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MEMORANDUM FOR THE MINISTER

POTENTIAL CAUSES OF POOR RETURNS OF FRASER RIVER SOCKEYE SALMON; WITH FOCUS ON DISEASE-RELATED FACTORS

(Information Only)

SUMMARY

- In a previous briefing note, ten factors were listed which could have led to the poor returns of Fraser sockeye in 2009. The three factors considered most likely to account for the scale of the mortality observed are: toxic algal blooms in the Strait of Georgia, low food abundance in Queen Charlotte Sound and disease. This note elaborates on one emerging disease factor.
- Pacific Region Science staff has documented an association between poor survival of adult migrating sockeye salmon and a particular pattern of gene responses which control physiological responses and could indicate viral activity.
- Sockeye salmon have also been found to have brain lesions. Lesions were first detected in 2009 in samples from 2006, a year when 13 million sockeye returned to the Fraser River.
- In subsequent examinations, Fisheries and Oceans Canada (DFO) staff found lesions in the brains of southern BC coho, chinook, and sockeye salmon, and across a range of life stages and sample years. The gene response pattern has also been observed across species.
- The gene response pattern and the presence of lesions have not been directly linked, but they are thought to be related to a viral infection. Molecular screening to date has not yielded a positive identification. Parasitic infections are also likely present.
- Analysis is ongoing. However, given its widespread distribution, the disease agent is thought to be endemic.
- Disease usually acts in combination with other factors (e.g., warm water conditions) rather than causing mortality directly.

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Background

- In a previous briefing note (2009-507-00143, copy attached), disease was suggested as one of a number of possible factors which could have contributed to the poor returns of Fraser sockeye in 2009. These factors were:
  - Most likely – toxic algal blooms in the Strait of Georgia, low food abundance in Queen Charlotte Sound and **disease,**
  - Possible – predation by Humboldt squid, interception by US fisheries, sea lice from farms in Discovery Passage,
  - Unlikely – pollution in Fraser River, Canadian fisheries, predation on juvenile salmon in the Strait of Georgia, low food abundance in the Strait of Georgia.
- Work is continuing in Pacific Region to assess each of these factors and further information will be provided as it becomes available. Science teams have been formed to focus on each of three high profile and/or likely causes; a disease-related event, interactions with aquaculture (sea lice), and low food abundance in Queen Charlotte Sound (as well as in the Strait of Georgia).
- This note describes one emerging disease factor. Forthcoming notes will describe the progress on the other two.

Disease as a potential factor:

- In studies conducted over the past few years, Fisheries and Oceans Canada (DFO) staff noted evidence of poor survival in migrating adult sockeye salmon that had a particular pattern of gene response which is consistent with a viral infection. In 2006, Fraser sockeye showing this gene response experienced 30-60% higher mortality while approaching the coast and in the river than salmon that did not show the gene response pattern.
- While this pattern was first observed in samples collected from 2006, it has since been found in samples from other years back to 2003. However, a variable proportion of fish were affected each year.
- On further investigation in 2009, DFO scientists found that significant numbers of adult migrating sockeye salmon in these earlier years also contained lesions in the optic lobe of their brain and that the proportion of such fish declined sharply during the return migration. For instance, in 2009, over 70% of the sockeye salmon had lesions as they approached the coast, but this dropped to 50% in the lower river and to less than 30% at the spawning grounds. This suggests an association between the presence of lesions and en-route mortality.
- The same pattern has been found in sockeye smolts prior to them leaving the river, and in juveniles of three species (sockeye, coho, and chinook) during their first summer at sea, indicating an association with early ocean mortality in all three species.

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Analysis

- The widespread observations of lesions and gene response pattern across different species, stocks, life history stages, and sample years suggest that any disease agent is endemic and has been present in salmon populations for some time.
- The gene response pattern is thought to be related to a virus. A virus from the retroviral family would be consistent with the pattern, however, few retroviruses have been described in salmon and no conclusive identification of a specific retrovirus has been made.
- The evidence of brain lesions is new and it will take some time to document the geographic extent and to understand a relationship (if any) between a disease agent and mortality.
- Other causes (than a virus) have been considered. Several different parasites are known to infect adult sockeye salmon as they migrate up the Fraser River. A myxosporean (parasitic) infection has been found (in 11of 12 fish) in a small sample of brains of sockeye salmon so examined. Myxosporean infections are known to have a significant impact on swimming performance of sockeye smolts.
- Aquaculture operations are not considered a factor since lesions and the gene response pattern have been found in samples of sockeye smolts collected before they would have entered the marine environment.
- Other factors commonly act in combination with disease to cause mortality, rather than disease causing mortality directly. The virulence of pathogens can depend upon the level of stress of the fish (for example, those chronically stressed because of high river temperatures). Also, non-lethal infections can weaken immunity and increase the susceptibility of fish to other pathogens and to predation.
- The presence of a virus or parasite may not manifest itself as a disease or cause mortalities. In 2006, 13 million salmon returned to the Fraser River despite a high incidence of brain lesions.
- Confirmation of a disease would require isolation of the disease agent along with a demonstration of infectivity in controlled experiments.

Next Steps

- More samples are being analyzed to determine the extent of the pattern observed, for example, whether or not lesions or gene response patterns can be detected in sockeye salmon originating outside of southern BC. Additional research is also attempting to clarify which disease agents might be present.
- Further briefings on this issue will follow as necessary/requested.

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- **Subsequent briefings will focus on several other high profile potential causes: sea lice and low food abundance.**

Claire Dansereau

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Government of Canada
Fisheries and Oceans

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To: Pour: Mme. Claire Dansereau, Deputy Minister Date: NOV - 2 2009

Object:

FACTORS AFFECTING THE 2009 FRASER SOCKEYE RETURN
(For the Minister's Information)

Obtained under the Access Act by Ken Rubin from Fisheries

From: Paul Sprout, Regional Director General, Pacific Region NOV - 2 2009

Via: Wendy Watson-Wright, Assistant Deputy Minister, Science

Via: David Balfour, A/Assistant Deputy Minister, Fisheries and Aquaculture Management

☐ Your Signature / Votre signature	☒ Information
☐ For Comments / Observations	☐ Material for the Minister / Documents pour le Ministre

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MEMORANDUM FOR THE MINISTER

FACTORS AFFECTING THE 2009 FRASER SOCKEYE RETURN

(Information Only)

SUMMARY

- Sockeye salmon returns to the Fraser River in 2009 are significantly below the pre-season forecast. While the explanation for the poor 2009 Fraser return is not known, a number of factors could be important.
- Viral disease, toxic algal blooms and/or low food availability in Queen Charlotte Sound could have led to sockeye mortality at the level observed.
- Sea lice from fish farms, Humboldt squid predation and U.S. fisheries could have contributed to the sockeye mortality but are likely insufficient in themselves to explain the poor return.
- Staff continue to assemble data and analyze the key hypotheses which could inform a post-season review.

Background

- Sockeye salmon returns to the Fraser River in 2009 are significantly below the pre-season forecast. The actual return is now estimated to be on the order of 1.4 million fish, whereas more than 6 million fish were expected. One exception is Harrison sockeye, which returned to the Fraser system significantly above expectation.
- Unlike other recent years when returns to the Fraser were poor, sockeye returns to Barkley Sound and the Columbia system were above expectations. However, returns to the Skeena were also poor.
- While the explanation for the poor 2009 Fraser return is not known, staff have now considered factors which could have impacted sockeye at different stages of their life cycle as they migrated from their lake-rearing habitats to the Strait of Georgia.(spring/early summer 2007), on to the Gulf of Alaska and the Bering Sea and back again to spawn.

Analysis / DFO Comment

- The following factors are unlikely to have contributed to the poor 2009 return:
  1. **Pollution in the Fraser River**. There is no record of any Fraser Basin wide environmental incident that could have impacted the fish.

2. **Capture by Canadian fisheries.** In 2009, the Canadian fishery was minimal and did not contribute to the poor return.
3. **Predation on juvenile salmon in Strait of Georgia.** There are no known shifts in predator abundance that could explain increased predation in 2007.
4. **Low food abundance in the Strait of Georgia.** Juvenile sockeye feed on krill. A krill fishery takes place in Jervis Inlet, but it removes a small amount of krill relative to the total krill biomass. Staff will review survey data for any evidence that juvenile sockeye were food deprived.

- The following factors may have contributed to sockeye mortality, but not at a magnitude sufficient to explain the poor return in 2009:
  1. **Predation by Humboldt squid.** Humboldt squid is a voracious predator that has increased dramatically in abundance in Canadian waters since 2007. Salmon have not been identified in their diet. Surveys in 2009 will be analyzed to assess any possible link to salmon.
  2. **Capture by U.S. fisheries**. Fraser sockeye are intercepted in U.S. Gulf of Alaska fisheries and Bering Sea fisheries. The level is not well documented but appears to be very low.
  3. **Mortality attributed to sea lice from fish farms in Discovery Passage.** While sea lice from farms could have contributed some mortality of juvenile sockeye, sea lice from natural sources could also be a factor. Staff are assessing the lice loads on farms at the time of the 2007 migration.
- The following factors could possibly have led to sockeye mortality at the scale observed:
  1. **Toxic algal blooms in the Strait of Georgia -**Extensive blooms of toxic marine algae were identified in the Strait of Georgia during 2007 when juvenile sockeye were present. Staff are working with Vancouver Island University and the aquaculture industry to assess any possible link.
  2. **Low food abundance in Queen Charlotte Sound**. Poor food supply may have impacted the survival of juvenile sockeye in Queen Charlotte Sound in the spring of 2007.
  3. **Viral disease.** Preliminary evidence suggests that Fraser sockeye may be infected with a virus that could lead to mortality throughout the salmon life cycle. Staff are conducting further tests to confirm whether or not a virus could be present.

Recommendations / Next Steps

- Staff are continuing to assemble data and analyze the key hypotheses which could inform a post season review.
- Studies on the link to a potential viral disease are proceeding and more information is expected within the next month.

Claire Dansereau