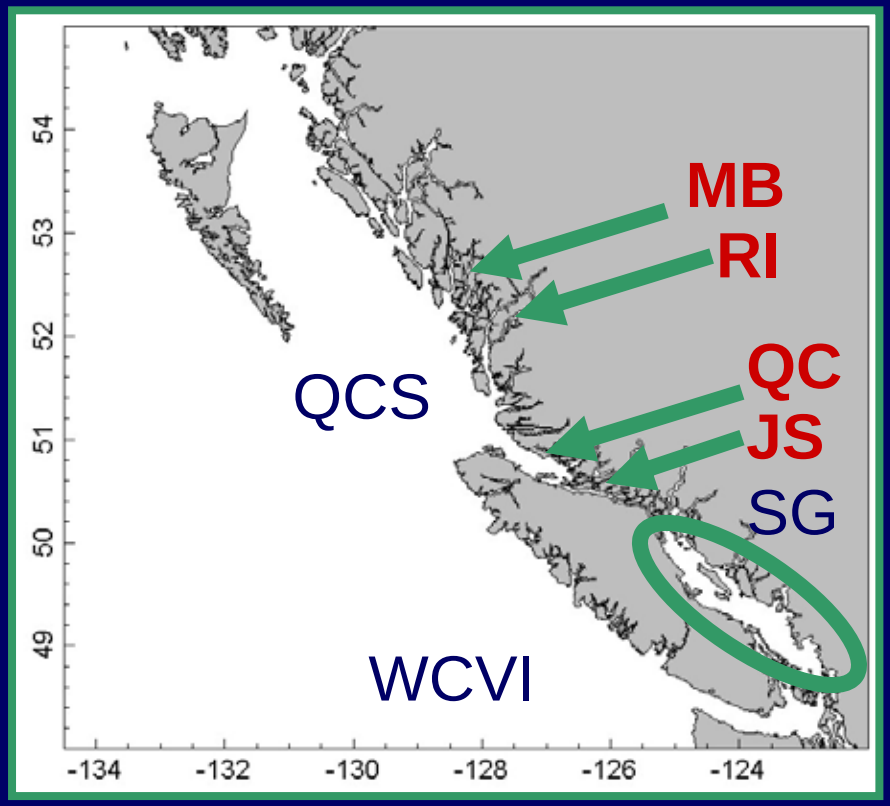
Impacts on other Competitors– other Pacific hake?

- resident population in the Strait of Georgia
- winter fishery on spawning aggregates
  - separate quota
- distinct from the offshore migratory stock
  - concave otoliths
  - absence of parasite *Kudoa paniformis*
  - smaller size at age



Resident Pacific hake stocks

- the events of 2006 were so drastic and unprecedented that fishers raised concern over potential impacts on resident fish that might be feeding in QCS
- deep inlets adjacent to QCS
  - Rivers Inlet
  - Milbanke Sound
  - Queen Charlotte Strait
  - Johnstone Strait



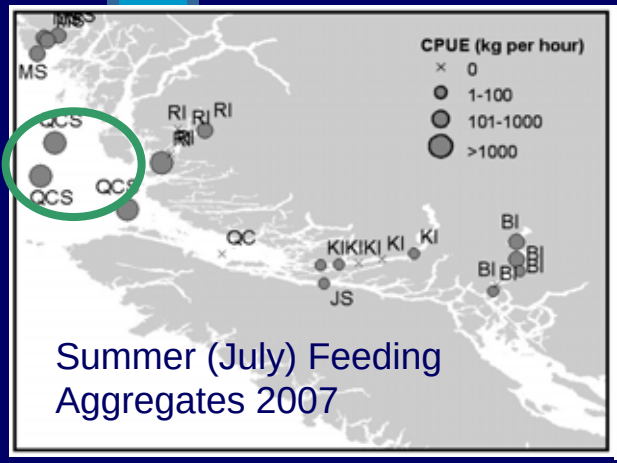
Stock delineation of migratory and resident Pacific hake in Canadian waters

King et al. 2011. ***Fisheries Research***
doi:10.1016/j.fishres.2010.12.024

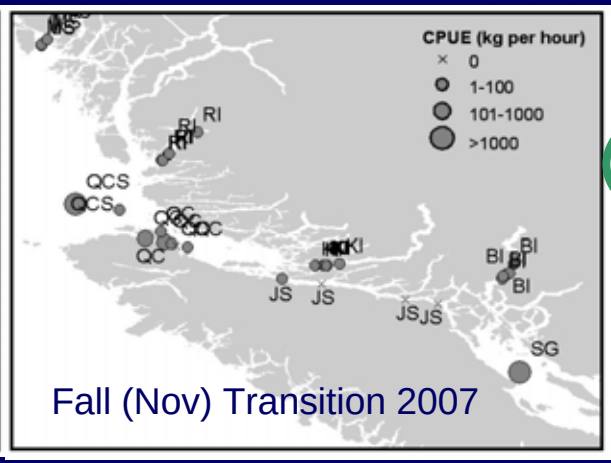
Hake stock delineation surveys

- size distribution; population genetics; parasite presence applied to determine the demographic connectivity of Pacific hake found in Queen Charlotte Sound in summer to:
  1. the coastal migratory population of the California Current System
  2. the known resident population of the Strait of Georgia
  3. potential resident populations in adjacent deepwater inlets

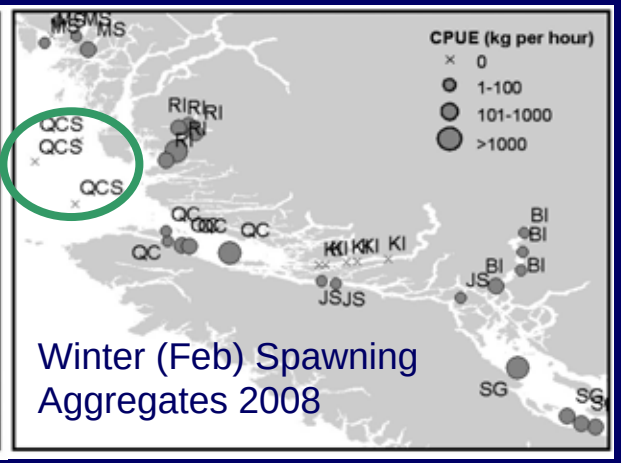
CPUE and size distributions



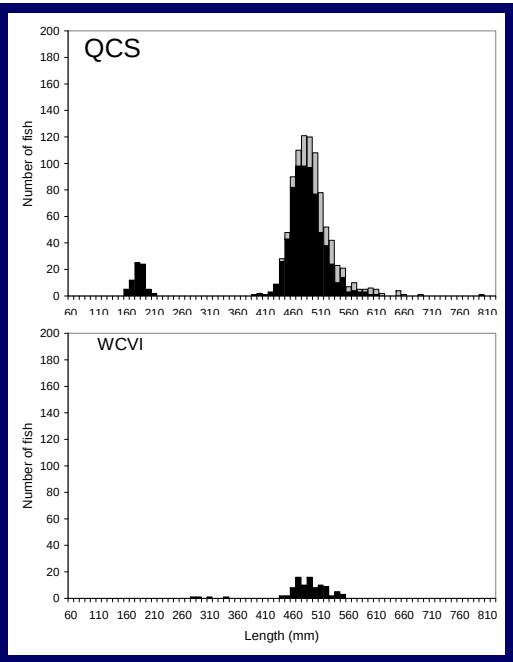
Summer (July) Feeding Aggregates 2007



Fall (Nov) Transition 2007

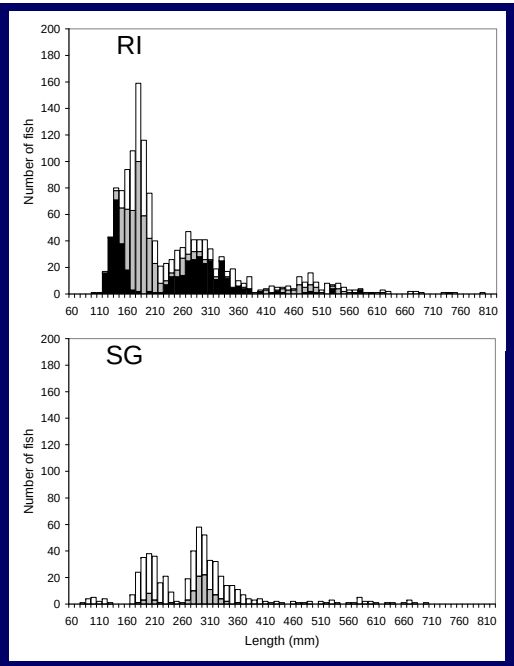


Winter (Feb) Spawning Aggregates 2008



Size distribution

- QCS: big and small
  - WCI similar big
- inlets: similar small



Population genetics

- n=1,430 tissue samples; mtDNA
- pairwise F_{ST} estimates to determine stock

QCS hake in summer not distinct from:

- WCVI hake
- Milbanke Sound hake
- Rivers Inlet

WCVI hake are distinct from:

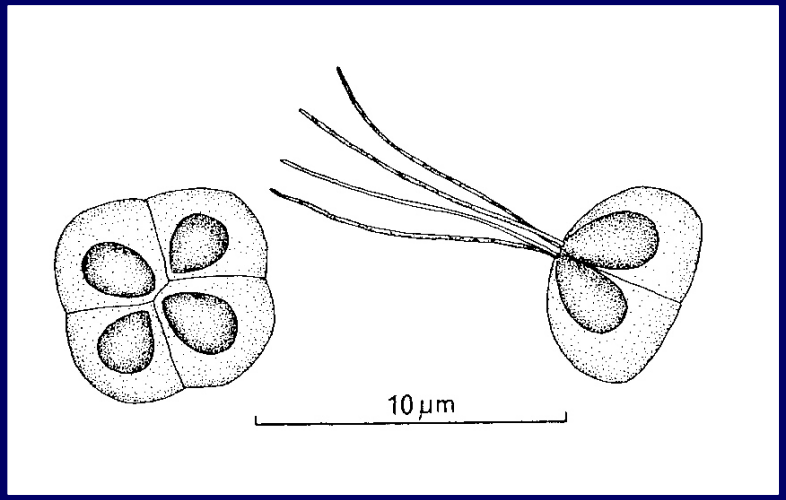
- Strait of Georgia + inlets
- Rivers Inlet
- Milbanke Sound
- Queen Charlotte Strait + Johnstone Strait

- the summer feeding aggregate in QCS is mixed with resident populations – except for SofG hake
- there are several distinct resident stocks in Canada

Parasite presence

- previous stock delineation augmented by:
  - *Kudoa thyrsites* present in both migratory and resident stock (old parasite)
  - *Kudoa paniformis* present only in migratory (new parasite)

Kabata and Whitaker. 1981. CanJZool.



Parasite presence

- new detection of *K. paniformis* in all resident populations; albeit at very low infection levels
  - could have been previously rare and undetected
  - Strait of Georgia hake do not appear to mix with other stocks so not likely due to new patterns in summer mixing
  - intermediate invertebrate host (oligochaete or polychaete) is unidentifed
    - environmental changes with intermediate host's distribution or abundance changes in Strait of Georgia and other inlets

Pacific hake migration changes

- dramatic changes in 2006
  - previous extrinsic mechanisms do not match
  - direction of intrinsic mechanism may require separate extrinsic mechanisms
- the signals of 2010 did not have a lasting impact in 2011 on Pacific hake migratory patterns
- given the biomass and diet of euphausiids, this migration change has a large ecosystem impact
- implications of competition in summer with resident stocks
  - fishery impacts on unassessed resident fish