Annual Progress Report – Oil Spill Recovery Institute

Date: February 22, 2004

Name of Awardee: Richard E. Thorne, Prince William Sound Science Center

OSRI Contract Number: Contract # 03-10-23

Project Title: Biological Monitoring of Herring and Pollock in Prince William Sound

Dates this progress report covers: January 31, 2003-January 31, 2004

Abstract:
Surveys were conducted during March 2003 to determine the populations of adult herring (*Clupea pallasi*) and adult pollock (*Theragra chalcogramma*) in Prince William Sound. Two vessels contributed to the herring surveys, the F/V Kyle David chartered by the Prince William Sound Science Center, and the ADF&G research vessel RV Montague. The Montague conducted the purse seining for biological samples, as well as some acoustic transecting. The Kyle David located substantial concentrations of herring in Saint Mathews Bay, Two Moon Bay and Zaikof Bay. The total estimate for the PWSSC surveys was 13,200 mt with 95% confidence limits of 11,300 to 15,100 mt. The Montague successfully conducted surveys in Two Moon Bay and Zaikof Bay with similar results as the Kyle David. In addition, the Montague located and surveyed a huge concentration of fish (18,200 mt) in the North Montague region on March 26. The two surveys combine for an estimate of 31,700 mt confidence bounds of 23,100 to 40,300 mt.

The total estimate represents a substantial increase compared to the previous year and represents the second consecutive annual increase. The increased biomass results from an exceptional recruitment of the 1999 year class. The overall numerical contribution of these 4-year old fish was 80%.

The pollock survey was also conducted by the Kyle David. Areas that were surveyed included Hinchinbrook Entrance, Montague Trench, East Knight Island, Port Bainbridge and part of the main basin. Biological data was provided by ADF&G from midwater trawls and shoreside samples from the commercial fishery.

The estimated total biomass of pollock was 22,101 mt (95% C.I. 19,589 to 23,930). Overall, the population has dropped 22% from 2000 and 49% from the peak estimate in 1998. The change has been most dramatic in Port Bainbridge where the population has declined from 27,366 mt in 1995 to 1,695 mt in 2003.

Pollock have been the dominant pelagic biomass in PWS since the monitoring began in 1995. However, herring are now slightly more abundant because of the current pollock decline combined with the recent increase in herring biomass. That change may be reflected in a reversal of the Steller sea lion abundance. Late spring aerial counts by

ADF&G and NMFS show a recent increase in the number of SSL in Prince William Sound, reversing a multiyear decline.

Review of objectives: The objectives of this project were to obtain estimates of the abundance and distribution of adult herring and adult pollock in Prince William Sound.

Problems encountered: The herring concentrations were more mobile than observed in previous years, perhaps because of slightly warmer temperatures or perhaps as a result of intensive sea lion foraging. The increased daily movements resulted in wider than usual confidence intervals despite the two-vessel operations. However, the precision was still acceptable, and the mean estimate was in reasonable agreement with the mile/days of spawn index and estimates from the age-structured model.

Highlights:
Cooperative efforts between PWSSC and the Cordova office of ADF&G were excellent. The continued increased population of herring was very encouraging. The stock hit a historic low in 2001. The surveys in 2004 will be critical since the herring population is near the threshold for commercial fishing.

A detailed report of the herring survey is attached as Appendix 1 (pages 3-14), and on the pollock survey as Appendix 2 (pages 15-24).

A paper on the herring research was recently published in Aquatic Living Resources. Reprints are available from the P.I. A presentation on the research was recently presented at the ASLO Ocean Sciences Meeting. Another presentation has been accepted for the World Fisheries Congress in May 2004 with an associated publication.

Conclusions:
Overall, the monitoring effort was very successful. The increased herring population relieves concerns over the depressed nature of the stock and provides some encouragement that a fishery may resume in the near future. The minor decline of the pollock stock over the past four years is a source of some concern. However, fishing effort on this stock is low, and the trend is more likely the result of processes occurring in the Gulf of Alaska.

APPENDIX I - Assessment of the Herring Population in Prince William Sound during Spring 2003

INTRODUCTION

The Prince William Sound Science Center initiated annual surveys of the Pacific herring (*Clupea pallasi*) population in Prince William Sound (PWS), Alaska, in fall 1993 after traditional techniques predicted a large return in spring 1993 that failed to materialize. Subsequently, acoustic surveys of the adult herring were conducted during fall in 1994 and 1995, and annually during early spring since 1995. Support for the surveys since 2000 has been provided by the Oil Spill Recovery Institute.

The distributional characteristics of the herring in Prince William Sound from November to April are highly amenable to acoustic surveys. School groups are highly aggregated in a few select locations, reducing the area that needs to be surveyed (Thorne and Thomas 2000). Marine mammals, especially Steller sea lions, are closely associated with the herring school groups and can be readily detected from aerial surveys, which provide a very rapid method of locating concentrations and even further delineate the area to be surveyed (Thomas and Thorne 2001).

This report details the results of acoustic surveys on the PWS adult herring population that were conducted in spring 2003.

METHODS

Acoustic surveys have been conducted on herring populations for several decades (MacLennan and Simmonds 1992; Thorne 1977a,b; Thorne et al. 1983; Thorne and

Thomas 1990; Thorne 1998). Methods for pre-spawning herring were developed during the late 1970's (Trumble et al. 1983). The most effective survey techniques are based on multi-stage sampling: (1) location of the school or schools is detected by reconnaissance surveys, (2) intense small-scale surveys are conducted over the limited area encompassing the concentration, and (3) net sampling is conducted on the concentration for biological information, including species and size composition (McClatchie et al. 2000).

Spatial characteristics of herring populations in PWS are reported in Stokesbury et al. (2000). Annual herring estimates are detailed in PWSSC reports (DeCino et al. 1994; Kirsch and Thomas 1997, 1998, 1999; Thorne 2000, 2002). Thomas et al. (1997) describes general details of the assessment programs. Thomas et al (2002) details the target strength characteristics of herring that are used in the acoustic surveys. The annual surveys for herring are usually conducted in late March, prior to the April spawning period.

The initial survey stage, a PWS-wide reconnaissance effort guided by historical observations, is conducted to identify the overall distribution of the target species within Prince William Sound. The effort includes aerial surveys, sonar/echosounder surveys and sentinel vessel observations including fishing vessels. Once an area of herring abundance is located, a sonar survey delineates the boundaries of the concentration. Then series of closely-spaced zig-zag transects are run with the acoustic assessment system. Sonar monitoring continues at this stage to ensure that the survey covers the extent of the herring concentration. Lastly, net sampling using a commercial herring purse seine is directed toward the surveyed concentrations to obtain biological information (size, species composition).

Two vessels participated in the spring 2003 surveys: the FV Kyle David with PWSSC personnel and the RV Montague with ADF&G personnel. The Kyle David conducted an initial survey in Saint Mathews Bay the evening of March 18. A daytime survey of Saint

Mathews Bay and vicinity was conducted March 19, followed by an evening survey in Two Moon Bay and a search of Irish Cove. During the next day the vessel proceeded to the Native Village of Tatitlek to pick up two high school students and their counselor for a demonstration survey in Two Moon Bay. Later that day the Kyle David proceeded to Montague Island, searched Montague Point to Stockdale, then surveyed Zaikof Bay on the 21st. The Kyle David then switched to a pollock survey for March 22-25, before conducted a second herring survey of the Saint Mathews area on March 26-27. The RV Montague surveyed Saint Mathews Bay, Zaikof Bay, Green Island, Rocky Bay, and North Montague (Montague Point to Graveyard Point), on March 20-26. The combined coverage is shown in Figure 1. Both vessels deployed BioSonics 70 kHz DT4000 Digital Transducer systems with 6-degree transducers. Transect locations for all systems were written on acoustic data files using GPS receivers. All systems were calibrated using procedures documented in Foote and MacLennan (1982).

BioSonics Visual Analyzer software, Version 3.1.1, was used for basic analysis of data from the digital transducer systems. Density estimates (biomass per unit surface area) were made for each transect. The mean density for each survey was calculated from the estimates along each transect, weighted by transect length (Seber 1973, p 6.).

Calculation of absolute density was based on the equation originally developed by Thorne (1983):

$$TS_w = -5.98 \text{Log}(L) - 24.23$$

where TS_w is the target strength per unit biomass and L is fish length in cm. Subsequent research has shown that this value is accurate for herring at the depth ranges encountered in PWS (Thomas et al. 2002). The target strengths calculated from the mean sizes of herring in the various purse seine samples based on the equation above ranged from –31.7 dB/kg for Zaikof Bay to -32.1/kg for Two Moon Bay.

The surface areas covered by each survey were measured by plotting the transect endpoints from the GPS data, and abundance estimates were derived by multiplying the mean density per unit surface area by the total surface area of the survey. Confidence intervals for the biomass estimates were calculated from the variation among estimates from replicate surveys (Seber 1973; Cochran 1977; Scheaffer, Mendenhall and Ott 1986). For each run, an estimate was made from each set of zigs and zags (Thomas and Thorne 2003).

RESULTS

Detailed estimates of herring biomass from PWSSC surveys are given in Table 1. Substantial concentrations of fish were located in Saint Mathews Bay, Two Moon Bay and Zaikof Bay. Additional fish were observed in Irish Cove, Montague Point, Point Ehrlington, Sawmill Bay and Knowles Bay to Goose Island, but in insufficient quantities to survey. Herring schools were seen over much larger areas than any of the previous three years and were unusually mobile. For example, large concentrations were seen in Saint Mathews Bay on the evening of March 18, but had moved across Port Gravina by the next morning. The total estimate for the PWSSC surveys was 13,200 mt with 95% confidence limits of 11,300 to 15,100 mt. The Montague successfully conducted surveys in Two Moon Bay and Zaikof Bay with similar results as the Kyle David. In addition, the Montague located and surveyed a huge concentration of fish (18,200 mt) in the North Montague region on March 26. When the two vessel surveys are combined, the estimate increases to 31,700 mt with relatively large confidence bounds of 23,100 to 40,300 mt (Table 2).

The substantial day to day variation in the herring locations was a problem. In particular, the RV Montague survey of March 26 resulted in a surprisingly large estimate in the north Montague area where the Kyle David had located very few fish six days earlier, but the Montague found few fish in the Saint Mathews/Port Gravina area when it surveyed that area on March 24. Clearly movements between areas may have complicated the estimation procedure. However, synoptic surveys on March 26 by the two vessels add up to 27,100 mt with confidence bounds of 18,500 to 35,700 mt (Table 3).

The total estimate for 2003 represents a substantial increase compared to the previous year and the second consecutive major increase in the annual estimate (Figure 2). The increased biomass in 2002 was the result of an exceptional recruitment of 3-year old fish (1999 year class), which provided an overall numerical contribution of 48% of the estimate. The continued increase in 2003 was primarily the result of further growth and recruitment of this age class, which now constitutes about 80% of the herring numbers.

DISCUSSION

Previous annual reports to OSRI, as well as a recent publication (Thomas and Thorne 2003), discuss in considerable detail the factors affecting accuracy. It is well documented that acoustic surveys can provide an accurate estimate of the population under survey, but that estimates are typically conservative because of limited survey coverage. Considerable effort was made to cover as much of the population as possible in 2003, including the two-vessel sonar surveys and aerial reconnaissance of marine mammals, spawn and other indications of the presence of herring. However, the survey problem is exacerbated by day to day movements. Historically this has not been seen as a major problem. The variability during spring 2003 may have resulted from warmer than normal water temperatures and/or extensive predation by Steller sea lions.

Complementary Steller sea lion censusing was limited in 2003 by budget considerations. However, the single areal overflight conducted by PWSSC noted over 70 animals in the vicinity of the Saint Mathews population, which is one of the major concentrations. NMFS/ADF&G census of Steller sea lions in PWS (conducted on selected haulouts) has shown a recent increase from 126 in 2000 to 550 in the latest census (summer 2002).

Active and intensive foraging by the sea lions on the herring schools was noted during the surveys.

Thomas and Thorne (2003) discuss the relationship between the acoustic estimates and other measures of the herring population in PWS. The best correlation has been with the aerial surveys of the day-miles of spawn (milt) along beaches that has been conducted by ADF&G since 1974. In 2003, this index was 28.6 km (Fig. 3). Using the regression relationship prior to 2003, this value would predict a herring population biomass of 19,275 mt., which is within the confidence intervals obtained from the synoptic survey, but below those of the combined survey. However, given that the correlation is built on acoustic estimates that are inherently conservative, the mean 2003 estimate of 31,700 mt is not unreasonable. Another assessment technique, the age-structured model, provided an estimate of about 26k mt (Steve Moffit, ADF&G, personal communication). While the acoustic estimates are historically conservative, that margin of underestimation may have been eliminated in 2003 by the chance encounter of a large, and clearly mobile, group of herring during the last day of the survey, which resulted in an estimate of 18,200 mt from that area alone, but with relatively high error bounds of 9.7 to 26.7 mt.

CONCLUSIONS

The annual survey of the herring biomass in 2003 shows a continued rebound in the population that has resulted from an excellent 1999-year class recruitment. The results suggest that the herring population is near, and probably above, the historic fishing threshold of 22,500 mt. However, given the relatively large error bounds associated with the 2003 survey, and the historic collapses of this stock, prudence suggests confirming recovered stock abundance from the 2004 survey before considering a renewed fishery.

It is very apparent from the results of the last two years that reasonably comprehensive coverage as synoptic as possible is key to accurate estimation of the herring biomass.

The 2002 estimate was noted to be conservative because of a near-shore orientation of the fish distribution (Thorne 2003). The substantial increase between 2002 and 2003 and the relation of the two annual surveys to the regression with mile-days of herring spawn suggest the 2003 survey was much less conservative or even an overestimation. Since the population is near the fishing threshold, the estimate for 2004 will be critical to Alaska Dept. of Fish and Game. Consequently, a more extensive, multiship operation is recommended for spring 2004 to improve the accuracy of the critical 2004 estimate. As the OSRI project funds are fixed, serious consideration will be given to shifting effort from the less critical pollock surveys in order to enhance the herring survey effort for the coming year.

ACKNOWLEDGEMENTS

This study was a cooperative effort between the Prince William Sound Science Center and the Alaska Department of Fish and Game, Cordova. In particular, ADF&G conducted the purse seining for biological samples and provided the length and age information cited in this report.

LITERATURE CITED

Cochran, W.G. 1977. Sampling Techniques, 3rd Edition. John Wiley & Sons, 428 p.

DeCino, R., J. Wilcock, V. Patrick, R. Thorne and G. Thomas 1995. Acoustic estimate of herring biomass in the Green Island area of Prince William Sound, Alaska, 1993. Regional Information Rept. No. 2A95-27, Alaska Dept. of Fish and Game, 20 p.

Foote, K.G. and D.N. MacLennan. 1982. Use of elastic spheres as calibration targets. Pp. 52-58, in O. Nakken and S.C. Venema (eds) Symposium on fisheries acoustics, ICES/FAO, Bergen, Norway.

Kirsch, J. and G.L. Thomas 1997. Acoustic biomass estimate of adult herring in Prince William Sound, Alaska, in Spring 1997. Final Rept. to Alaska Dept. of Fish and Game, Prince William Sound Sci Ctr, 42 p.

Kirsch, J. and G.L. Thomas 1998. Acoustic biomass estimate of adult herring in Prince William Sound, Alaska, in Spring 1998. Final Rept. to Alaska Dept. of Fish and Game, Prince William Sound Sci Ctr, 21 p.

Kirsch, J. and G.L. Thomas 1999. Acoustic biomass estimate of adult herring in Prince William Sound, Alaska, in Spring 1999. Final Rept. to Alaska Dept. of Fish and Game, Prince William Sound Sci Ctr, 19 p.

MacClennan, D.N. and E.J. Simmonds 1992. Fisheries Acoustics. Chapman & Hall, London, 325 p.

McClatchie, S., R. Thorne, P. Grimes and S. Hanchet 2000. Ground truth and target identification for fisheries acoustics. Fisheries Research 47:173-191.

Scheaffer, R.L., W. Mendenhall and L. Ott 1986. Elementary Survey Sampling, 3rd Edition. Duxbury Press, Boston, 324 p.

Seber, G.A.F. 1973. The Estimation of Animal Abundance and related parameters. Griffin, London, 506 p.

Stokesbury, K.D., J. Kirsch, E.D. Brown, G.L. Thomas and B.L. Norcross. 2000. Spatial distributions of Pacific herring, *Clupea pallasi*, and walleye pollock, *Theragra chalcogramma*, in Prince William Sound, Alaska. Fish. Bull. 98:400-409.

Thomas, G.L., E.V. Patrick, J. Kirsch and J.R. Allen. 1997. Development of a multi-species model for managing the fisheries resources of Prince William Sound. In D.A. Hancock, D.C. Smith, A. Grant and J.P. Beumer. Developing and Sustaining World Fisheries Resources - the State of Science and Management. 2nd World Fisheries Congress. CSIRO Publishing, Collingwood, Australia. Pages 606-613.

Thomas, G.L. and R.E. Thorne 2001. Night-time predation by Steller sea lions. Nature **411:**1013

Thomas, G.L., J. Kirsch and R.E. Thorne 2002. *Ex-situ* target strength measurements of Pacific herring and Pacific sand lance. North American Journal of Fisheries Management 22:436-445.

Thomas, G.L. and R.E. Thorne 2003. Acoustical-optical assessment of Pacific herring and their predator assemblage in Prince William Sound, Alaska. Aquatic Living Resources 16:247-253.

Thorne, R. E. 1977a. Acoustic assessment of hake and herring stocks in Puget Sound, Washington, and southeastern Alaska. pp. 265-278. *In* A. R. M. (ed). Hydroacoustics in fisheries research. ICES Rapp. et P-v, Vol 170.

Thorne, R. E. 1977b. A new digital hydroacoustic data processor and some observations on herring in Alaska. J. Fish. Res. Bd. Can. 34: 2288-2294.

Thorne, R.E. 1983. Assessment of population abundance by echo integration. Proc. Symp. On Assessment of Micronekton. Biol. Ocean. J. 2:253-262.

Thorne, R.E. 1998. Review: experiences with shallow water acoustics. Fish. Res.35:137-141, Elsevier Science, Amsterdam

Thorne, R.E. 2000. Biological Monitoring of Herring and Pollock in Prince William Sound. Annual Progress Report to Oil Spill Recovery Institute, Prince William Sound Science Center, Cordova, AK, 57 p.

Thorne, R.E. 2002. Biological Monitoring of Herring and Pollock in Prince William Sound. Annual Progress Report to Oil Spill Recovery Institute, Prince William Sound Science Center, Cordova, AK, 34 p.

Thorne, R.E. 2003. Biological Monitoring of Herring and Pollock in Prince William Sound. Annual Progress Report to Oil Spill Recovery Institute, Prince William Sound Science Center, Cordova, AK, 48 p.

Thorne, R.E., R. Trumble, N. Lemberg and D. Blankenbeckler 1983. Hydroacoustic assessment and management of herring fisheries in Washington and southeastern Alaska. FAO Fish. Rep. 300:217-222.

Thorne, R.E. and G.L. Thomas 1990. Acoustic observation of gas bubble release by Pacific herring. Can. J. Fish. Aquat. Sci. 47(10):1920-1928.

Thorne, R.E. and G.L. Thomas 2000. Biological considerations for scaling ecosystem research in Prince William Sound, Alaska. Keynote presentation, International Symposium on Advance Techniques of Sampling Gear and Acoustical Surveys for Estimation of Fish Abundance and Behavior, Hakodate, Japan, 8p.

Trumble, R., R.Thorne and N. Lemberg 1983. The Strait of Georgia herring fishery: A case history of timely management aided by hydroacoustic surveys. Fish. Bull. 80(2):381-388.

Table 1. Results of PWSSC surveys during spring 2003

Location	Date	Run	Area sq.km	Density kg/sq.m	Biomass 1000 mt
St. Mathews	18-Mar	1	11.0	0.96	10.5
	19-Mar	2	4.0	0.14	0.6
		3	2.0	0.01	0.0
	26-Mar	4	5.8	1.52	8.8
		5	4.0	0.27	1.1
	26-Mar	4	5.8	1.00	5.8
		5	4.0	0.50	2.0
Two Moon Bay	19-Mar	1	4.0	0.32	1.3
Zaikof Bay	21-Mar	1	3.5	0.61	2.2
		2	3.9	0.88	3.4
		3	2.9	0.75	2.2

Table 2. Results of combined PWSSC and ADF&G surveys during spring 2003

Location	Biomass (1000 mt)	Lower	Upper
Saint Mathews Bay	9.3	8.4	10.2
Two Moon Bay	1.9	1.0	2.8
Zaikof Bay	2.3	1.9	2.7
Montague Pt	18.2	9.7	26.7
TOTAL	31.7	23.1	40.3

Table 3. Results of synoptic surveys on March 26, 2003

Location	Biomass (1000 mt)	Lower	Upper
Saint Mathews Bay	8.9	7.3	10.5
Montague Pt	18.2	9.7	26.7
TOTAL	27.1	18.5	35.7

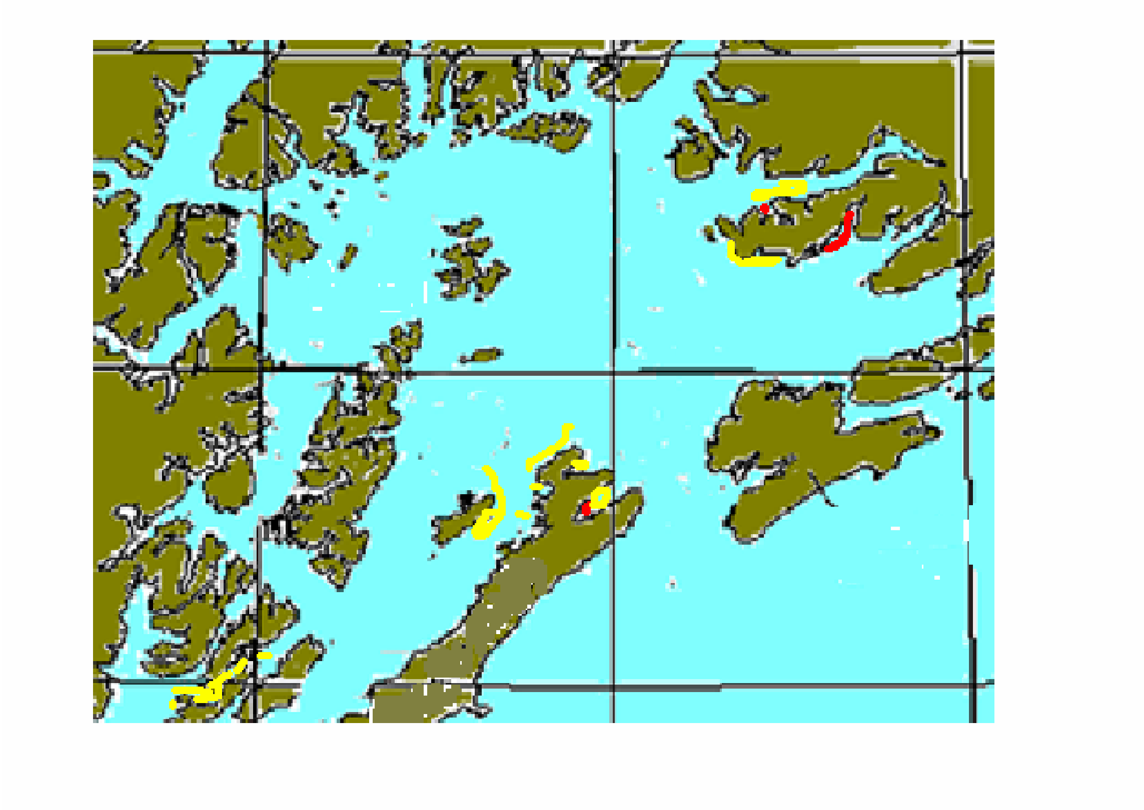

Figure 1. Location of surveys during spring 2003.

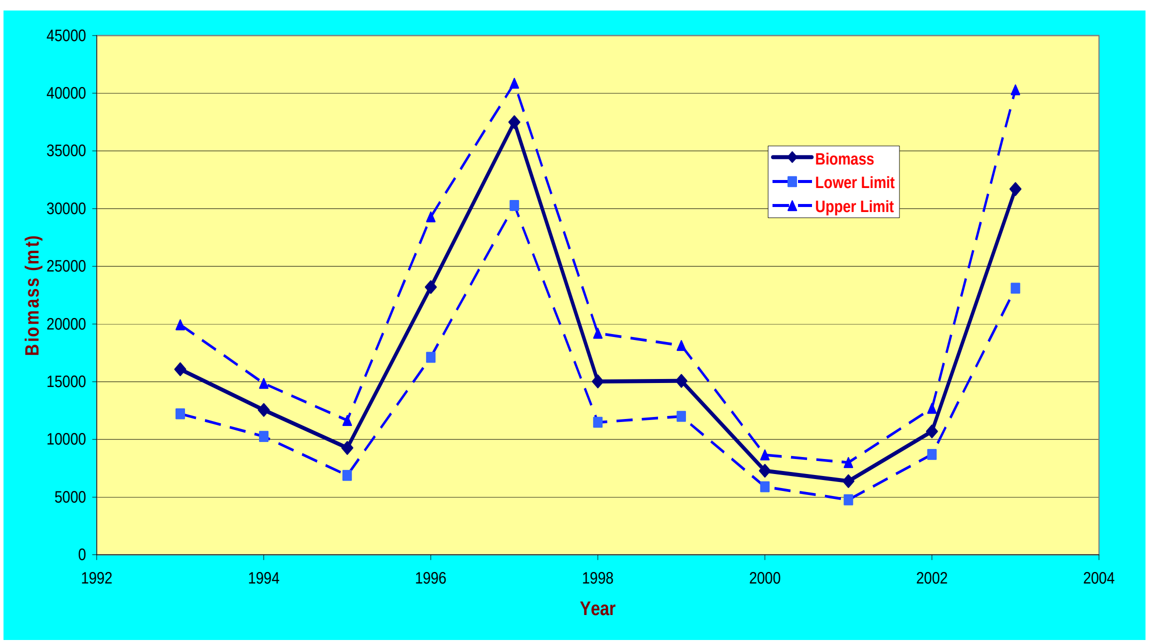

Figure 2. Estimates from acoustic surveys 1993 to 2003.

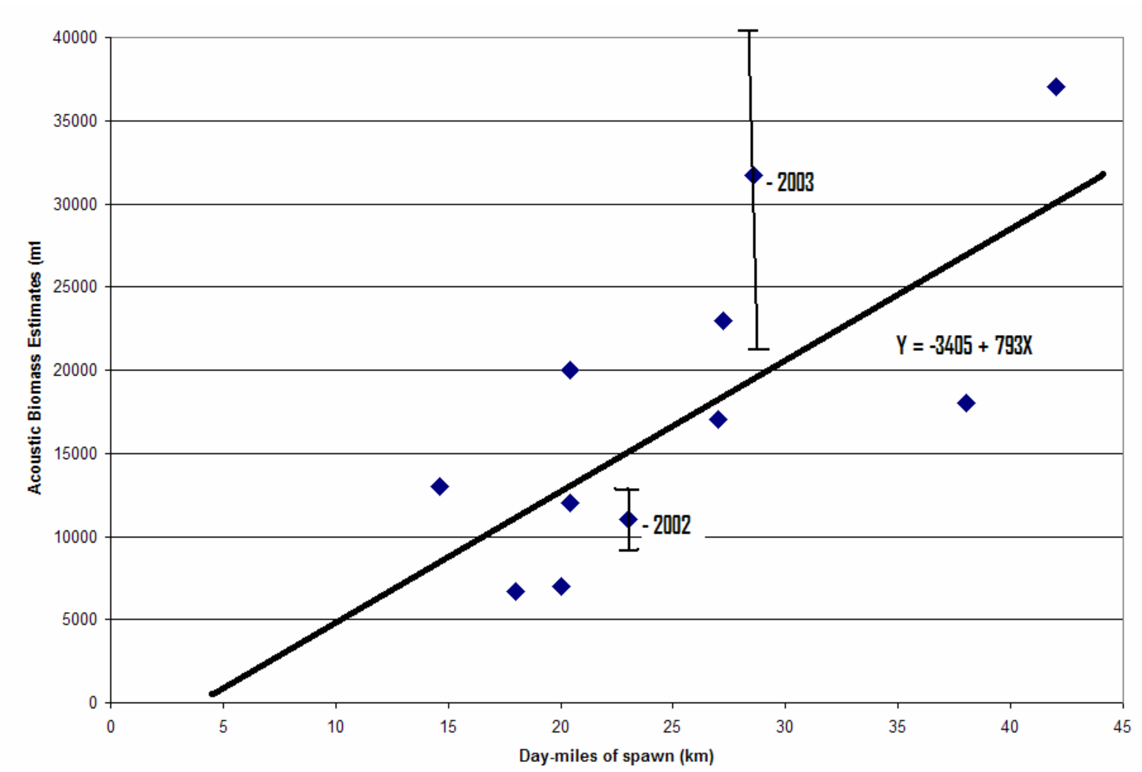

Figure 3. Comparison of acoustic estimates and aerial surveys of day-miles of spawn. The regression line excludes the 2003 estimate. Confidence intervals are shown for the 2002 and 2003 estimates.

APPENDIX 2 - Assessment of Adult Walleye Pollock Abundance in Prince William Sound, Alaska, March 2003

by

Richard E. Thorne
Prince William Sound Science Center
P.O. Box 705, Cordova, AK 99574
thorne@pwssc.gen.ak.us

Annual Progress Report to the Oil Spill Recovery Institute

ABSTRACT

An acoustic survey was conducted on the adult walleye pollock (*Theragra chalcogramma*) population in Prince William Sound (PWS) during March 2003. The survey covered Hinchinbrook Entrance, Montague Trench, Port Bainbridge, East Knight Island and a portion of the main basin. The estimated pollock biomass was 22,101 mt with 95% confidence bounds of 19,589 to 23,930. The result continues a declining trend of about 7% per year since 2000. It is likely that the decline represents broader scale changes rather than an impact of the relatively small commercial fishery that takes place in Prince William Sound. The decline in pollock biomass in PWS contrasts with an increasing biomass of Pacific herring over the past two years. For the first time since monitoring began in 1995, pollock are no longer the most abundance pelagic fish in PWS. This change may have positive ramifications for many marine mammals and birds.

Assessment of Adult Walleye Pollock Abundance in Prince William Sound, Alaska, March 2003

INTRODUCTION

Acoustic/midwater trawl surveys of the abundance of walleye pollock (*Theragra chalcogramma*) in Prince William Sound (PWS) were initiated in winter 1995 after the observations of the Sound Ecosystem Assessment (SEA) program during 1994 indicated substantial biomass of this species. Subsequently, surveys were conducted in 1997, 1998, and annually since 2000. This report describes the results of surveys conducted during March 2003.

METHODS

Acoustic techniques, specifically echo integration (Thorne 1970, 1971, 1983*a,b*), have been used for decades to assess abundance of pelagic fishes (MacLennan and Simmonds 1992; Thorne 1977). Walleye pollock are managed as groundfish. However, younger age pollock are almost exclusively pelagic (Brodeur and Wilson 1996). Adult pollock tend to be demersal on the continental shelf (less than 200 m) and pelagic off the continental slope (Thorne 1979). In the Gulf of Alaska, walleye pollock populations are assessed both by echo integration/midwater trawl surveys and groundfish surveys (Hollowed and Megrey 1990; Hollowed et al. 1991, 1993, 1994, 1995, 1996; Wilson 1994; Wilson et al. 1995, 1996).

Evidence from acoustic records suggests that adult pollock begin to accumulate in PWS in early winter, and remain in aggregations until after spawning in April. During this time, the distribution is almost exclusively pelagic. The acoustic surveys are designed to take advantage of this accessible and relatively restricted distribution.

The PWS survey design typically consists of a three stage sampling procedure (Cochran 1977; Scheaffer, Mendenhall and Ott 1986). First, historical patterns, information from commercial fishermen and broad area sonar/echosounder surveys are used to identify the general distribution of the pollock within Prince William Sound. Second, a quantitative (echo integration) acoustic survey is conducted, with sampling intensity proportional to abundance indicated in stage One. Third, midwater trawl net sampling is directed toward the surveyed concentrations to obtain biological information (McClatchie et al. 2000). Published target strength relationships for pollock (Traynor and Williamson 1983; Traynor 1996) are used to convert echo integration values to absolute density estimates. The validity of the target strength values has been verified by several *in situ* measurements at various frequencies in PWS (Thomas and Stables 1995; Kirsch 1997; Kirsch and Thomas 1998; Thorne 2000). The Alaska Dept. of Fish and Game conducted the midwater trawling in 2003Additional biological data were obtained from the ADF&G sampling of commercial fishing landings in Cordova.

Historically, acoustic systems at several frequencies have been used for the pollock surveys in Prince William Sound. The original survey in 1995 used both 38 and 120 kHz (Thomas and Stables 1996). The survey in 1997 used both a high power 120 kHz system with a preamp transducer and a 70 kHz system (Kirsch 1997). The 120 kHz had better detection because of superior transducer characteristics. A 38 kHz digital transducer system was applied in the 1998, 2000 and 2001 surveys along with the high power 120 kHz system. A 70 kHz system was applied along with the 120 kHz system in 2003. However, the signal to noise characteristics of the 120 kHz system have been consistently better than either the 38 kHz or the 70 kHz systems. The problem appears to be associated with excessive noise from the propeller at the lower frequencies. Consequently, the high-power 120 kHz system has the primary equipment used for surveys all years, including 2003. The acoustic systems are calibrated with a tungsten carbide spheres following procedures of Foote et al. (1987). System time-varied gains are measured and corrections are made for deviation from theoretical. Attenuation values are corrected based on salinity/temperature characteristics measured with a SeaBird Electronics Model 19.03 CTD.

All 120 kHz acoustic data were recorded on a Digital Audio Tape System and replayed in the laboratory. Echo integration measurements were made on the taped data using a BioSonics model 221 Echo Integrator. Data were analyzed in 5-m depth intervals to 400 m. Editing and averaging functions were made using Microsoft Excel spreadsheets. Occasional bottom intrusions were edited from the data. Water column densities for the pollock depth layers were integrated to determine biomass per unit area values for each transect, and weighted averages were calculated for each run. Population estimates were made by extrapolating the average surface area biomass values to the surface area represented by the survey. Variances were estimated from variations among the replicates using standard formulas (Seber 1973; Cochran 1977; Scheaffer, Mendenhall and Ott 1986). Grouping of the zigs and the zags in the survey pattern allows two independent measurements of the mean density from each survey, both composed of several parallel transects. This approach combines the best elements of systematic survey coverage without the problems of autocorrelation.

The survey was conducted using the FV *KyleDavid* in conjunction with a survey of herring. The survey plan was to cover the more exposed areas where pollock are located during relatively fair weather, and survey herring in protected areas during adverse weather. The pollock survey was initiated March 22 and completed March 25. Areas that were surveyed included Hinchinbrook Entrance, Montague Trench, Port Bainbridge, East Knight Island and a portion of the main basin.

In addition to analysis of the 2003 survey, calibration characteristics of previous surveys were examined. An error was found in the scaling factor used in 2002. The analysis had been scaled assuming a different connection from the one that had been actually used. Consequently, the 2002 results were rescaled and recalculated.

RESULTS AND DISCUSSION

Sampling data from the midwater trawls and the commercial fishery showed a smaller mean length than previous years. A backscattering cross section of 0.00055 was selected as the most representative value to convert the acoustic data to biomass for all surveys. The value corresponds to an acoustic target strength of –32.6 dB/Kg.

The results of the 2003 survey are given in Table 1. The estimated total biomass of pollock was 22,101 mt (95% C.I. 19,589 to 23,930). Results of the revised estimates for the 2002 surveys are given in Table 2. The estimated biomass was 26,455 mt (95% C.I. 25,510 to 27,399. The population trend from 1995 to 2003 is illustrated in Figure 1. Overall, the population has dropped 22% from 2000 and 49% from the peak estimate in 1998. The change has been most dramatic in Port Bainbridge where the population has declined from 27,366 mt in 1995 to 1,695 mt in 2003.

Little is known about the relation of PWS pollock to that of the Gulf of Alaska. For current management purposes, PWS pollock are considered to be part of the GOA population (Lloyd and Davis 1988; Bechtol 2001). If that is the case, variations in the PWS pollock population may represent larger scale changes, or even variation in distributional patterns. In contrast, a number of stocks have been identified along the west coast of Canada (Saunders et al. 1988) and there is some concern that the large areas used to manage pollock may not represent distinct stocks. Pollock quotas in PWS are based on summertime bottom trawl observations that are more synoptic with the summertime surveys by NMFS of the GOA stock. As a consequence, annual harvest is very limited, typically under 2,000 mt. It is highly unlikely that these conservative harvest levels have contributed significantly to the observed decline in PWS. While a continuing decline would become a source of concern, the current rate of decline, only about 7% per year, does not yet warrant a change in management or monitoring procedures.

Thomas and Thorne (2001) suggested that pollock and herring were competitors for dominance in the pelagic fish guild, and the outcome of that competition had immense ramifications to the rest of the ecosystem. Pollock have been the dominant pelagic biomass in PWS since the monitoring began in 1995. However, the current pollock decline contrasts with a recent increase in herring biomass to the point that herring are now slightly more abundant. That change may be reflected in a reversal of the Steller sea lion abundance. Late spring aerial counts by ADF&G and NMFS show a recent increase in the number of SSL in Prince William Sound, reversing a multiyear decline.

LITERATURE CITED

Bechtol, W. 2001. Prince William Sound walleye pollock: current assessment and 2002 management recommendations. Regional Information Rept 2A01-23, Alaska Dept. of Fish and Game, Division of Commercial Fisheries, Anchorage, AK., 34p.

Brodeur, R. and M. Wilson 1996. Meso-scale acoustic patterns of juvenile walleye pollock (Theragra chalcogramma) in the western Gulf of Alaska. Can. J. Fish. Aquat. Sci. 53:1951-1963.

Cochran, W.G. 1977. Sampling Techniques. John Wiley & Sons. New York, 428 pp.

Foote, K.G., H.P. Knudsen, G. Vestnes, D.N. MacLennan and E.J. Simmonds 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. Int. Coun. Explor. Sea coop. Res. Rep. No. 144: 57 Pp.

Hollowed, A.B. and, B. Megrey 1990. Walleye pollock. In Stock Assessment and Fishery Evaluation Report for the 1991 Gulf of Alaska Groundfish Fishery. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Hollowed, A.B., B.A. Megrey, P. Munro and W. Karp 1991. Walleye pollock. In Stock Assessment and Fishery Evaluation Report for the 1992 Gulf of Alaska Groundfish Fishery. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Hollowed, A.B., B. Megrey and E. Brown, 1993. Walleye pollock. In Stock Assessment and Fishery Evaluation Report for the 1994 Gulf of Alaska Groundfish Fishery. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Hollowed, A.B., C. Wilson, E. Brown and B. Megrey, 1994. Walleye pollock. In Stock Assessment and Fishery Evaluation Report for the 1995 Gulf of Alaska Groundfish

Fishery. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Hollowed, A.B., E. Brown, P. Livingston, B. Megrey and C. Wilson, 1995. Walleye pollock. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska As Projected for 1996. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Hollowed, A.B., E. Brown, B. Megrey and C. Wilson, 1996. Walleye pollock. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska As Projected for 1997. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Kirsch, J. 1997. Acoustic biomass estimate of adult walleye pollock in Prince William Sound, Alaska, in winter 1997. Final Rept. To Alaska Dept. of Fish and Game, Prince William Sound Sci Ctr, 20 p.

Kirsch, J. and G.L. Thomas 1998. Acoustic biomass estimate of adult walleye pollock in Prince William Sound, Alaska, in Winter 1998. Final Rept. to Alaska Dept. of Fish and Game, Prince William Sound Sci Ctr, 25 p.

Lloyd, D, S. and S. K. Davis 1988. Biological Information required for improved management of walleye pollock off Alaska. Proc. Int. Symp. Biol. Mgmt. Walleye Pollock. Pp. 9-31.

MacLennan, D.N. and E.J. Sommonds 1992. Fisheries Acoustics. Chapman and Hall, London, 325 p.

McClatchie, S., R. Thorne, P. Grimes and S. Hanchet 2000. Ground truth and target identification for fisheries acoustics. Fisheries Research 47:173-191.

Saunders, G., A. McFarlane, and W. Shaw 1988. Delineation of walleye pollock (*Theragra chalcogramma*) stocks off the Pacific Coast of Canada. Proc. Int. Symp. Biol. Mgmt. Walleye Pollock. Pp. 379-401.

Scheaffer, R., W. Mendenhall and L. Ott, 1986. Elementary Survey Sampling, Duxbury Press, Boston, 324p.

Seber, G.A.F. 1973. The Estimation of Animal Abundance and related parameters. Griffin, London, 506 p.

Thomas, G.L. and T.B. Stables 1996. Winter 1995 estimate of the prespawning biomass of walleye pollock in Prince William Sound, Alaska. Rept. to Alaska Dept. of Fish and Game, Prince William Sound Sci Ctr, 15p.

Thorne, R.E. 1970. Investigations into the use of an echo integrator for measuring pelagic fish abundance. Ph.D. Thesis, University of Washington, Seattle.

Thorne, R.E. 1971. Investigations into the relationship between integrated echo voltage and fish density. J. Fish. Res. Bd Canada 28:1265-1274.

Thorne, R.E. 1977. Acoustic Surveys, Pp. 20-38 in A. Saville (ed.) Survey Methods of Appraising Fishery Resources. FAO Tech. Paper 171, FAO, Rome

Thorne, R.E. 1979. Acoustic/midwater trawl survey of Gulf of Alaska. FRI-UW-7910, Fisheries Research Institute, University of Washington, Seattle, 38 pp.

Thorne, R.E. 1983a. Assessment of population abundance by echo integration. Proc. Symp. On Assessment of Micronekton. Biol. Ocean. J. 2:253-262.

Thorne, R.E. 1983b. Hydroacoustics. Chapt 12 in L. Nielson and D. Johnson (eds), Fisheries Techniques. American Fisheries Society, Bethesda, MD.

Thorne, R.E. 2000. Biological Monitoring of Herring and Pollock in Prince William Sound. Annual Progress Report to Oil Spill Recovery Institute, Prince William Sound Science Center, Cordova, AK, 57 p.

Traynor, J.J. 1996. Target-strength measurements of walleye pollock (Theragra Chalcogramma) and Pacific whiting (Merluccius productus). ICES J. Mar. Sci. 53:253-258.

Traynor, J.J. and N.J. Williamson 1983. Target strength measurement of walleye pollock (*Theragra chalcogramma*) and a simulation study of the dual-beam method. FAO Fisheries Rept. 3000:112-124.

Trumble, R., R. Thorne and N. Lemberg 1983. The Strait of Georgia herring fishery: A case history of timely management aided by hydroacoustic surveys. Fish. Bull. 80(2):381-388.

Wilson, C. 1994. Echo integration-trawl survey of pollock in Shelikof Strait, Alaska in 1994. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska as Projected for 1995. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Wilson, C., M. Guttormsen and D. McKelvey 1995. Echo integration-trawl survey of pollock in Shelikof Strait, Alaska in 1995. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska as Projected for 1996. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Wilson, C., M. Guttormsen and S.K. DeBlois 1996. Echo integration-trawl survey of pollock in Shelikof Strait, Alaska in 1996. In Stock Assessment and Fishery Evaluation Report for Gulf of Alaska as Projected for 1995. Prepared by the Gulf of Alaska Groundfish Plan Team, North Pacific Fishery Management Council, Anchorage, AK

Table 1. Results of pollock assessment from 2003 surveys

Location	Density (kg/m^2)	Density (mt/nm^2)	Area (nm2)	Biomass mt	Lower	Upper
MidSound	0.023	78.5	100	7850	6925	8775
Hinchinbrook Entrance/ Montague Trench	0.023	77.3	90	6953	6089	7817
East Knight Island	0.051	175.5	20	3510	1865	5155
Port Bainbridge	0.033	113.0	15	1695	1068	2321
Lower Knight Is. Pass	0.031	104.6	20	2093	1987	2198
Total				22,101	19589	23930

Table 2. Revised results of pollock assessment from 2002 surveys

Date	Location	Density (kg/m2)	Density (mt/nm2)	Area (nm2)	Biomass mt	Lower	Upper
1-Mar	MidSound	0.031	105.1	100	10512	10207	10817
27-Mar	Hinchinbrook Entrance	0.008	27.4	50	1372	1206	1538
27-Mar	Montague Trench	0.031	105.0	80	8397	8001	8792
28-Mar	East Knight Island	0.032	109.8	40	4390	3729	5052
29-Mar	Port Bainbridge	0.026	89.2	20	1784	1362	2205
	Total				26455	25510	27399

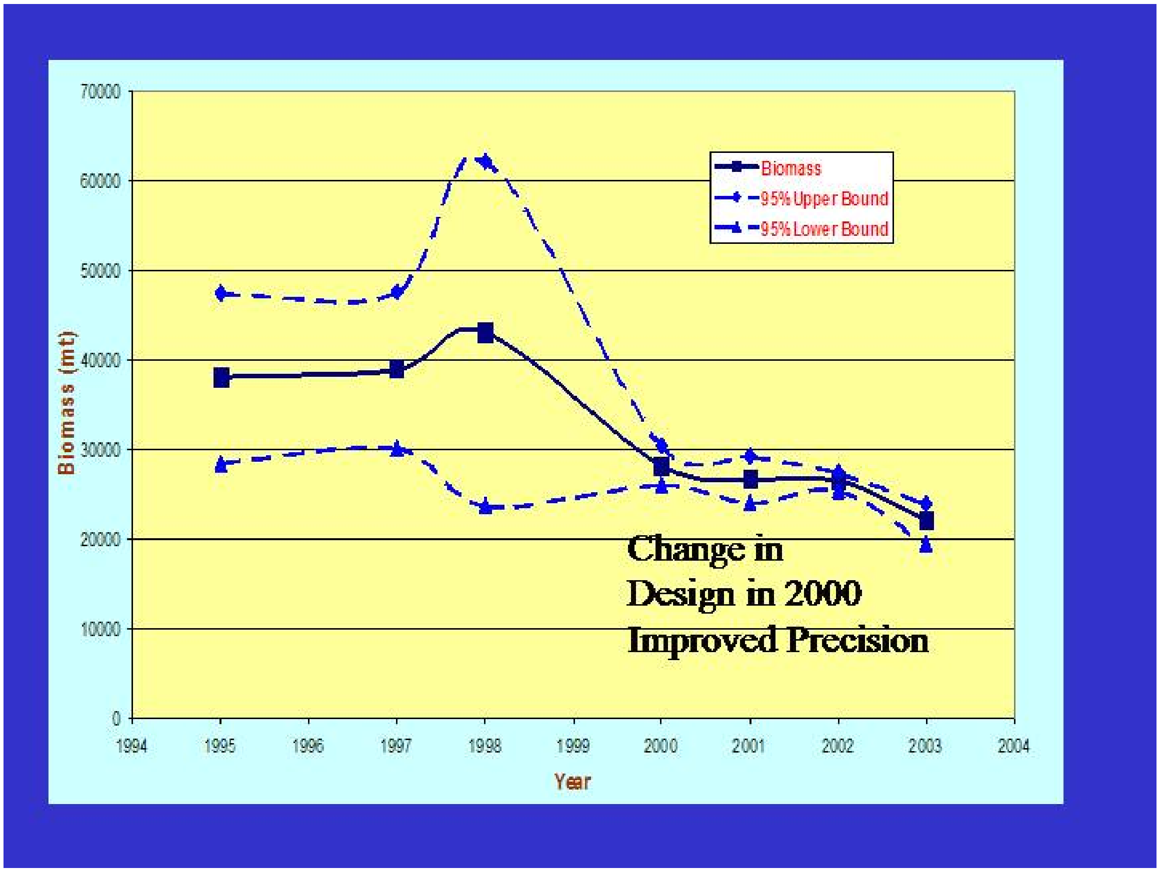

Figure 1. Biomass of pollock in Prince William Sound, 1995-2003