

From: Richards, Laura
Sent: Friday, August 14, 2009 3:50 PM
To: Saunders, Mark <Mark.Saunders@dfo-mpo.gc.ca>; Mackas, Dave <Dave.Mackas@dfo-mpo.gc.ca>
Cc: Tompkins, Arlene <Arlene.Tompkins@dfo-mpo.gc.ca>
Subject: FW: Fraser River sockeye mortality, alternative contributing factors?

more thoughts on this story.....

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From: Haigh, Rowan
Sent: August 14, 2009 3:42 PM
To: Richards, Laura
Cc: Brown, Laura (Pacific)
Subject: RE: Fraser River sockeye mortality, alternative contributing factors?

Hi Laura,
I haven't really followed the SoG plankton blooms for a while, but I do know that *Heterosigma akashiwo* (a.k.a. *H. carterae*) blooms every year in the SoG. It can form quite extensive purple-brown discolourations. We found that it usually excysts from seed beds in shallow protected inlets like Nanoose Harbour and spreads out into open water. In English Bay it usually became prevalent and often predominant once the surface waters exceeded 15°C. Additionally there was often a concurrent drop in salinity from river freshets. This latter in combination with warmer waters might even strengthen *Heterosigma* blooms.

I'm guessing that other researchers by now have studied the mechanism behind fish mortality more fully. When I was monitoring harmful algal blooms from UBC, the theory was gill membrane damage from peroxide free radicals excreted by *Heterosigma*. Usually wild fish just swim away or avoid these blooms but caged fish don't have this option. I suppose wild juvenile fish might find it hard to escape, especially given the extent of some of the *Heterosigma* patches. The other striking observation is an inverse relationship between abundance of *Heterosigma* and that of the primary diatom species *Skeletonema costatum*. And as we all know diatoms lead to healthy, diverse food chains whereas flagellates usually leave us with a sea full of jellyfish.

Other people that might have additional information are Terri Sutherland (DFO, West Van Labs) and Nicky Haigh (no relation) who used to work with Ian Whyte and is now based at VIU in the shellfish building (<http://www.mala.ca/fisheries/faculty.aspx>). Nicky is funded by the aquaculture industry to monitor phytoplankton samples from sea farms.

Cheers, Rowan

From: Richards, Laura
Sent: Friday, August 14, 2009 2:57 PM
To: Haigh, Rowan
Cc: Brown, Laura (Pacific)
Subject: FW: Fraser River sockeye mortality, alternative contributing factors?

Rowan - do you have any additional info on this possible story? thanks. Laura

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From: Richards, Laura
Sent: August 14, 2009 2:54 PM
To: Mackas, Dave; Crawford, Bill
Cc: Brown, Robin; Saunders, Mark
Subject: RE: Fraser River sockeye mortality, alternative contributing factors?

Thanks. This story gets more and more interesting. I recall seeing large blooms over the last few years (including 2009) during my flights to RHQ, but I obviously don't have the full context. Rowan Haigh still works at PBS in the groundfish group. I can check whether he still follows any of this discussion. Laura

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From: Mackas, Dave
Sent: August 14, 2009 2:43 PM
To: Richards, Laura; Crawford, Bill
Cc: Brown, Robin; Saunders, Mark
Subject: RE: Fraser River sockeye mortality, alternative contributing factors?

The suggestion that *Heterosigma* blooms could have caused elevated sockeye mortality seems entirely plausible to me. I don't know if this is better characterized as 'disease' or 'algal toxicity' (the algae do produce toxins but there is also a lab study suggesting that the worst damage to fish gills involves a combination of algal irritant and bacterial infection), I agree with Rensel that *Heterosigma* blooms concentrate very strongly at the sea surface, which would put them in the path of

baby sockeye if they also overlap in date.

If Roland Haigh is still around, he may be able to offer insights into whether 2007 was unusually bad in SofG. Suzanne Strom's lab reported dense blooms in N Puget Sound in both 2006 and 2007.
(http://www.ac.wvu.edu/~stromlab/Strom_June%2009_Heterosigma.ppt)

Abstract from a 1993 paper by Max Taylor and Roland Haigh (suggesting that blooms originate on or near the Fraser delta). :

The ecology of fish-killing blooms of the chloromonad flagellate *Heterosigma* in the Strait of Georgia and adjacent waters.

Taylor, FJR | Haigh, R

DEV. MAR. BIOL. 1993.

Blooms of the chloromonad flagellate *Heterosigma*, formerly referred to as *H. akashiwo*, occur on an annual basis in B.C. waters, particularly within the Strait of Georgia and in Barkley Sound on the west coast of Vancouver Island. Although not inevitably associated with kills of farmed salmonids, there are usually some losses and certain years, e.g. 1986, 1989, are particularly bad. Our data indicate that the blooms in the Strait are seeded from shallow areas in the vicinity of the Fraser River plume, e.g. English Bay, Vancouver, and are spread by currents. Eventually the entire Strait can be affected. Within the seed areas temperature seems to be a reliable indicator of bloom development as long as the Strait is sufficiently "preconditioned" by run-off from the Fraser, with the appearance of the early bloom when the surface water reaches and exceeds 15 degree C. Run-off contributes, both by stratifying the water column and presumably adding iron and other micronutrients. The bloom can last for four months or more, depending on persistent stratification. As stratification is rarely deeper than 10 m they can exploit the nutricline indefinitely by vertical migration. Tolerance of a wide salinity range and lack of grazing also appear to be key competitive factors.

Angelica Pena says that there were many reports of discolored water in inner coast waters in early summer of 2007. But we can't provide any good information about what phytoplankton species were in these blooms.

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From: Richards, Laura
Sent: August 14, 2009 1:54 PM
To: Crawford, Bill; Mackas, Dave
Cc: Brown, Robin; Saunders, Mark
Subject: FW: Fraser River sockeye mortality, alternative contributing factors?

Dave / Bill : I would be interested in your take on this. thanks. Laura

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From: Beamish, Richard
Sent: August 14, 2009 1:49 PM
To: Saunders, Mark; Richards, Laura; Johnson, Stewart
Subject: FW: Fraser River sockeye mortality, alternative contributing factors?

Mark, Laura and Stewart, as you know, I have been looking at the possibility that disease is a factor in the early marine mortality of coho and chinook. This is an email that is worth considering.
In the 2008 FOG report we wrote that the sockeye salmon returns in 2009 could be "extremely poor" because of the very small catches in our July 2007 surveys. The juvenile sockeye either died or left by the time we surveyed in July. Because there is a genetic control associated with the juvenile migration in the ocean, I am inclined to suspect that there was a very high mortality of the lake rearing sockeye in fresh water or in the the Strait of Georgia or both in 2007. Disease would be a possible source of this mortality. Harrison sockeye that entered the Strait of Georgia about one month later, survived much better as indicated by our large catches in September 2007.
Dick

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-----Original Message-----

From: Jack Rensel [mailto:jackrensel@worldnet.att.net]
Sent: Friday, August 14, 2009 10:51 AM
To: Beamish, Richard
Cc: Connie Mahnken; Tim.Tynan@noaa.gov
Subject: Fraser River sockeye mortality, alternative contributing factors?

Hi Dick,

As you may know, beside aquaculture impact monitoring and modeling, I have been involved in harmful algae research and mitigation work for decades down here in Puget Sound and elsewhere around the world, especially anything related to *Heterosigma* and large-bodied *Chaetoceros* (*Phaeoceros*). I copy this to our mutual friend Connie Mahnken who has an interest in this matter as one of our WDFW commissioners.

Along with a colleague at NOAA who works with US-Canada fisheries relations (Tim Tynan, in Olympia), we are interested in the chance that *Heterosigma* is reducing the abundance of outmigrating or returning Fraser Rv. sockeye. The timing of the blooms (May through September) is about right and the extent and intensity of the blooms has been massive in 2006, 2007 and probably this year. USGS was collecting data up there with the Tribes recently and got some 130 ug/L+ chlorophyll hits and thought the water was a red as they had ever seen. I will try to interview them soon, but we have long thought that the bulk of the *Heterosigma* that affects North Puget Sound is associated with the Fraser River plume as the aerial observations that my colleagues at the fish farms make show it. Such observations have been going on for 20 years, but do show some contribution of blooms moving out of shallow Bays from Bellingham south and possibly north too..... see the report I did for NOAA on the WHOI national HAB website:
<http://www.whoi.edu/files/server.do?id=39383&pt=2&p=29109>

It may be true that some scientists in B.C. tend to focus on the sockeye survival mystery as a function of warm water in the river and not consider the marine environment. Surely hot river water is a problem, but it may be a red herring. If it is real warm in the river, the fish may be delaying up river migration and in the river mouth/plume areas conditions are ripe for a HAB hit. Warm, conditions in the river are often accompanied by warm conditions in the highly vertically

stratified river plume and boundary. My B.C. HAB colleagues like Max Taylor in the past never really considered this when they did their Georgia Strait work and although I work with the HAB monitoring people (Nicky Haigh) there appears to be less critical mass of HAB work in B.C. these days than a decade ago. And now we are seeing new HAB species such as *Cochlodinium* in Puget Sound and B.C. that were never present a decade ago. *Cochlodinium* has devastated many Asian and more recently Persian Gulf fish farms and wild fish populations as is truly a nasty species. (I am part of a WHOI team soon to be working on the Persian Gulf problem).

Many people think that *Heterosigma* only affects farmed fish but we have evidence and even publications from past blooms that show that wild fish (and other food web components, especially larvae and zooplankton) can be killed or injured by these blooms as shown by Suzanne Strom and her team at Shannon Point Marine Lab. In part I believe this misconception is also due to the fact that salmonids in our waters usually sink when killed by a bloom, and with strong tides and numerous predators, the Hong Kong type fish kills are never seen because gas production is slowed and the fish are dispersed. During our fish farm mortality events, probably 95% of the fish sink, which is why removing the fish rapidly is job number one to prevent net and structure collapse. Moreover, sockeye travel in large schools that are very shallow (I know, I owned a Bristol Bay fishing boat for several years) and therefore the fish are more susceptible to intense surface blooms. Additionally, *Heterosigma* may occur in fish killing concentrations at much deeper depths common at our NPS fish farms, see the above report where the surface mixed layer extended many tens of meters deep due to the Fraser River plume.

I contact you in part because you are one of B.C.'s most knowledgeable experts in fish populations and because apparently few are considering *Heterosigma* and other HABs as a possible cause. I realize that everyone has a bias related to their toolbox contents, (all problems look like nails if you only have a hammer!) and I may be guilty of that.

Tim and I would be interested in your comments and would be interested in hearing your perspective, confidentially or otherwise. Maybe I will see you at the PICES meetings again in Korea this year too.

All the best,

Jack Rensel

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