

**Interactions among Steller Sea Lions, Pollock and Herring  
and an Examination of Variability Associated with  
Acoustic Surveys of Pollock**

A Project Funded by the Pollock Conservation Cooperative

Principal Investigators:

**John J. Goering, University of Alaska, Fairbanks  
Richard E. Thorne and Gary L. Thomas  
Prince William Sound Science Center  
Cordova, Alaska**

The background for this project is found in eight preceding years of herring surveys and four preceding annual estimates of pollock in Prince William Sound (PWS) conducted by the Prince William Sound Science Center. The pollock surveys suggested a temporal source of variability that could affect the accuracy of acoustic surveys for pollock. In addition, during herring surveys in March 2000, an infrared scanner detected intense nighttime foraging activity of Steller sea lions on the overwintering herring schools. This observation, subsequently published in *NATURE* (Vol. 411:1013), indicated that the Steller sea lions in PWS targeted herring schools during the overwinter period to the exclusion of pollock. Consequently, funding from the Pollock Conservation Cooperative (PCC) was requested to explore the implications of these observations.

The PCC project was originally proposed as a three-year, \$246,519 program in cooperation with an ongoing Oil Spill Recovery Institute (OSRI) program on monitoring pollock and herring populations in PWS. It was funded as a one-year, \$40,000 project including purchase of an infrared scanner. The revised objectives centered on examination of the effectiveness of the infrared scanner for study of Steller sea lion foraging behavior. The revised project remained tightly coupled with the OSRI monitoring program and allowed a slight expansion of survey effort to examine variability in pollock biomass estimates associated with survey timing.

Late winter and early spring surveys of pollock, herring and Steller sea lions in PWS were conducted in 2001. The surveys included a combination of acoustics, aerial surveys, boat census using visual and infrared, and direct capture (midwater and purse seine). The findings can be summarized as follows:

- (1) Steller sea lions were coincident with and actively foraging on all herring concentrations-SEE NOTE 1, FIGS. 1-2,
- (2) No Steller sea lions were coincident with, or actively foraging on, any pollock concentration- SEE NOTE 1, FIGS. 1-2,
- (3) There is a temporal component of variability in pollock acoustic surveys that can affect the accuracy of biomass estimates-SEE NOTE 2, TABLE 1,

(4) Infrared scanning technology is an effective tool for nighttime detection of Steller sea lion foraging activity, but its effectiveness is weather dependent-SEE NOTE 3,

(5) Evidence strongly indicates that marine mammal foraging on herring in PWS has contributed to precipitous declines in the herring population-SEE NOTE 4, and

(6) Precipitous declines in both herring and Steller sea lion populations in PWS are closely linked, and appear to be related to lingering impacts of the Exxon Valdez Oil Spill-SEE NOTE 5, FIGS. 3-4.

This annual report constitutes the final report for this one-year project.

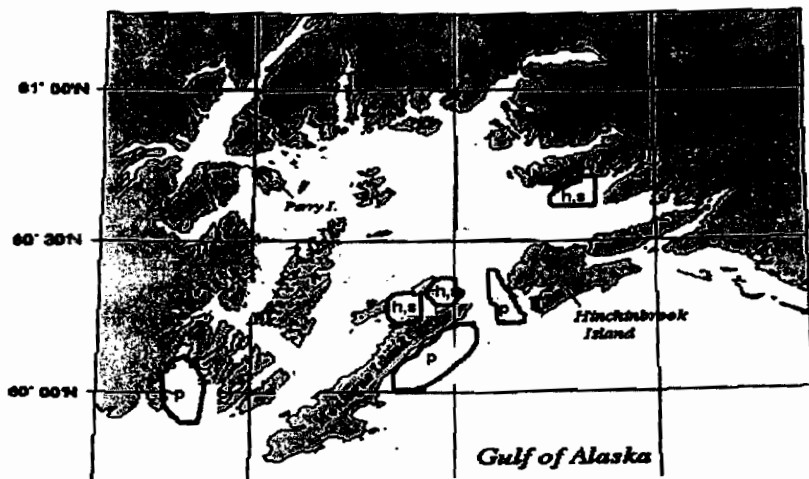


Fig. 1. Distribution of pollock (p), herring (h) and Steller sea lions (s) during March 2000.

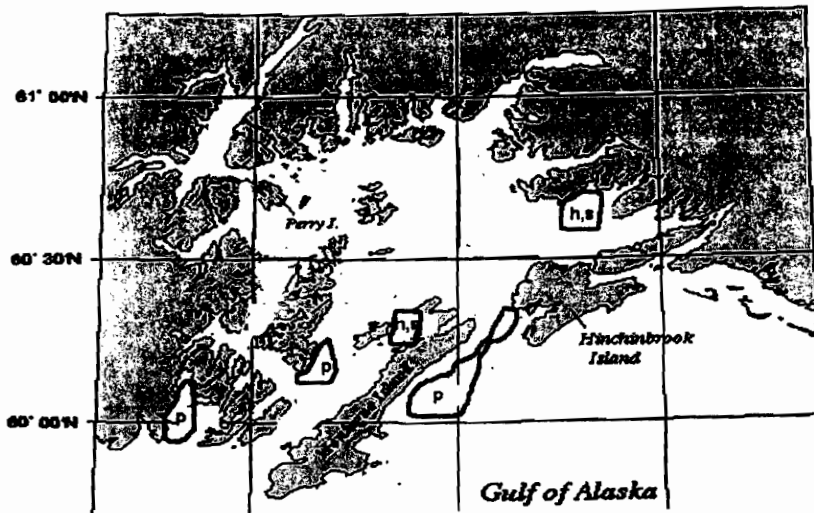


Fig. 2. Distribution of pollock (p), herring (h) and Steller sea lions (s) during March 2001.

Note 1. During March 2000, prior to the PCC project, aerial and boat surveys had shown Steller sea lions coincident with all three major areas of herring concentration: St. Mathews Bay, Rocky Bay and NW Montague Island. No Steller sea lions had been observed coincident with the pollock concentrations in Port Bainbridge, Montague Trench and Hinchinbrook Entrance. During early and late March 2001, aerial and boat surveys, including infrared scanning, showed the same result as the previous year except that the concentration of herring in Rocky Bay had disappeared, and the concentration of Steller sea lions in that location had also disappeared. Despite two intensive, day and night surveys on pollock concentrations, not a single Steller sea lion was observed above any pollock concentration.

Table 1. Results of March 2001 Pollock Surveys

	<u>Location</u>		<u>Area</u> (nm <sup>2</sup> )	<u>Mean</u> (mt/nm <sup>2</sup> )	<u>Mean</u>	<u>Var</u>	<u>Pop</u> (mt)	<u>PopVar</u>	<u>95% CI</u> (mt)
<b>Cruise 1</b> (3/1-4)	<b>Port Bainbridge</b>	Zig	22	108					
		Zag	22	221	164	3179	3612	1538490	2481
	<b>SE Knight Island</b>	Zig	25	143					
		Zag	25	190	167	537	4166	335463	1158
	<b>Montague Trench</b>	Zig	70	97					
		Zag	70	116	106	95	7442	466283	1366
	<b>Subtotal</b>			117			15220	2340235	3060
	<b>Cruise 2</b> (3/28-31)	<b>Port Bainbridge</b>	Zig	22	39				
Zag			22	39					
<b>Port Bainbridge</b>		Zig	22	49					
		Zag	22	45	43	6	942	2749	105
<b>L. Knight I. Pass/ SE Knight Island</b>		Zig	50	67					
		Zag	50	61	64	8	3212	20637	287
<b>Montague Trench</b>		Zig	100	76					
		Zag	100	74	75	1	7499	7707	176
<b>Subtotal</b>			172			11653	31093	353	

Note 2. The two pollock surveys, conducted at the beginning and end of March, showed significant changes in the distribution and abundance within Prince William Sound. In particular, a major change was noted within Port Bainbridge, which historically has been the major location of pollock. This result agrees with limited previous observations. It has been documented that adult pollock enter the PWS area during early winter, and spawn in April. It appears that there are temporal changes in this migration that impact the results of acoustic surveys. Accurate estimates of annual variability will only be obtained when this pattern of seasonal variability is understood. An expansion of effort considerably beyond the scope of this project would be required to accomplish this objective.

Note 3. The infrared scanner purchased under this project was a Raytheon Model 200 Nightsight. Its characteristics are very similar to the Texas Instruments Model M100 Nightsight system that was used in the March 2000 study that was subsequently published in *NATURE* 411:1013. The conditions during the March 2000 study were ideal, calm and dry, and the detection capability was amazing, even detection of individual fish flipping at the surface. During the March 2001 study we found the system performance degraded considerably in the presence of precipitation. While the infrared system does turn "night into day", its detection range is restricted by precipitation even more than such conditions would restrict daytime detection. This limitation to detection needs to be incorporated into future survey plans.

Note 4. As noted in Figs. 1 and 2, a major change was seen in the distribution of herring between March 2000 and March 2001. For many years, Rocky Bay has been the location of the largest overwintering concentration of herring in PWS. This was the site of the intense nighttime marine mammal foraging that was noted and subsequently published in *NATURE* 411:1013. That concentration, nearly 4,000 metric tons, was reduced to 302 m.t. by March 2001. Steller sea lions were also conspicuously absent. The abundance of herring in the Rocky Bay area has progressively decreased, from over 30,000 m.t in 1997, even in the absence of a commercial fishery. The Steller sea lion foraging activity that was present at Rocky Bay in March 2000 appears to have shifted to the herring concentration in St. Mathews Bay, which is now the largest remaining herring concentration in PWS.

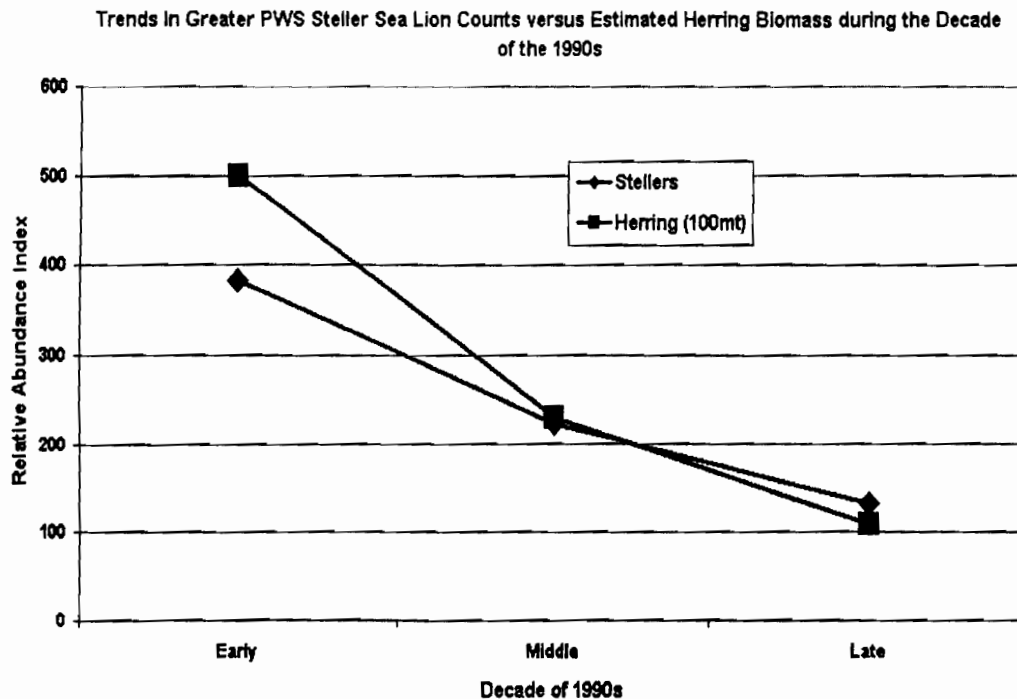


Fig. 3. Trends in relative abundance of herring and Stellers in PWS during past decade. Steller sea lion data are scaled from the NMFS/ADF&G Trend Site Census.

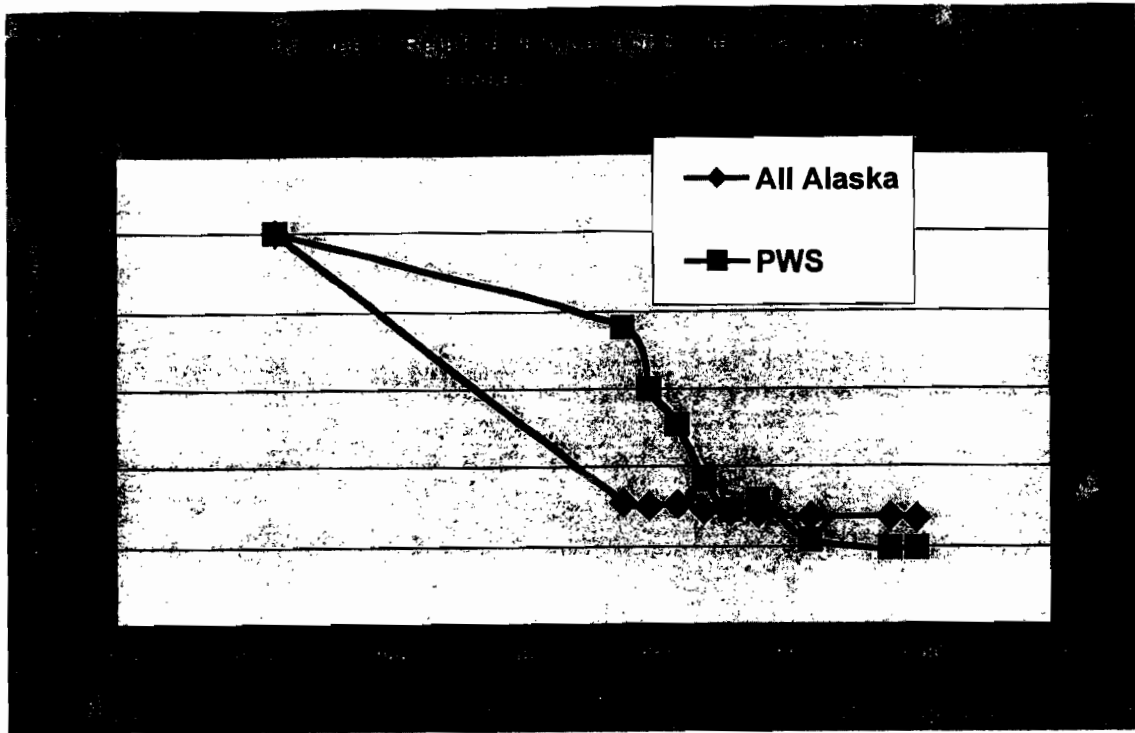


Fig. 4. Comparison of population trends for Steller sea lions in all Alaskan waters and those in and around Prince William Sound: Source-NMFS/ADF&G Trend Site Census.

Note 5. Most of the Steller sea lion decline for Alaskan waters in general took place between 1975 and 1989. It is well known that a change in ocean climate conditions in the North Pacific took place in the late 1970s, and that the climate change resulted in a biological change to a regime dominated by cods, especially pollock. It is believed by many scientists that this regime shift was the major factor in the decline of Alaskan Steller sea lions. There have been indications in the last decade that the regime is shifting back toward its earlier state, and clearly the decline of Steller sea lions in Alaskan waters as a whole have leveled off. However, the population in and around PWS decreased only slightly between 1975 and 1989. This is probably because the inshore, protected habitat of PWS was partially insulated from the changes that were taking place in the larger North Pacific Ocean. However, since 1989 the population in greater PWS has declined precipitously, the fastest decline of any Steller sea lion population in the world. The beginning of this precipitous decline in 1989 is probably not a coincidence. Substantial evidence links the *Exxon Valdez* oil spill (EVOS) with the subsequent demise of the PWS herring stock. The close linkage between Steller sea lions and herring in PWS, as shown in Fig. 3, and the foraging studies of this project, are the strongest documentation to date of a relationship between a declining Steller sea lion population and its forage base. Such a relationship has been postulated, but not demonstrated, probably because most speculation has incorrectly focused on pollock as the forage species. The close linkage between Steller sea lion and herring declines and its timing also strongly suggests that EVOS is the indirect source of the decline of Steller sea lions in PWS.

