Resource Analysts International

December 21, 2006

Mr. Skip Sahlin
SSA Marine
1131 SW Klickitat Way
Seattle, WA 98134

Dear Mr. Sahlin,

I have reviewed the material you provided me to review the hydroacoustic surveys of herring distribution in the Cherry Point area in 1998 and 2004. The question I was asked to address is: "Are there preferred nearshore migration corridors/schooling area at or near the Gateway Pacific Terminal project site?"

The documents I reviewed were:

Nealson, P.A. 1998. Hydroacoustic evaluation of herring school distribution near Cherry Point, Washington in Spring, 1998. Hydroacoustic Tech. Inc. Seattle.

Nealson, P.A. 2004. Hydroacoustic evaluation of herring school distribution near Cherry Point, Washington in Spring, 2004. Hydroacoustic Tech. Inc. Seattle.

1998. Appendix C Herring Monitoring Program to evaluate the effects of the Pacific International Terminal trestle/wharf structure and shipping activity on the behavior of herring at Cherry Point.

2004. Appendix C 4/2/2004 amendment, Herring Monitoring Program to evaluate the effects of the Pacific International Terminal trestle/wharf structure and shipping activity on the behavior of herring at Cherry Point.

Gateway Pacific Terminals Herring Monitoring Plan Team Meeting. 5/20/2005, WDFW Mill Creek, 3pp.

Position of Washington Environmental Council on PIT's Compliance with Herring Monitoring Provisions of 1999 settlement Agreement. 8/2006, 3pp.

4/18/2005 Letter – J. Arum of Ziontz, Chestnut, Varnell, Berley and Slonim to S. Sahlin, Stevedoring Services of America. Re: Gateway Pacific Terminal Project. 5pp.

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Additionally, I examined WDFG spawn deposition survey records that were provided by Mark Pedersen of AMEC at my request.

The first aspect of the surveys is the equipment utilized and the survey methodology. The terms of the monitoring agreement (1998 Appendix C) set forth that parallel track lines would be established; with one at the 10 fathom (fa) depth contour and a second located 500 meters (m) seaward of the 10 fa transect line. These transect lines were surveyed repeatedly over the historic spawning period during day and night and various tide stages to examine diel and tidal effects on distribution and movement.

In 2004, the survey was repeated using the same survey protocols; however, the equipment used to ensonify and record fish schools was different than in 1998. The 1998 survey used an American Pioneer Fishscanner 201 forward-looking sonar; while in 2004, a HTI system of downward and forward looking transducers were used. The forward looking transducer was configured to emulate the American Pioneer sonar. Another difference was that in 2004 the data were collected and stored digitally so data could be further processed and analyzed. In 1998, the survey the data were recoded to VHS tapes for later viewing.

Without some conversion of the analog tapes recorded from the 1998 survey, the comparison between years is largely a school mapping exercise of location and relative school size. ,

Do significant differences in the equipment or the survey design between years to preclude a comparison of relative distribution?

Downward looking sounders were used in both years, but the 1998 survey used a non-calibrated sounder, which had a much wider field than the HTI sounder use in 2004. The significant observation from the 1998 survey was that there were herring observed that were not seen with the sounder indicating that there are fish beyond the sonar beam width.

The equipment was operated in a similar fashion in both surveys, the forward-looking sonar transducer tilt angle was set at 17˚ at the 10 fa transect and at 25˚ at the transect 500m further offshore, to maintain a constant sampling volume. One primary difference between years was that in 1998 survey used a forward-looking sonar sweep of 180˚ centered on the bow, while in 2004 the forward-looking sonar was replaced by a fixed forward-looking transducer with a 10˚ horizontal beam angle centered on the bow. Thus the number of fish and schools encountered by the 2004 sonar could be expected to be less in 2004 than in 1998 to some degree by the reduced area swept with the sonar.

A concern often expressed in near shore herring surveys is avoidance. Clupeid fish, like herring, anchovies, and sprats, can detect sound frequencies up to around 40 kilohertz (KHz), way beyond the hearing range of most other fish. (The normal range of human hearing is 20 to 20,000 KHz.). In this survey, 200 KHz sonars were utilized, thus making it unlikely that the sonar pulses were causing the herring to react. A frequency of 200 KHz is well beyond the hearing range of herring, but herring are sensitive to low frequency sound in the 10 KHz range, and may react to low frequency vessel noise.

One shortcoming of both surveys is a lack of sampling of acoustic sign. There could be some misidentification, but these would likely be individuals or small schools. Generally, there are very few other fish in the near shore area during the herring spawning area spawning period. The fish most likely to be encountered would be smelts and surf perch, but their acoustic characteristics are different from herring. The lack of sampling could have resulted in some misclassification of non-herring as herring, but given the high presence of large to medium schools; the likelihood of misclassification is minor and limited to some small schools.

Instrument sensitivity were set to comparable settings to calibrate the HTI system with the American Pioneer Fishscanner 201 sonar and to record similar color level fish density in both systems. The HTI system was set to emulate the 1998 survey and maintain comparability of the sonar signal, while at the same time a downward looking quantitative system estimated fish density that was used to extrapolate school dimensions to biomass.

The reported survey procedures and equipment were relatively the same in both years, although the HTI system used in 2004 is superior to Fishscanner 201 because the system is fully calibrated and data are recorded and raw files are available for post processing. The 2004 data were recorded using a 4 second (sec) ping interval and the data integrated at 30 sec intervals. At the setting employed and the vessel speed over ground, there is very little chance of not recording all fish encountered on the track line. The exception might be very small schools, but most studies of herring spawning behavior indicate that herring generally aggregate into large and medium schools during spawning (Hay 1985, Thomas and Thorn 2001)

In 1998 the American Pioneer sonar was tested against a target to measure the system properties and to insure that target distance and angle did not bias the signal, thus a test to see if the time varying gain (TVG) was operating and producing significant results. There was no attempt to calibrate the sonar transducer since it was not going to be used to obtain quantitative information. In 2004, the HTI system was calibrated against a known target with measured water properties to insure the system was properly calibrated since quantitative estimates of the acoustic scattering per unit volume (S_v) were being obtained. The forward looking sonar was calibrated to insure internal consistency, but the data were only used to measure relative school size and not density.

From examination of the methods and equipment employed, I conclude the relative school size and location information can be used to examine the relative distribution of herring relative to the Cherry Point shoreline for concentrations in time and space suggesting potential migration pathways. The 2004 survey had the added advantage of being able to correlate the school distribution data from the sonar with absolute school sizes calculated from the downward-looking sounder density estimates and sonar school size estimates.

Survey results - are the results comparable between years?

The equipment used and survey design used can produce comparable results, but the question remains if there are differences due to other factors such as local climate, stock size and other factors such as the presence of predators or vessels will alter the distribution of herring and bias the results. One factor already shown to affect the results is the different sweep angles of the survey, with less area scanned in 2004. However, this element can be examined by going back to the 1998 data and selecting only data within the same 10˚ beam angle as in 2004, to determine if it is a significant issue.

The question of whether or not the survey delay affected results of herring distribution and migration is a largely speculative one. One can assume that spawning behavior is a very conservative trait with natural selection working to optimize spatial and temporal aspects of spawning to harmonize with local conditions. Thus one would expect some interannual variation in spawning distribution due to spawn substrate variation, local climate variation and sea conditions. Spawning usually occurs about the same time annually, plus or minus 1 to 2 weeks (Hay 2001, Wespestad and Gunderson 1991) at the same locations. For Cherry Pont herring, peak spawning usually occurs the first or second week of May and can occur from late April to early June (Nealson et al. 2004).

Do results show any pattern of movement?

The historic range of herring spawning of the Cherry Point stock is larger than the area surveyed. Historically spawning has occurred in areas further to the north, so it is possible that some herring may have been missed. Also, it is possible that herring could be entering the area to the north of the transect line and not recorded on transects. However, that issue was likely considered at the time of agreement on the survey design, and can not be addressed with available data.

Examination of the distributional results presented for 1998 and 2004 do not indicate any particular spatial pattern. In both years, the relative distributions of herring are very similar. In both years, herring were found distributed throughout the survey area. Nealson et al. (2004) provide distribution maps of schools by size category from the sonar (Nealson et al. (2004) Figure 3) and estimated biomass distribution extrapolated from the down sounder data (Nealson et al. (2004) Figure 25) which suggests sonar based school size estimates can serve as a general proxy for biomass. A similar sonar based distribution map appears in Appendix J of the 1998 survey report. That figure shows a very similar distribution to the 2004 data.

One interesting aspect of the surveys is the difference in numbers of schools between years. This may be due to chance or reflect some difference in herring behavior. As expected, the total number of schools recorded was reduced in 2004. The reduction was primarily in small and medium schools, while the number of large schools was similar in both years (16 vs. 11). The reduction could be due to the narrower beam sampled by the 10˚ fixed transducer than the 180˚ scanning sonar used in 1998. As stated previously this can be examined by reviewing the VHS tapes of the 1998 survey to tally the schools beyond 5˚ of center on both sides of the vessel.

Another potential for differences in schools encountered between 1998 and 2004 may relate to time of spawning. In 1998, the spawning was concentrated toward the beginning of May with only one spawning event recorded in Birch Bay on May 2-3: while in 2004, spawn deposition studies indicate significant spawning in late May after the last survey. It is possible that the greater number of small school and medium schools may be post spawning fish leaving the area in 1998. However, there is no pattern in the school numbers by size results suggests smaller schools are more likely to be post spawners; nor is there any diel trend in school sizes that is consistent between years and across categories.

It would have been interesting to have had some age data to see if there was an age effect associated with schools size. Also, the spawning condition of the fish might have also helped to interpret school types. There is often a behavioral difference between pre and post spawning herring. In the Togiak herring fishery of Northern Bristol Bay herring enter from the west or south, spawn and then move to the east an form large resting shoals before exiting the spawning grounds (Barton and Wespestad 1980, Nioki 2005?).

Although additional data may have refined interpretation of the sonar data, it would not alter significantly the result that herring appear to be widely distributed throughout the area, but with a slight tendency toward higher abundance toward the northern end of the survey transects. There is no evidence in either year that the herring favored one area over another for entering or leaving the nearshore spawning grounds.

How do acoustic data compare to spawn deposition surveys?

A way to examine the acoustic data is to compare it with estimates of abundance from spawning distribution and spawning stock estimates recorded in WDFW spawn deposition surveys in recent years (Table 1). The spawn deposition data is recorded by area and day through the spawning season. These records were examined to determine the distribution of spawning through out the stock spawning area. The location of peak biomass was selected in each year as a measure of primary spawning location, and the second largest spawning event was selected as the secondary location of spawning.

Table 1. Distribution of herring spawning recorded in WDFW spawning surveys by peak spawning date and location of spawning and estimated spawning biomass with regard to largest spawn (primary) and second largest (secondary), 1998-2006.

Year	*Peak spawing date*	*Primary spawning location*	*Spawning biomass (t)*	*Secondary Spawning Date*	*Secondary spawning location*	*Spawning biomass (t)*
1998	May 2-3	So. Birch Bay	480		None	0
1999	May17	North of Intalco Dock	623	May 2-3	So. Birch Bay	328
2000	May 17	North of Intalco Dock	507	Apr. 24	No. Birch Bay	85
2001	May 2-3	So. Birch Bay	229	May 22-23	Viewpoint (1 mi N of ARCO)	184
2002	May 2-3	So. Birch Bay	251	May 21	Birch Point	186
2003	May 6	1 mi. north of ARCO/BP dock	308	May 1	Gulf Road	229
2004	May 26	1/2 - 2 mi. north of BP dock	387	May7-8	Conoco Dock to Sandy Point	220
2005	May 10-11	So. Birch Bay	387	May 6	So. Birch Bay	343
2006	May 7-9	So. Birch Bay	314	Apr. 23	So. Birch Bay	263

Since 1998, the peak spawning biomass appears to be in south Birch Bay, where peak spawning biomass occurred in 5 of 9 years. Birch Bay was also the site of the second highest spawning biomass in 5 of 9 years. Thus, similar to the acoustic and sonar data, the spawning distribution data points toward herring favoring the northern end of the spawning distribution. In two years, 1999-2000, the largest spawning biomass was estimated in the "North of Intalco area" which could have included the proposed pier site.

Evidence of movement from other stocks and herring reproduction strategies

Migration and "homing" studies of herring have been conducted through out the North America and Europe since the early 1900s. Some stocks have shown dramatic changes in location primarily as a result of changes induced by very concentrated fishing activity, or climate change. Pacific herring have not exhibited significant relocation of spawning grounds as in some Atlantic herring stocks. This may be because Pacific herring generally prefer complex marine vegetation upon which to deposit eggs, and the preferred spawning substrates only occur in specific habitat zones like sandy (for eelgrass) zones or rocky headlands (attached macroalgae). While most spawning areas are characterized as calm and protected waters, and marine vegetation or rocky intertidal spawning-substrate, human-made structures such as pier pilings and riprap have also been noted to be frequently used spawning substrates, especially in San Francisco Bay (http://www.dfg.ca.gov/mrd/status/pacific_herring.pdf).

Recent and past tagging studies of Pacific herring do not indicate specific migration patterns, other than confirming major, inshore-offshore migratory movements and fidelity to relatively broad geographical regions that may encompass several discrete spawning aggregations (Hay et al. 2001).

Pacific herring are reported to usually spawn at night in the shallow subtidal zone (Bargman 1998, Emmett et al. 1991). The 1998 or 2004 data do not indicate any increase in school counts or numbers at night. In fact, the 1998 data shows more herring schools sighted during daylight hours.

Conclusions

After reviewing the two acoustic surveys of fish schools off Cherry Point in 1998 and 2004, I believe the survey methodology is comparable for doing acoustic mapping of fish schools along fixed transects off Cherry Point. The results of the two surveys show essentially similar distribution patterns and there is no evidence of any site specific ingress or egress point from the grounds. The two surveys and WDFW spawning biomass surveys both confirm that there is a tendency for spawning to be skewed to the northern end of the survey range. I would expect that within so small an area, that available spawning substrate and proximity to favorable larval rearing areas are primary determinates of spawn distribution.

References

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This concludes my review; if you have questions or require further assistance please contact me at your convenience.

Sincerely,

Signature Not Verified

Vidar G. Wespestad

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cc: Mark Pedersen
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