

1. Irvine, J.R., Godbout, L., Brown, L., Borstad, G., Mackas, D., and Thomson, R., 2010: Do marine conditions in Queen Charlotte Sound limit the marine survival of Chilko Sockeye Salmon?, in Crawford, W.R., and J.R. Irvine. 2010. State of physical, biological, and selected fishery resources of Pacific Canadian marine ecosystems in 2009. *DFO Can. Sci. Advis. Sec. Res. Doc.* 2010/053. viii + 137 p.

This paper shows statistical correlation between concentrations of chlorophyll in spring and returns of Chilko sockeye out migrating in that spring. This tries to get at the complicated "time and space" problem that was discussed in part 1 of the Marine Environment hearings. Related to this report is the following journal publication:

2. Borstad, G., Crawford, W.R., Hipfner, J.M., Thomson, R., and Hyatt, K. 2011. Environmental control of the breeding success of rhinoceros auklets at Triangle Island, BC. *Marine Ecology Progress Series* **424**: 302.
[Exhibit 806](#)

While this publication focuses on the seabirds, these seabirds are eating similar food to that of migrating juvenile salmon. Perhaps related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Pacific salmon in BC.

3. Welch, D. W., Y. Ishida, et al. (1998). "Thermal limits and ocean migrations of sockeye salmon (*Oncorhynchus nerka*): long-term consequences of global warming. doi:10.1139/f98-023." *Canadian Journal of Fisheries and Aquatic Sciences* **55**(4): 937-948.

This paper uses the results from an early global climate model and published relationships between sea surface temperature and sockeye salmon distribution to develop a forecast or scenario for future distribution of sockeye salmon. It suggests that sockeye salmon might be restricted to the Bering Sea in the summer, under a doubling of atmospheric CO₂. This was a controversial result when it was published. Perhaps not tightly related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Pacific salmon, especially those at the southern end of their range.

4. Ikononou et al. 2011 Residues of Polybrominated Diphenyl Ethers (PBDEs) in North-Eastern Pacific Marine Fish: Evidence for Spatial and Temporal trends. *Environ. Toxicol. Chem.*

This is a very new publication which summarizes some of the information on a contaminants of emerging concern. Unlikely to be related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Fraser River sockeye salmon.

5. Ware, D.M. and Thomson, R.E. 2005. Bottom-up ecosystem trophic dynamics determine fish production in the Northeast Pacific. *Science* **308**: 1280-1284.
[Exhibit 1312](#)

This is an important paper in an important journal. The authors compared productivity of RESIDENT fish stocks (those that don't move around a lot) with primary and secondary productivity estimates from satellite and other sources. It confirmed that "bottom up" forcing seemed to be controlling the productivity (catch) of fish stocks, as opposed to "top down" control exerted by fishing (a HUGE ongoing debate in marine science; the equivalent scientists in DFO on the East Coast have come to the OPPOSITE conclusion and both are probably correct - fishing probably does/did control the productivity, structure and function of the Atlantic zone). The authors excluded salmon and other highly migratory stocks from this

analysis because of the difficulty in assigning them to an identified area with and identified primary (or secondary) productivity. Both of these authors are previous recipients of the Timothy R. Parsons Medal.

6. Mackas,D., Batten,S.D., and Trudel,M. 2007. Effects on zooplankton of a warming ocean: recent evidence from the Northeast Pacific. *Progress in Oceanography* **75**: 223-252.

This paper documents changes in zooplankton composition, in comparison with west coast coho growth and marine survival, and with seabird reproductive success. Perhaps related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Pacific salmon in BC.

7. Thomson,R.E. and Hourston,R. 2011. A matter of timing: the role of ocean conditions in the initiation of spawning migration by late-run Fraser River sockeye salmon (*Onchorhynchus nerka*). *Fisheries Oceanography* **20**: 47-65.

This paper addresses the issue of how ocean conditions control the migration of late run sockeye and may explain the "late-run problem". Perhaps not tightly related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Fraser River sockeye salmon.

8. Morrison, J., M.C. Quick, and M.G.G. Foreman. 2002. Climate change in the Fraser watershed: Flow and temperature predictions. *Journal of Hydrology*, 263: 230-244.

This publication uses future climate predictions derived from downscaling output from the CCCMa global climate model to look at future river conditions for Fraser River sockeye. These are the kind of bleak predictions that Mike Healey referred to in his manuscript/publication and submission.. Perhaps not tightly related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Fraser River sockeye salmon.

9. Denman,K.L., Christian,J.R., Steiner,N., Portner,H.O., and Nojiri,Y. 2011. Potential impacts of future ocean acidification on marine ecosystems and fisheries. *ICES Journal of Marine Sciences*. 68(6), 1019-1029.doi:10.1093/icesjms/fsr074

This publication uses the CCCMa Canadian Earth Simulator Model (CanESM) to assess potential ocean acidification changes and impacts. It makes a particular point that a "multiple stressors" framework will be required to properly anticipate impacts on organisms, as there are expected to be simultaneous in other important stressors (i.e. temperature, dissolved oxygen and micronutrients) along with changes in pH. Perhaps not tightly related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Pacific salmon, especially those at the southern end of their range.

10. Hamme,R.C., Webley,P.W., Crawford,W.R., Whitney,F.A., DeGrandpre,M.D., Emerson,S.R., Eriksen,C.C., Giesbrecht,K.E., Gower,J., Kavanaugh,M.T., Pena,M.A., Sabine,C.L., Batten,S.D., Coogan,L.A., Grundle,D.S., and Lockwood,D. 2010. Volcanic ash fuels anomalous plankton bloom in subarctic northeast Pacific. *Geophy.Res.Letts.* **37**.

This publication has received attention in earlier testimony. There is debate about the impact of this on 2010 Fraser Sockeye returns (In part 1 of the marine Environment testimony), but it is instructive on the kinds of changes in the structure, function and productivity of the North Pacific that are possible. The *in*

situ measurements would have been hard to believe and understand without the temporal and areal coverage provided by the satellite chlorophyll measurements.

11. Foreman, M.G.G., Pal, B. and Merryfield, W.J. (2011) Trends in Upwelling and Downwelling Winds along the British Columbia Shelf. Accepted for publication in J. Geophys. Res

This is a careful retrospective analysis of winds along the continental shelf of BC. Winds and their ability to drive upwelling of nutrient-rich water are thought to have a significant impact on the productivity of the continental shelf ecosystem which is inhabited by migrating Pacific salmon. Perhaps not tightly related to the question of the returns of Fraser Sockeye in 2009 and 2010, possibly somewhat related to the long term decline but more likely related to the future of Pacific salmon, especially those at the southern end of their range.