The Cohen Commission of Inquiry
into the Decline of Sockeye Salmon
in the Fraser River

February 2011
TECHNICAL REPORT 8

Predation on Fraser River Sockeye Salmon

Villy Christensen and Andrew W. Trites

Marine and freshwater predators

Villy Christensen, University of British Columbia

Cohen Commission Science Workshop
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SFU Wosk Centre For Dialogue, March 27, 2013

COHEN COMMISSION

The mystery of the vanishing salmon

Fisheries detectives have plenty of suspects, but say they can point to no single factor in the collapse of the Fraser River sockeye

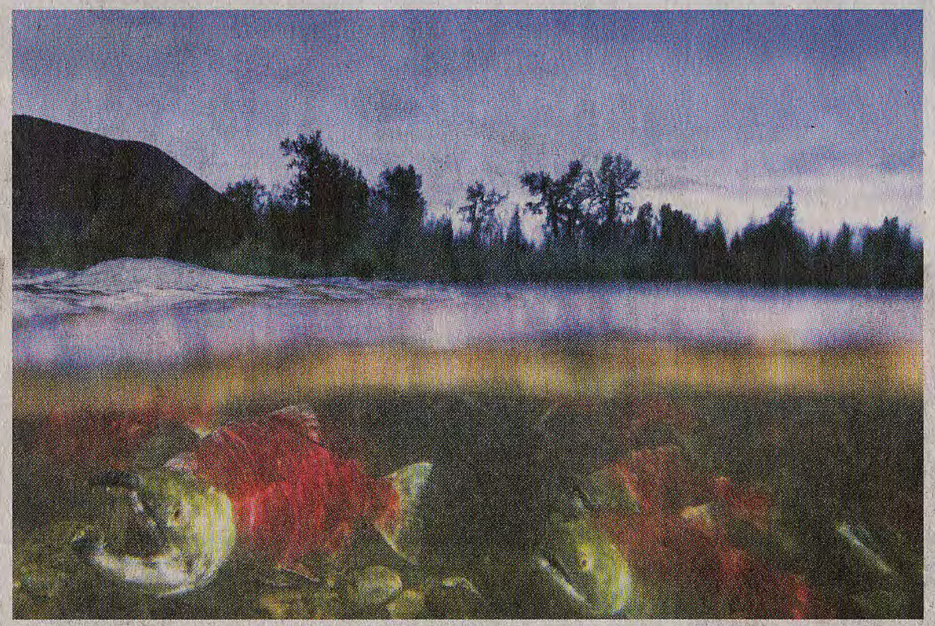
MARK HUME VANCOUVER

The disappearance of millions of sockeye salmon from the Fraser River has been compared to *Murder on the Orient Express* by two scientists helping a federal inquiry solve an environmental mystery.

Andrew Trites and Villy Christensen, both professors at the University of British Columbia Fisheries Centre, made the comparison to the Agatha Christie whodunit as they testified Wednesday at the Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River.

Led by B.C. Supreme Court Justice Bruce Cohen, the commission has been given more than two years and a $25-million budget to figure out why sockeye salmon stocks have been in decline for the past two decades, and why only about one million fish returned to spawn in 2009, when 10 million were expected.

As part of the inquiry, Judge Cohen has assigned teams of scientists to look at 12 different issues, examining everything from climate change to sport fishing to determine the impact on salmon.



Predation alone cannot explain the long downward trend of the sockeye population or the sudden collapse in 2009. JOHN LEHMANN/THE GLOBE AND MAIL

In a report on predation, Dr. Trites and Dr. Christensen tried to find which, among the myriad predators that feast on salmon, could have been responsible for killing so many sockeye as to decimate the population.

They came up with a long list of suspects and then narrowed it down to the six most fearsome killers: salmon sharks (220 kilograms and so aggressive they sometimes bump fishing boats), blue sharks (triangular teeth with finely serrated edges), daggertooths (the name says it all), sablefish (black cod with gaping mouths), lamprey (jawless fish that suck blood) and the common murre (a bird that dives 60 metres deep and can swim faster than a fish).

"It's six," Dr. Christensen said of the top suspect list. "We could have made it eight or 10. ... It's subjective. Salmon shark is at the top of the list. For the rest, it's hard to say [how to rank them]. We found evidence for all of these six, that they might have considerable impact."

In their report, the two science investigators say they are unable to point the finger at any one suspect, because so many factors are at work. They compared their dilemma to the one faced by the detective Hercule Poirot, who finds a passenger has been murdered while the Orient Express is speeding across Europe.

"The murderer had to be on board," states the report. "M. Poirot interviewed everyone on the train, but there was no 'usual suspect,' no smoking gun and no butler. Rather, it seemed that all of the passengers (save M. Poirot) had a motive and an opportunity. That made for a difficult case – who did it?"

The scientists concluded the mysteries on the Fraser River and on the Orient Express had the same answer: "All the suspects played a role and all are guilty."

They state that while all the predators feed on sockeye salmon, none of them does so exclusively, and none to such an extent that it could explain the population collapse. And predation alone, even by all the suspects combined, cannot fully explain the long downward trend of the sockeye population or the sudden collapse in 2009, they say.

"For the Fraser River sockeye, it may well be that the declining survival trend over the last decades was caused by a combination of effects, and not by any single one," they write. "If predation had been the smoking gun in the disappearance of Fraser River sockeye salmon, it should have been smelled by now."

Dr. Trites and Dr. Christensen said the study was hampered by a shortage of up-to-date data and they called for more research on what happens to Fraser River sockeye after they leave fresh water and enter the ocean.

Dr. Christensen said the last major ocean research projects on salmon were undertaken in the 1950s and 1970s, and a new effort, using modern technology, is warranted.

Perhaps it might even solve the mystery of what killed all the salmon.

Fishes live in the sea, as men do a-land;
the great ones eat up the little ones
William Shakespeare

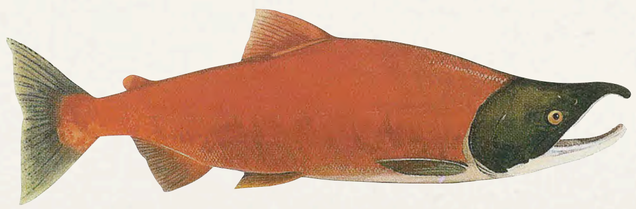
Everybody loves sockeye salmon!

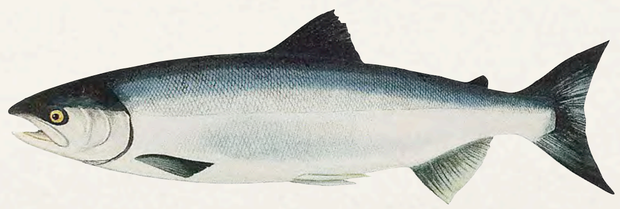
- Through much of their life cycle Fraser River sockeye are a nice mouthful, mostly freely available in the open waters

- Living in the ocean is living in a state of fear:
  - Fish eat fish – when two meet, the smaller one tends to become prey
  - What species it is doesn't really matter as long as the size is about right
  - Most smolts will be eaten, mortality rates are high

Potential predators: whodunit? Required evidence

- The prey and predator must overlap in time and space
- The prey has to be eaten or preferred by the predator
- There has to be a sufficient abundance of the predator for it to have an impact
- The predator abundance must have been increasing in recent decades, or there must be indications that the predator have shifted to feed more on sockeye, e.g., because other prey have become less abundant



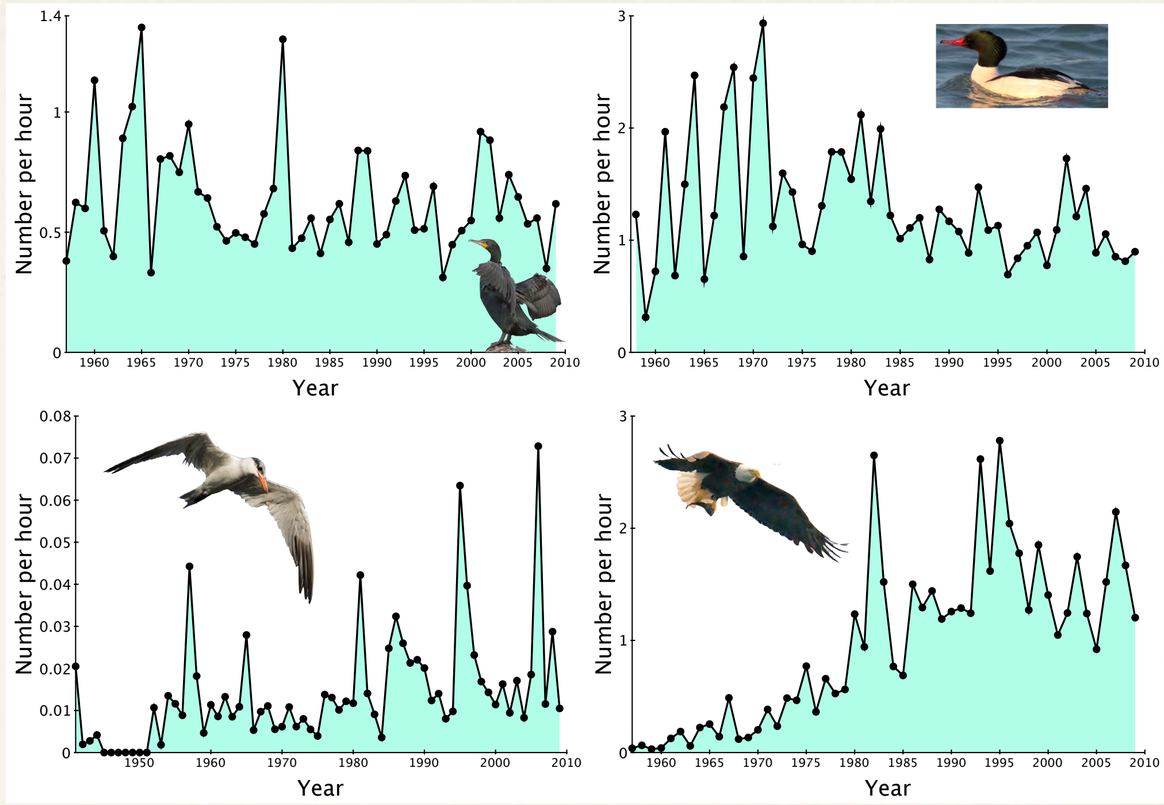


Potential freshwater fish predators

Shading indicates status of knowledge: from no (light) to reliable (dark)

Species		Abundance estimates	Trend estimates	Monitoring
Common name	***Scientific name***			
River lamprey	*Lampetra ayresi*			
Coho salmon	*Oncorhyncus kisutch*			
Chinook salmon	*Oncorhyncus tshawytscha*			
Coastal cutthroat trout	*Oncorhyncus clarkii clarkii*			
Rainbow trout/steelhead	*Oncorhyncus mykiss*			
Bull trout	*Salvelinus confluentus*			
Dolly Varden	*Salvelinus malma*			
Lake trout	*Salvelinus namaycush*			
Northern pikeminnow	*Ptychocheilus oregonensis*			
Burbot	*Lota Lota*			
Smallmouth bass	*Micropterus dolomieu*			
Largemouth bass	*Micropterus salmoides*			
Yellow perch	*Perca flavescens*			
Sculpin spp.	*Cottus* spp.			

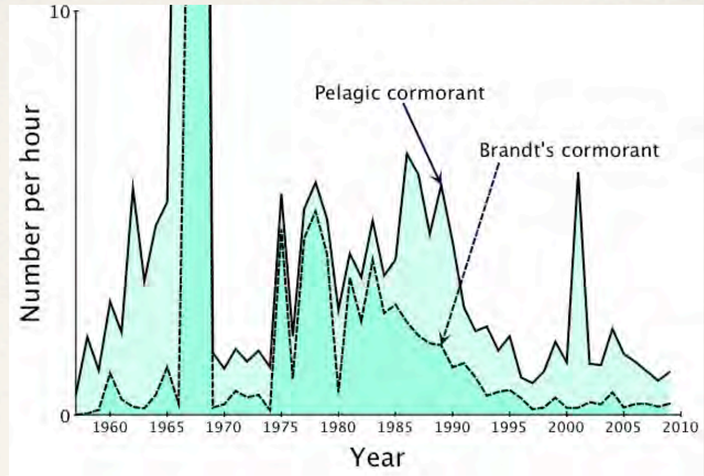
Potential predatory birds in freshwater

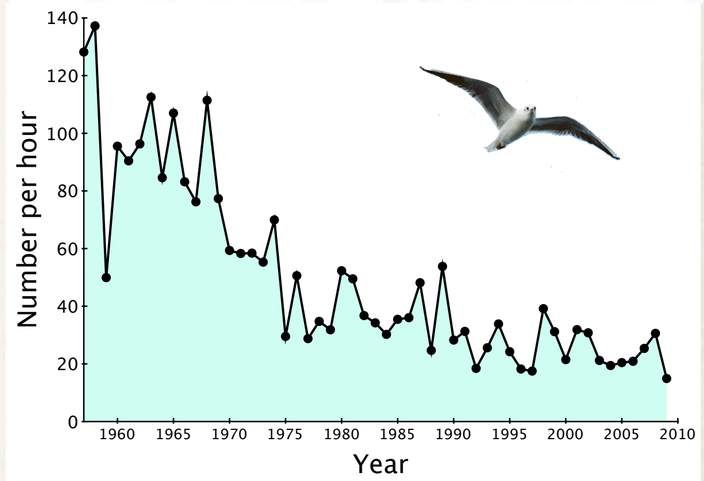


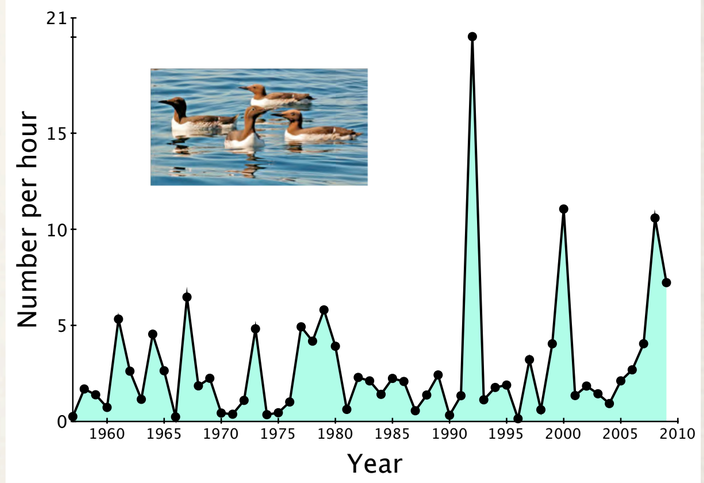
Species		Abundance estimates	Trend estimates	Moni-toring
Common name	***Scientific name***			
Double crested cormorant	*Phalacrororax auritus*			
Common merganser	*Mergus merganser*			
Gulls	*Larus spp.*			
Caspian tern	*Hydroprogne caspia*			
Bald eagle	*Haliaeetus leucocephalus*			
Osprey	*Pandion haliaetus*			

Potential predatory marine birds

Common name	*Scientific name*	Abundance estimates	Trend estimates	Monitoring
Pelagic cormorant	*Phalacrorax pelagicus*			
Brandt's cormorant	*Phalacrorax penicillatus*			
Common merganser	*Mergus merganser*			
Gulls	*Larus spp.*			
Terns	*Sterna spp.*			
Common murre	*Uria aalge*			





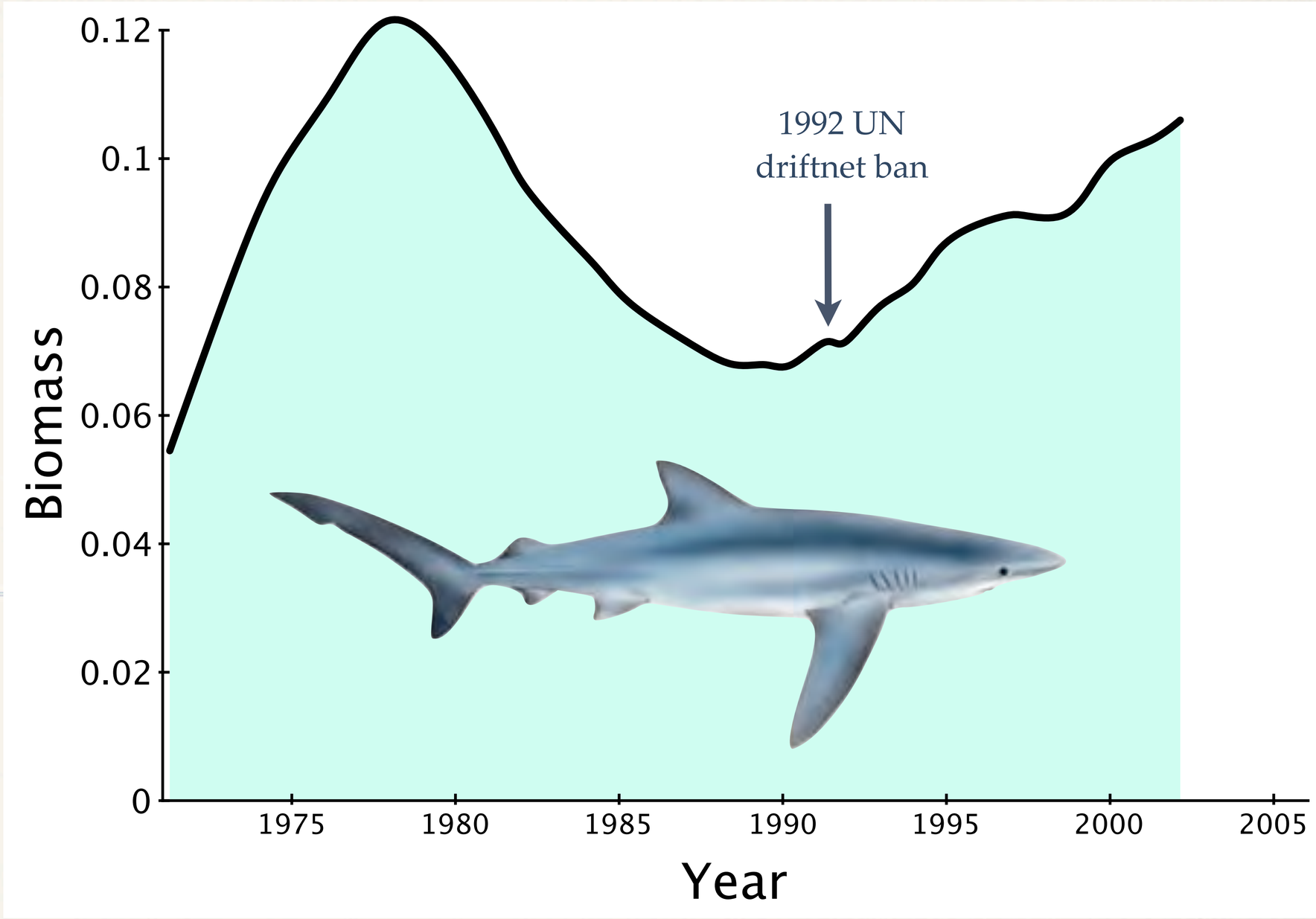


Potential marine fish predators

Species		Abundance estimates	Trend estimates	Monitoring
Common name	***Scientific name***			
Humboldt squid	*Dosidicus gigas*			
River lamprey	*Lampetra ayresi*			
Spiny dogfish	*Squalus aconthias*			
Salmon shark	*Lamna diprosis*			
Blue shark	*Prionace glauca*			
Pacific sleeper shark	*Somniosus pacificus*			
Pacific herring	*Clupea harengus pallasi*			
Coho salmon	*Oncorhyncus kisutch*			
Chinook salmon	*Oncorhyncus tshawytscha*			
Daggertooth	*Anotopterus nikparini*			
Sablefish	*Anapoploma fimbria*			
Pacific cod	*Gadus macrocephalus*			
Tomcod	*MIcrogadus proximu*			
Walleye pollock	*Theragra chalcogramma*			
Pacific hake	*Merluccius productus*			
Arrowtooth flounder	*Atheresthes stomias*			
Pacific jack mackerel	*Trachurus symmetricus*			
Pacific mackerel	*Scomber japonicus*			

Potential marine fish predators: blue shark

- Blue sharks are abundant (100,000 t)
- Diet is varied
- Predator on salmon, but not specialized



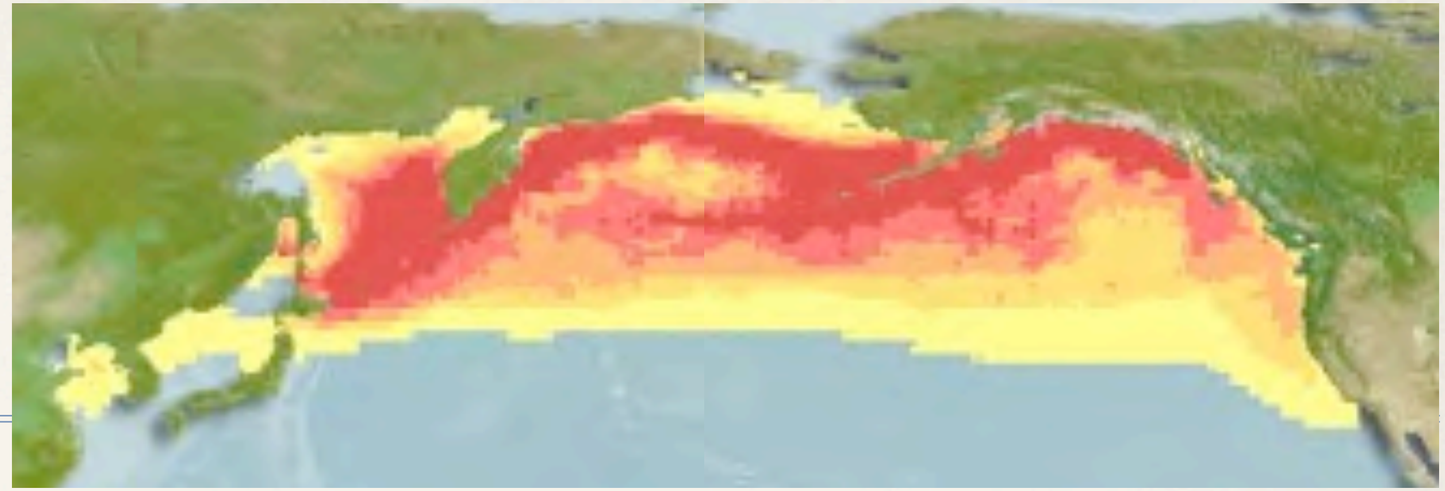
Salmon shark

- Up to 3 meter and 300 kg

- “Salmon are preferred food during the summer months for salmon sharks that move to coastal areas”
- Feed primarily on salmon in spring and winter in the western North Pacific and Bering sea with sockeye averaging 40% of stomach content (in 1958-59)
- Abundance: Lower than blue shark
- Trend: similar to blue shark?

Salmon shark

- Post-Cohen estimates:
  - Williams et al (2010) estimated the salmon shark population in the BC surface waters to ~17,000 individuals
- Annual consumption of sockeye by these salmon shark could be 700,000



http://www.topp.org

Daggertooth

- Pelagic species, up to 146 cm; prey up to half its size
- Diet is varied and include sockeye salmon
- Abundance?
- Trends?
- ~15% of maturing sockeye had daggertooth injuries in 2003-2004

Daggertooth. Photo: William van Orden

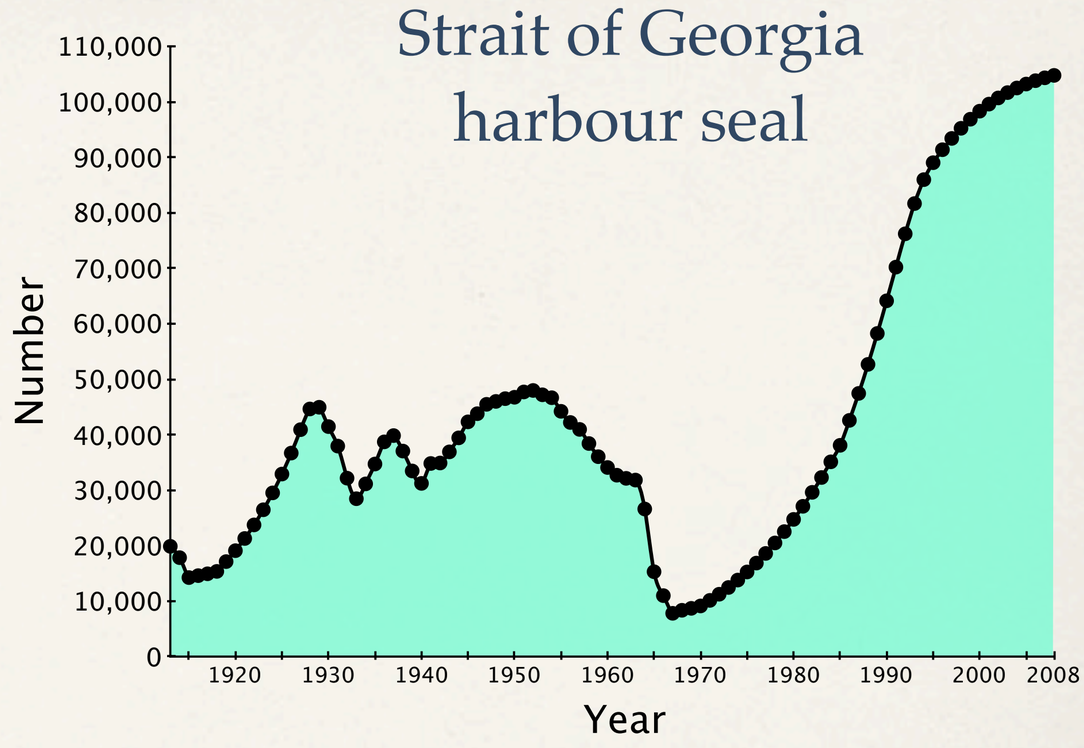
Angler with a Fraser River sockeye salmon with recent, presumed daggertooth slash wound, Aug. 2010

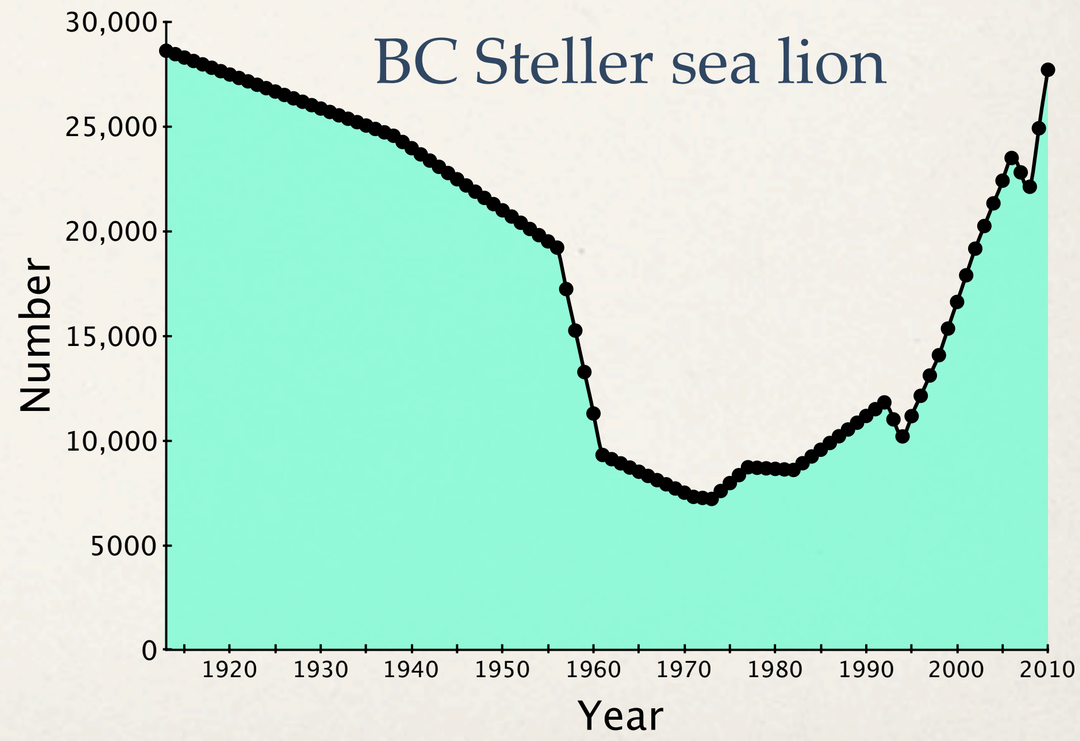
Potential marine mammal predators

Species		Abundance estimates	Trend estimates	Monitoring
Common name	***Scientific name***			
Harbour seal	*Phoca vitulina richardsi*			
Steller sea lion	*Eumetopias jubatus*			
California sea lion	*Zalophus californianus*			
Northern fur seal	*Callorhinus ursinus*			
Killer whale (residents)	*Orcinus orca*			
Dall's porpoise	*Phocoenoides dalli*			
Pacific white-sided dolphin	*Lagenorhynchus obliquidens*			
Harbour porpoise	*Phocoena phocoena*			
humpback whales	*Megaptera novaeangliae*			

Usual suspects: seals and sea lions

- Seal diet (1982-1988): mainly hake & herring, salmonids 4% of diet
  - No evidence of sockeye smolts being eaten
- Sea lion diet: 30% herring, 18% hake, 17% salmon, 15% rockfish, ...
  - Of salmon 9% were sockeye





Conclusions – the culprit?

- "Alternative prey" have decreased, which may have caused increased predation pressure on sockeye, but lack data to evaluate this
- Seal and sea lion populations have increased in BC and SE Alaska since late 1970s, but no evidence that sockeye is a preferred prey
- No indication that any individual mammal predator targeted sockeye or that any pose a threat to the population
- We conclude that no single predator may have caused the decline of Fraser River sockeye (but some may have contributed)
- Predation is more likely to be part of the cumulative threats facing sockeye

Did the butler do it?

Conclusions – cumulative threats

- Cumulative threats are far more difficult to evaluate than a single factor

- Stress from higher water temperatures and running the gauntlet through predators, whose alternative prey may have diminished, may all have had cumulative effects

- Assessing the cumulative effects of these and other stresses will require integrated evaluation, but information about ecosystem resources and interactions is not available

- We conclude that there is little to no information to evaluate the cumulative effect of predation on Fraser River sockeye salmon with certainty

- Overall: surprisingly little information about the ecology of Fraser River sockeye!

Recommendations: dynamics

- #64: DFO should undertake or commission research on Fraser River sockeye salmon smolts at the mouth of the Fraser River estuary to determine stock abundance, health, condition, and rates of mortality

- #65: DFO should undertake or commission research, in collaboration with academic researchers and, if possible, the Pacific Salmon Commission or another appropriate organization, into where and when significant mortality occurs in the nearshore marine environment, through studies of the outmigration from the mouth of the Fraser River through to the open ocean

Recommendations: cumulative effects

- #71: DFO should develop and carry out a research strategy to assess the cumulative effects of stressors on Fraser River sockeye salmon and their habitats. Cumulative effects may include multiple sources of a stressor, exposure to stressors over the life cycle of Fraser River sockeye, or exposure to multiple types of stressors interacting in a cumulative manner.

- #72: DFO should consider the cumulative effects of stressors on Fraser River sockeye health and habitat in its management of fisheries and fish habitat.

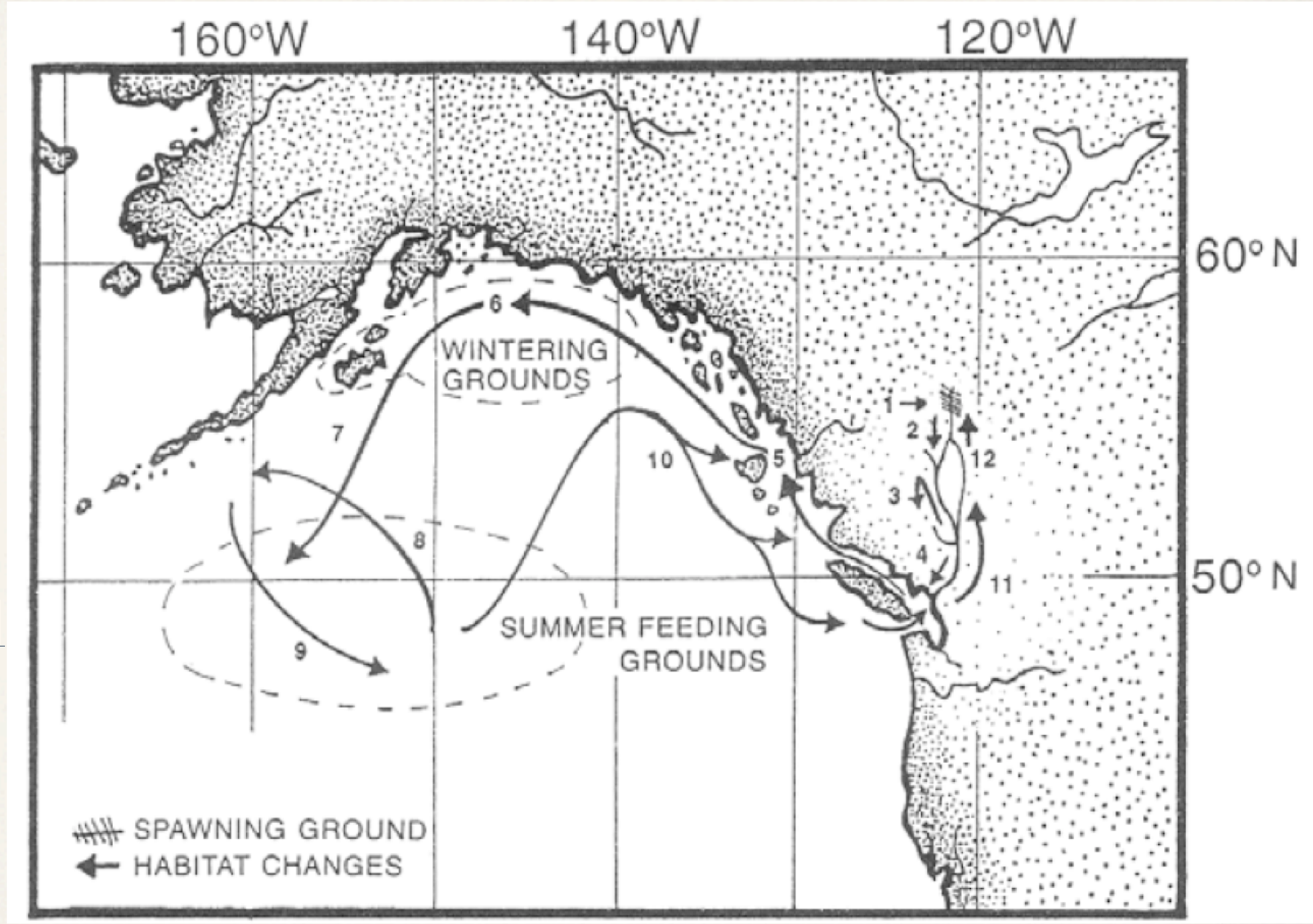
Recommendations: ecosystem info

- #73: DFO should develop and maintain a central inventory of information about existing and new Fraser River sockeye salmon research. DFO should make the inventory available to the public, and make the information in the inventory available to non-DFO scientific researchers.

- #66: In furtherance of Canada's understanding about what regulates Fraser River sockeye abundance and distribution, Canada should propose an international, integrated ecosystem research program to measure biological, chemical, and physical oceanographic variables in the offshore Gulf of Alaska. Some or all of the research would be conducted in collaboration with academic researchers, PICES, and/or the North Pacific Anadromous Fish Commission.

Overlap in time and space:

Last coordinated open ocean studies in the 1950s and 1970s



Can we afford it?

- Can we afford not to?

Federal budget cuts $100 million from fisheries and oceans over three years

BY PETER O'NEIL AND GORDON HOEKSTRA, VANCOUVER SUN MARCH 21, 2013

STORY PHOTOS (1)

The Harper government took another axe to the department of fisheries and oceans in Thursday's budget, chopping a total of roughly $100 million over three years starting in 2015-16.

Photograph by: Rebecca Blisset , Postmedia files

OTTAWA – The Harper government took another axe to the Department of Fisheries and Oceans in Thursday's budget.

The department will have to cut spending by $33 million a year starting in 2015-16 – the year the government vows to balance the budget.

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