Trends in South San Francisco Bay Fish Populations from 1972 to 2002

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DISCOVERING OUR BAY

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Introduction

The San Francisco Bay is a vitally important estuary for numerous species that spend at least part of their lives in the Bay, and it has been impacted by numerous anthropogenic influences since the rapid population increase in the area around 1850. A number of important studies have been conducted in the Bay to examine the species found throughout different regions of the estuary.

South San Francisco Bay is generally characterized by large areas of shallow expanse surrounding a deeper channel (10-15 m) that runs down the center of the bay. Salinity varies seasonally and is greatly influenced by rain and snowmelt coming into the North Bay from the Sacramento and San Joaquin Rivers. In the summer and fall, the salinity often exceeds 30 ppt and is generally not stratified (Powell et al., 1989). During the winter and spring, however, freshwater inputs from the North Bay and local streams can significantly decrease the salinity in the South Bay. This typically leads to stratification of the water column. These variations in salinity can have a significant impact on the phytoplankton biomass and contribute to the seasonal variability in the presence and abundance of various species of fishes in the South Bay.

A number of studies have investigated fish populations in the South San Francisco Bay. The earliest biological study of the San Francisco Bay occurred in 1912-3 on the research vessel the *Albatross* (Hedgpeth, 1979). Due to the deep draft of the vessel, efforts were concentrated in the deep water channel and collections were limited in scale.

A survey of fishes and invertebrates was conducted from 1963-1966 by Aplin

(1967). This study involved the monthly sampling of six stations over the four-year span of the study. Three of these sites were in the South Bay, and one of them was within the sampling area of the current study.

The California Department of Fish and Game has been conducting extensive and regular monitoring of fishes and certain invertebrates throughout the Bay since 1980. They currently sample on a monthly basis at 52 sites throughout the San Francisco Bay and Delta. The goal of their study is to understand the relative importance of natural and anthropogenic factors associated with variations in fish and invertebrate populations.

The current study by the Marine Science Institute spans 29 years of fish data in South San Francisco Bay. This study is unique; the study area included a subset of the South Bay, allowing for intensive sampling on a frequent basis. A subset of the data set was used for a study by Pearson (1989).

Methods

The Marine Science Institute (MSI) has conducted cruises with an educational focus in the South San Francisco Bay for 35 years, and fish population data were collected during the periods from February 1973 until June 1982 and from October 1992 until December 2002. The data were collected by MSI instructors or volunteers trained to identify and measure the fish collected.

Two cruises were often conducted per day, with three otter trawls made per cruise. The sampling region was divided into 20 zones, all located between the San Mateo Bridge and the Dumbarton Bridge. Most of the sites were bounded on one side by

the deepwater channel running down the center of the South Bay and on the other by shallows. The trawl depths varied from 2-15 meters. Fish were caught using an otter trawl, and sampling methods remained fundamentally the same throughout the 29-year period.

The otter trawl had a 4.9 meter headline, 3.8 cm mesh, 0.64 cm mesh in the cod end (Nylon Net Company, stock #SHT16). Between 1973 and 1982, the warps were 23 meters long; later the boat was equipped with 60-meter warps. This dissimilarity should not have biased the catches, as the net dragged the bottom in both cases.

The trawl was timed for 10 minutes from the time the net was fully deployed until the crew began to pull it in. All fish in the net were then sorted, counted, and measured. Bony fish were measured from the tip of the snout to the caudal peduncle. Skates and rays were measured across the body to the tips of their pectoral fins, and sharks were measured from the tip of the snout to the tip of the tail.

Water samples were collected from 1 meter below the surface. The temperature was measured with an electronic meter or a thermometer, and the salinity was determined with a hydrometer.

Due to the fact that the primary purpose of MSI's voyages is for the education of the children on board, data sampling was unequal between months. To minimize bias, data collected during months when there were fewer than five trawls have not been included in the analyses. To correct for the variability in the number of trawls per month, results are in terms of the mean catch per trawl per month.

Trawling frequency varies seasonally as a consequence of MSI's educational activity. Figures 1A and 1B show monthly activity over the two periods. Species

diversity is highly variable during the year, but does not change greatly from decade to decade, as can be seen from Figures 4A and 4B.

Species that proved consistently difficult for data collectors to identify, including sanddabs (family *Bothiidae*) and gobies (family *Gobiidae*) were grouped together by family.

Prior analysis of a subset of the data (1973-1982) by Pearson (1989) showed that there were no significant differences in the distribution of fish species between stations. Therefore, the data have been combined into a single population abundance value.

During the time period from January 1973 and June 1982, there was a total of 2,561 trawls used in the analyses, and between October 1992 and December 2002 there was a total of 4,264 trawls used for the analyses.

Results

A total of 62 different species of fish were collected during the course of the study. Of these, seven species were collected only during the time period from 1973-1982, and six species were collected only between 1992 and 2001. The twelve most common species for each time period were considered for analysis (see Table 1). The five most common species were the same for each of the two time periods with one exception. Pacific herring was replaced by staghorn sculpin in the 1990s as one of the five most common species.

Table I shows a comparison between data collected between 1973-1982 and data collected between 1992-2002. We believe that these tabulations are strictly comparable because the methods, locations, and conditions for accepting or rejecting data are

essentially the same. The mean number of fish caught per trawl is presented as a measure of abundance.

Species showing significant decreases are Northern anchovy (*Engraulis mordax*), English sole (*Parophrys vetulus*), shiner surfperch (*Cymatogaster aggregata*), and Pacific herring (*Clupea harengus*). The species showing the most striking declines are dwarf surfperch (*Micrometus minimus*), black surfperch (*Embiotoca jacksoni*), and white surfperch (*Phanerodon furcatus*). Species showing moderate population increases are gobies (all species considered together), staghorn sculpins (*Leptocottus armatus*), and bat rays (*Myliobatis californica*). Very large increases are seen for white croakers (*Genyonemus lineatus*), California halibut (*Paralichthys californicus*), and Pacific sardines (*Sardinops sagax caeruleus*). No significant changes occur for sanddabs (both species considered together) and leopard sharks (*Triakis semifasciata*).

Figure 3A shows a plot of the average monthly temperatures during the 1973-1982 period. Figure 3B is the average bottom temperature during the 1992-2002 period. We have plotted the bottom temperature rather than the average of the surface and bottom temperatures.

Salinity data from the 1973-1982 period are shown in Figure 2A. Of particular note is the almost monotonic rise of salinity during the drought years of 1976 and 1977. Figure 2B shows salinity during the 1992-2002 period. In very wet years, e. g. 1995 and 1998, salinity declines to one-third its dry season value.

Comparison of Trends

Fish abundances for the major species are summarized in Table I.

Temporal trends in the abundance of northern anchovies are presented in Figures 5A (1973-1982) and 5B (1992-2002). The large spike in abundance in 1973 is not repeated in later data. Seasonal trends are evident throughout both periods, with a bimodal peak in some years such as 1993 and 1995. The long term decline in the late 1990s is not understood.

English sole data are shown in Figures 6A and 6B. The greater than sixfold decline is not understood, though there have been significant declines in the catch of English sole offshore as well. Data published by the Interagency Ecological Program for the San Francisco Estuary for the 1980-1995 period show a significant decline in abundance, a result that is consistent with our observations. (Baxter et. al., p. 396)

Shiner surfperch abundance declined significantly between the 1970s and the 1990s (see Figures 7A and 7B). Peaks occurred in spring months with frequent secondary peaks in late summer. These seasonal peaks match time when shiner surfperch typically give birth to young. Dwarf surfperch (Figure 12B), black surfperch, and white surfperch (Figure 14) almost vanished during the 1990s. All nine species of surfperch found in the study area showed a similar and dramatic decline in population between the 1970s and the 1990s.

Species in the family *Gobiidae* showed a slight increase in abundance from the 1970s (Figure 8A) to the 1990s (Figure 8B). Peaks were usually in midsummer, but occasional spikes occurred at other times. Since the 1970s, there have been two

additional species of goby introduced into the Bay, the shimofuri goby (*Tridentiger bifasciatus*) and the shokihaze goby (*Tridentiger barbatus*), and both of these species have been collected in the study area by MSI.

Pacific herring exhibited a fourfold decline in abundance from the 1970s (Figure 9A) to 1990s (Figure 9B). Spikes are usually in spring months with exceptions in 1973 and 2000. The decline in abundance is consistent with the decline reported in the 1980-1993 period by the San Francisco Bay Monitoring Program. (Resources Agency, California Department of Fish and Game)

The abundance of sanddabs (Figures 10A and 10B) was unchanged for the two periods. Peaks occurred most often in the spring but sporadically in other seasons.

Staghorn sculpin populations increased almost threefold (Figures 11A and 11B). Peaks usually occurred in spring.

White croakers (Figures 13A and 13B) exhibited a very large increase, even excluding the atypical large peak in 1993.

White Surfperch (Figure 14), not numerous in the 1973-1982 period, have vanished from the South Bay in the more recent study. This result agrees with the disappearance reported by the Interagency Ecological Program for the1980-1995 period. (Baxter et. al., 1999)

The abundance of California halibut in the 1970s was rather low; only 252 halibut were collected over this nine-year period (see Figure 15A). In contrast, the abundance of halibut increased significantly in the 1990s. There were 8,773 halibut collected during this time period. While there was a significant increase in the overall abundance of halibut during the 1990s, there were also two large pulses in population numbers during

this period (see Figure 15B). These two pulses seem to be linked to offshore conditions in the Pacific Ocean rather than variations within the Bay itself. These results will be presented in greater detail in a future publication.

Leopard sharks (Figures 16A and 16B) have shown no change in abundance. Bat rays (Figures 17A and 17B) are sometimes discarded for safety reasons when the nets are heavily loaded. Therefore the increase in abundance is larger than shown because of this effect and the avoidance of areas where they congregate.

Pacific sardines have shown a remarkable increase in abundance in the South Bay (Figure 18) and the increase parallels the return of coastal populations of sardines after their precipitous decline in the late 1940s. The recovery of Pacific sardine populations has been linked to the period of warmer water temperatures, referred to as el Viejo (Chavez, et al., 2003).

Conclusions

A large body of data has been collected by the Marine Science Institute on fish populations in the South San Francisco Bay between 1972 and 2002. Trends in fish populations vary significantly between species. Changes in fish populations do not seem to be correlated with physical parameters within the Bay. In the case of the California halibut, the explanation for the change in population size can be explained, while in other species explanations for changes in population sizes are less apparent. Further analyses are required to elucidate some of these questions.

Table I

Fish Abundance from MSI Data

	Pearson's Study 1973-1982		**Current Study 1992-2002**	
	2561 Trawls	#/Trawl	4,264 Trawls	#/Trawl
Northern Anchovy	199,389	77.86	201,446	47.24
English Sole	49,469	19.32	12,317	2.89
Shiner Surfperch	37,469	14.63	26,973	6.33
Gobies	7,017	2.74	16,287	3.82
Pacific Herring	6,534	2.55	2,529	0.59
Sanddabs	6,052	2.36	11,965	2.81
Staghorn Sculpins	3,344	1.31	15,811	3.71
Dwarf Surfperch	2,446	0.96	148	0.03
Black Surfperch	1,107	0.43	37	-----
White Surfperch	919	0.35	0	-----
White Croakers	380	0.15	8,803	2.06
California Halibut	252	0.10	8,773	2.06
Pacific Sardine	40	-----	1,239	0.29
Leopard Shark	423	0.17	856	0.20
Bat Ray	333	0.13	1,955	0.46

Figure Captions

Figure 1A Number of Trawls per Month vs. Date, South Bay, 1973-1982

Figure 1B Number of Trawls per Month vs. Date, South Bay, 1992-2002

Figure 2A Mean Salinity vs. Date, South Bay, 1973-1982

Figure 2B Bottom Salinity vs. Date, South Bay, 1992-2002

Figure 3A Water Temperature vs. Date, South Bay, 1973-1982

Figure 3B Water Temperature vs. Date, South Bay, 1992-2002

Figure 4A Number of Species per Trawl, South Bay, 1973-1982

Figure 4B Number of Species per Trawl, South Bay, 1992-2002

Figure 5A Abundance of Northern Anchovies vs. Date, South Bay, 1973-1982

Figure 5B Abundance of Northern Anchovies vs. Date, South Bay, 1992-2002

Figure 6A Abundance of English Sole vs. Date, South Bay, 1973-1982

Figure 6B Abundance of English Sole vs. Date, South Bay, 1992-2002

Figure 7A Abundance of Shiner Surfperch vs. Date, South Bay, 1973-1982

Figure 7B Abundance of Shiner Surfperch vs. Date, South Bay, 1992-2002

Figure 8A Abundance of Gobies vs. Date, South Bay, 1973-1982

Figure 8B Abundance of Gobies vs. Date, South Bay, 1992-2002

Figure 9A Abundance of Pacific Herring vs. Date, South Bay, 1973-1982

Figure 9B Abundance of Pacific Herring vs. Date, South Bay, 1992-2002

Figure 10A Abundance of Sanddabs vs. Date, South Bay, 1973-1982

Figure 10B Abundance of Sanddabs vs. Date, South Bay, 1992-2002

Figure 11A Abundance of Staghorn Sculpins vs. Date, South Bay, 1973-1982

Figure 11B Abundance of Staghorn Sculpins vs. Date, South Bay, 1992-2002

Figure 12A Abundance of Dwarf Surfperch vs. Date, South Bay, 1973-1982

Figure 12B Abundance of Dwarf Surfperch vs. Date, South Bay, 1992-2002

Figure 13A Abundance of White Croakers vs. Date, South Bay, 1973-1982

Figure 13B Abundance of White Croakers vs. Date, South Bay, 1992-2002

Figure 14 Abundance of White Surfperch vs. Date, South Bay, 1973-1982

Figure 15A Abundance of California Halibut vs. Date, South Bay, 1973-1982

Figure 15B Abundance of California Halibut vs. Date, South Bay, 1992-2002

Figure 16A Abundance of Leopard Sharks vs. Date, South Bay, 1973-1982

Figure 16B Abundance of Leopard Sharks vs. Date, South Bay, 1992-2002

Figure 17A Abundance of Bat Rays vs. Date, South Bay, 1973-1982

Figure 17B Abundance of Bat Rays vs. Date, South Bay, 1992-2002

Figure 18 Abundance of Pacific Sardines vs. Date, South Bay, 1992-2002

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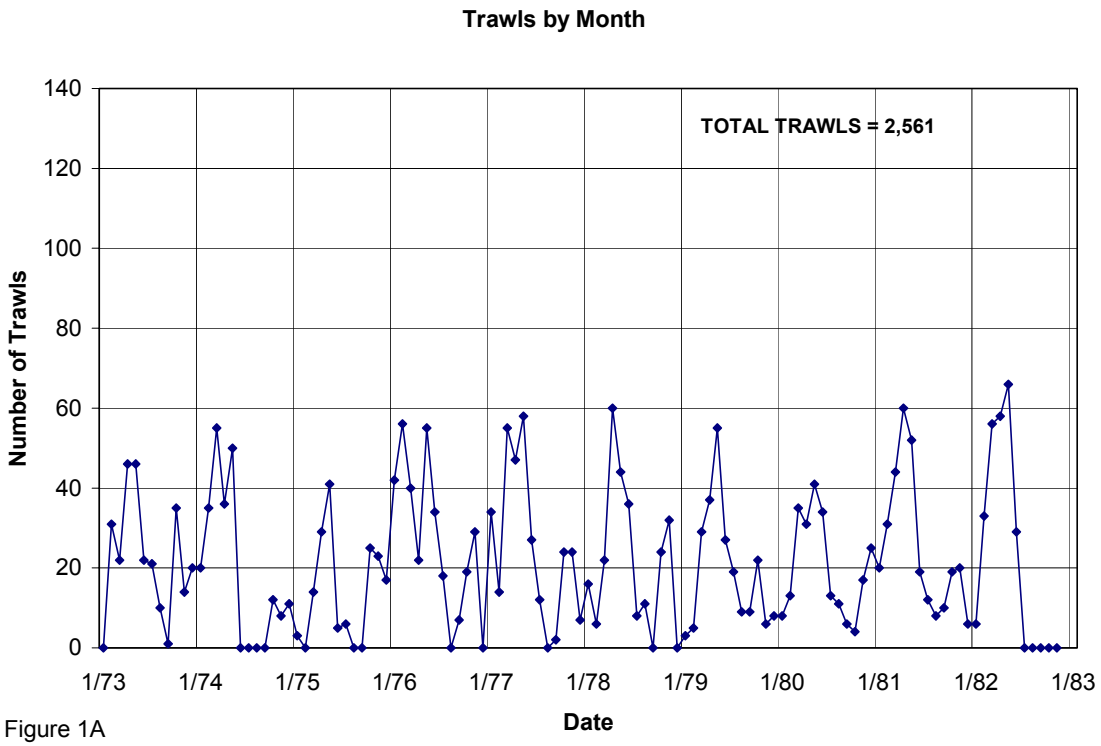
Authors

The information presented in this report was compiled and analyzed by Katherine L. Schafer, T. J. Diesel, and Michael D. Mancusi. The plots of 1973-1982 data are based on the tabulations published by Pearson.



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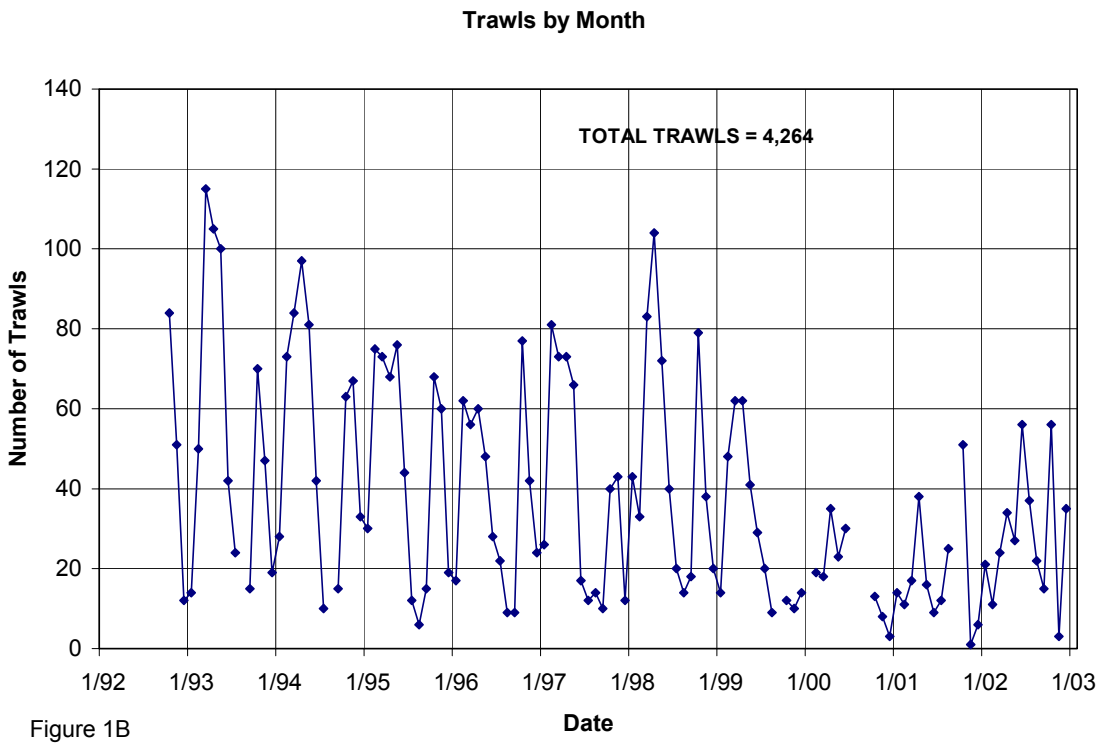

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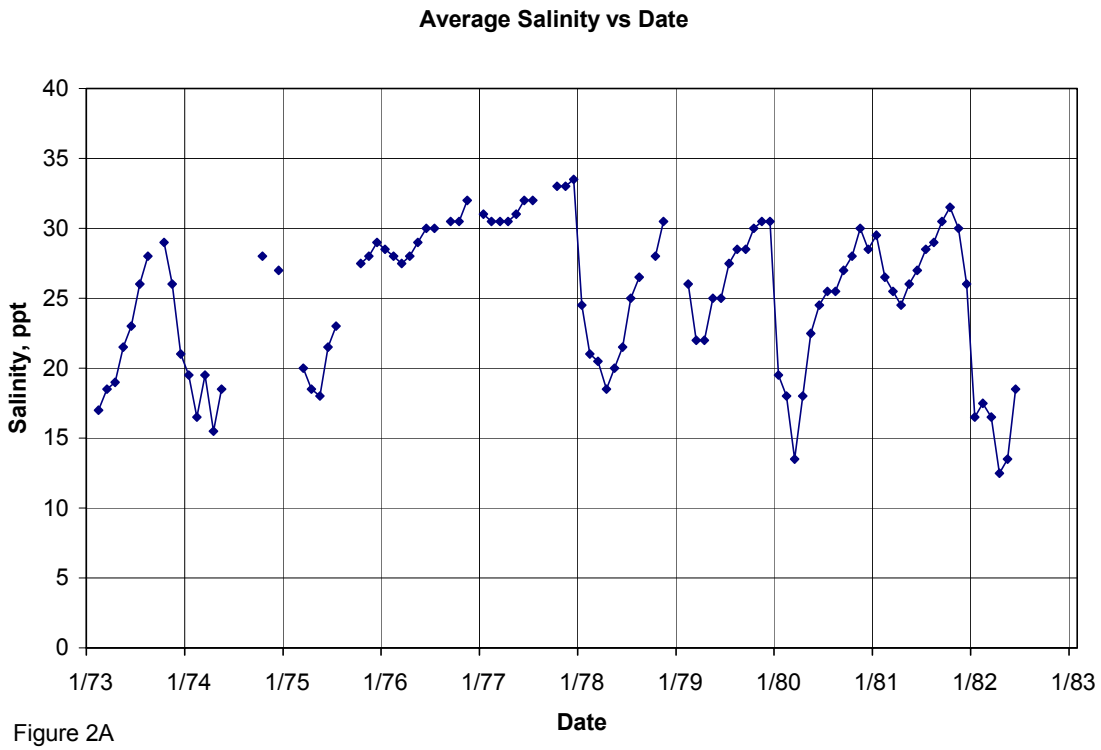

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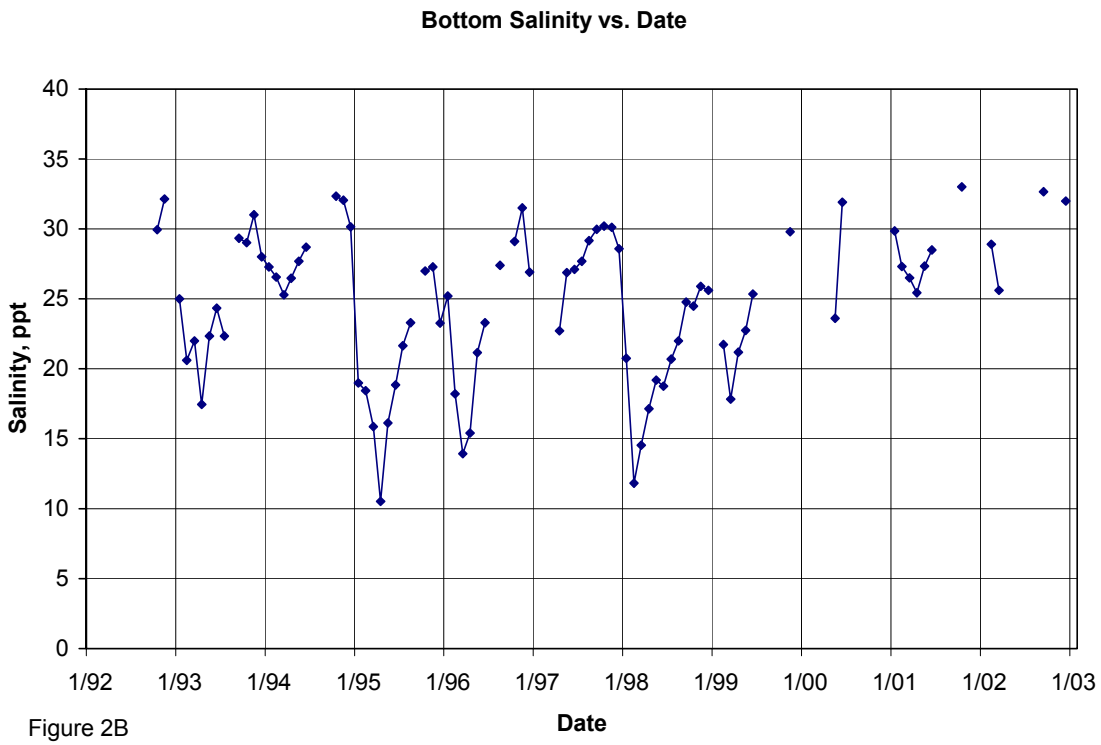

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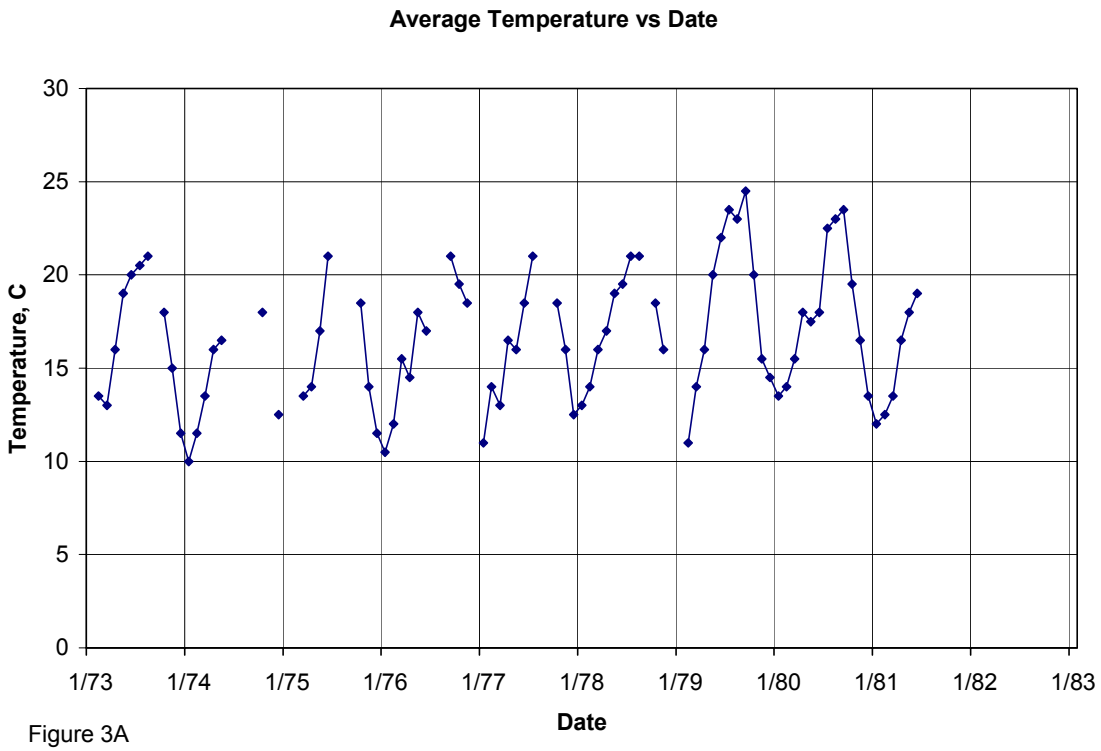

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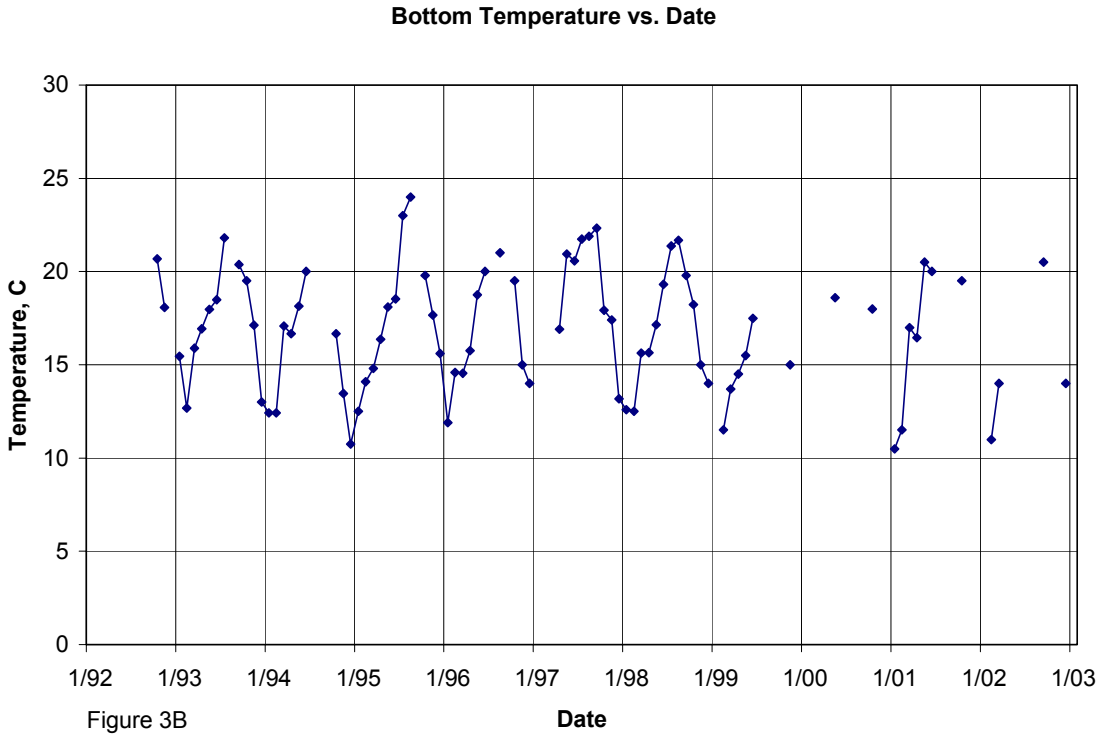

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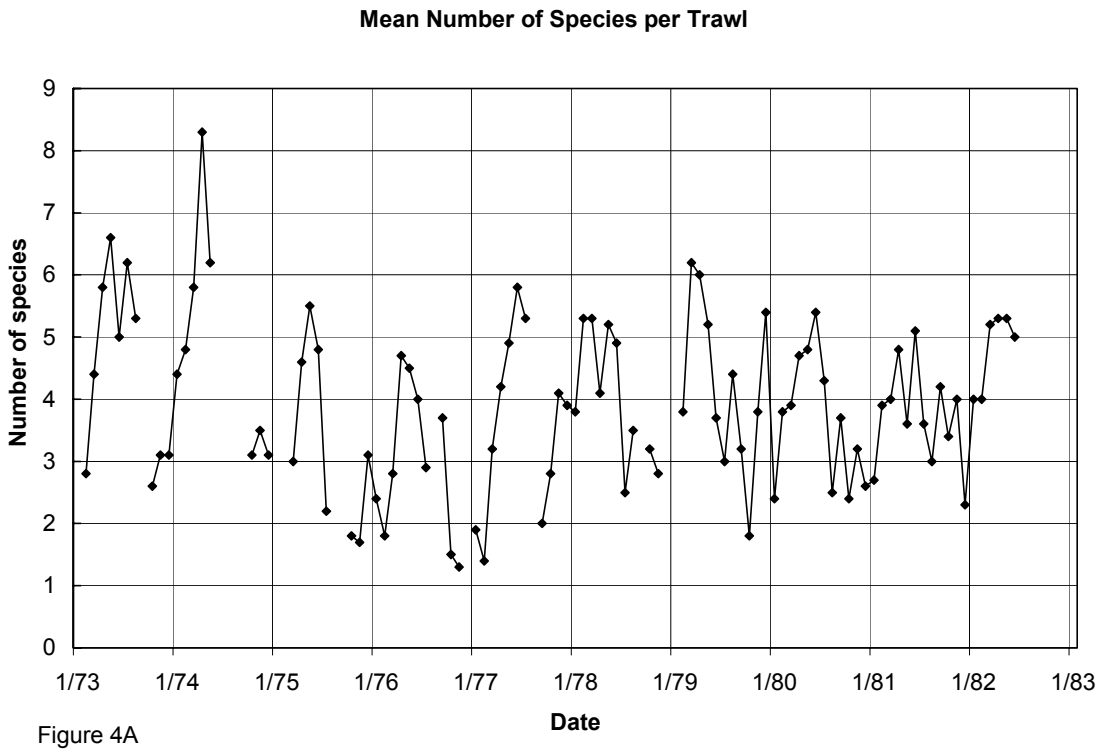

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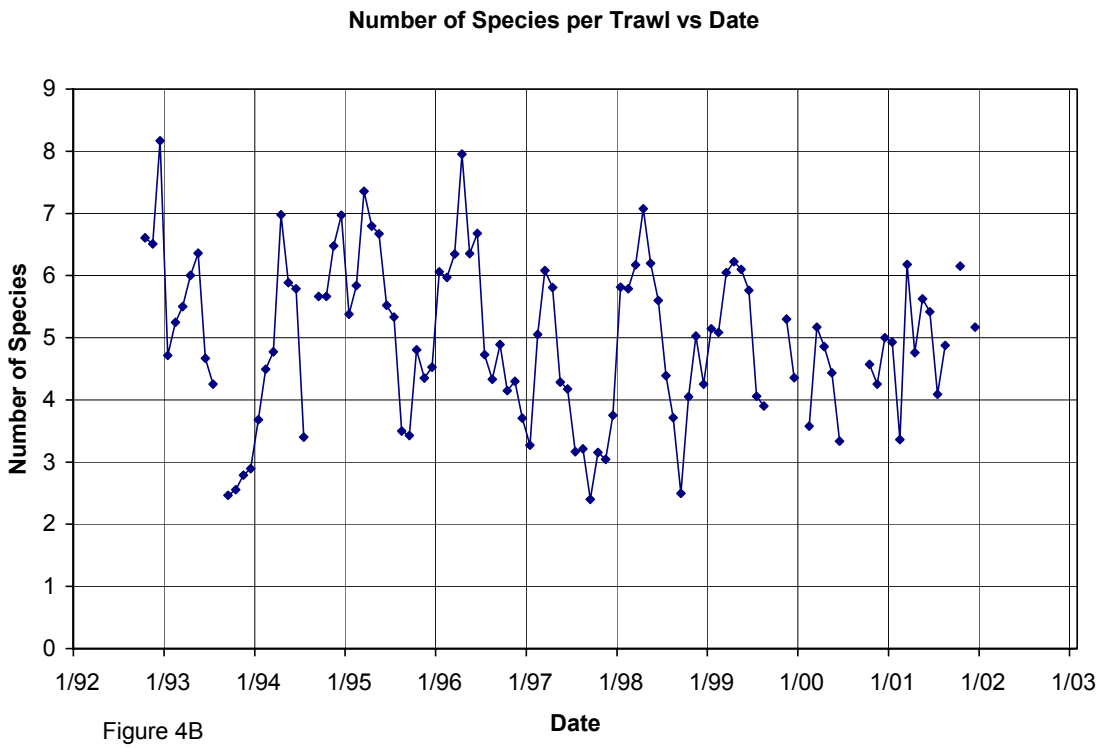

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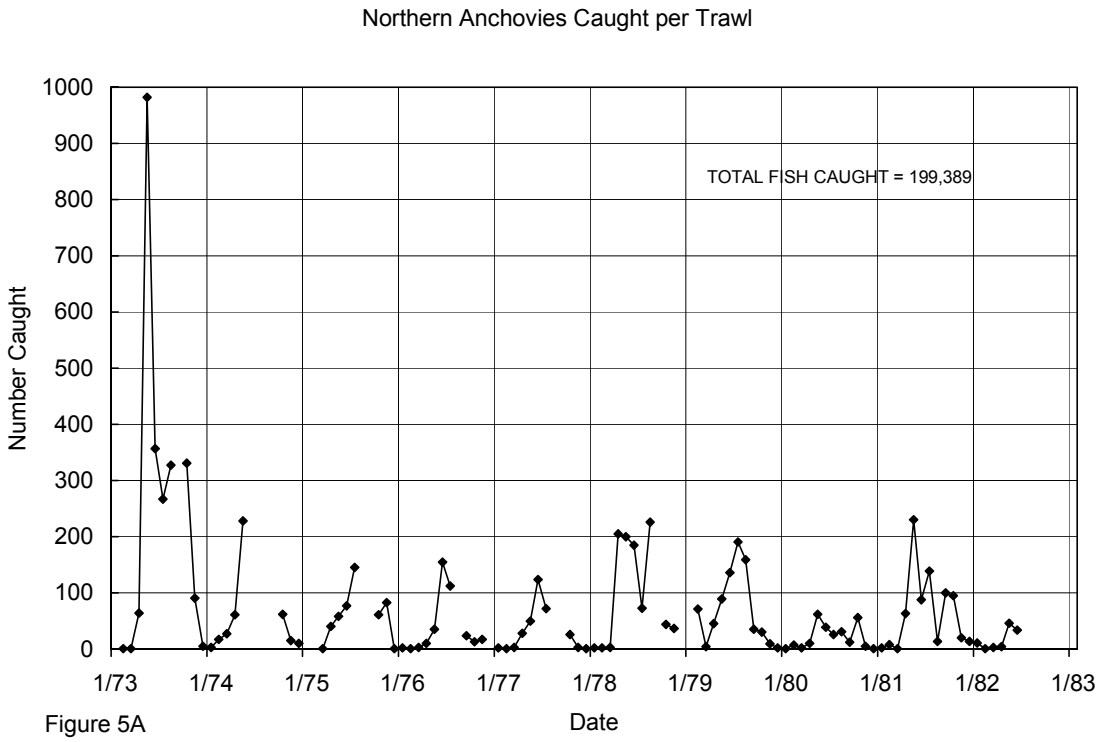

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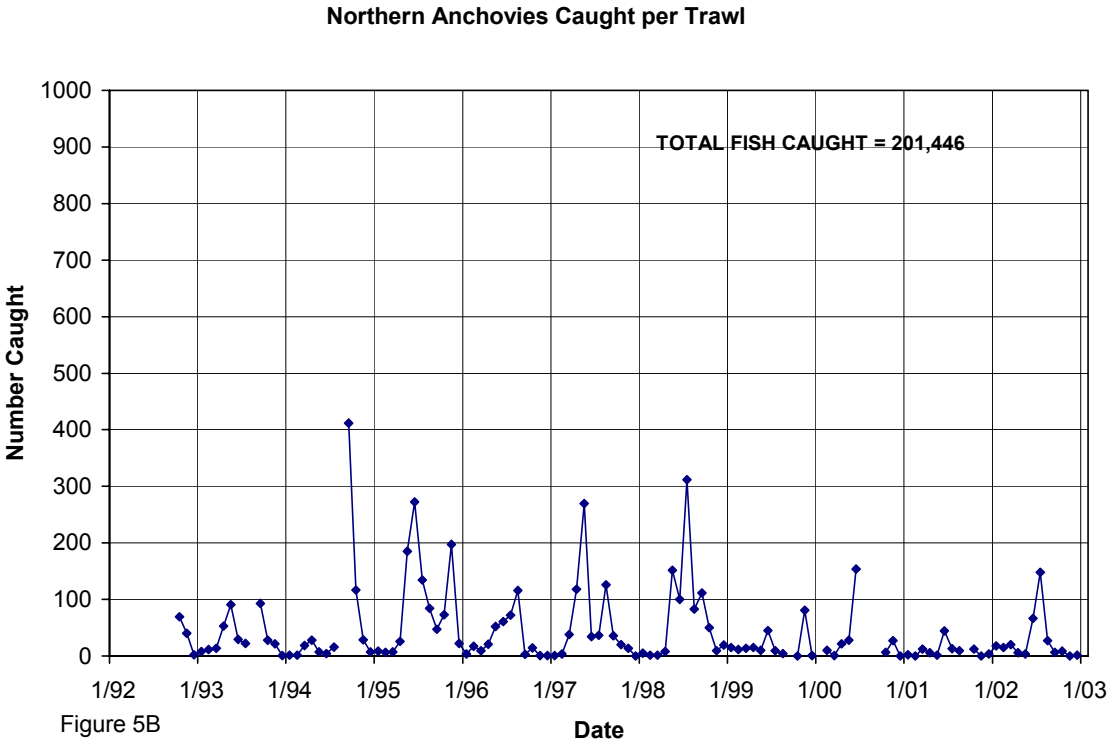

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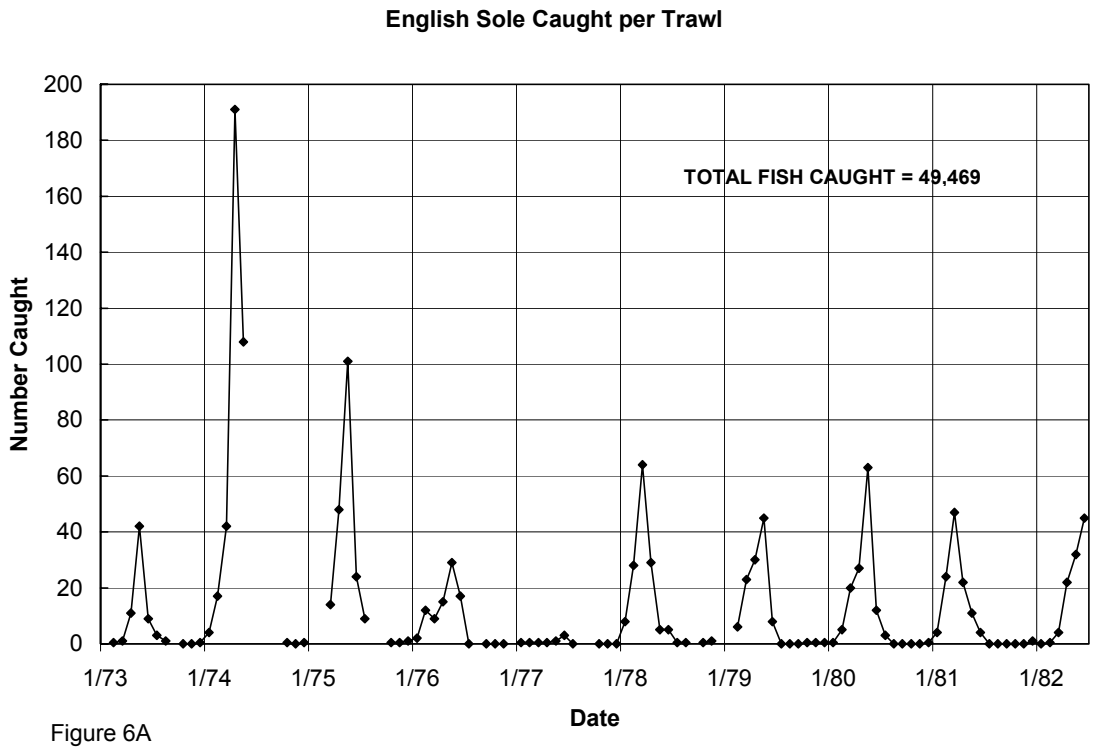

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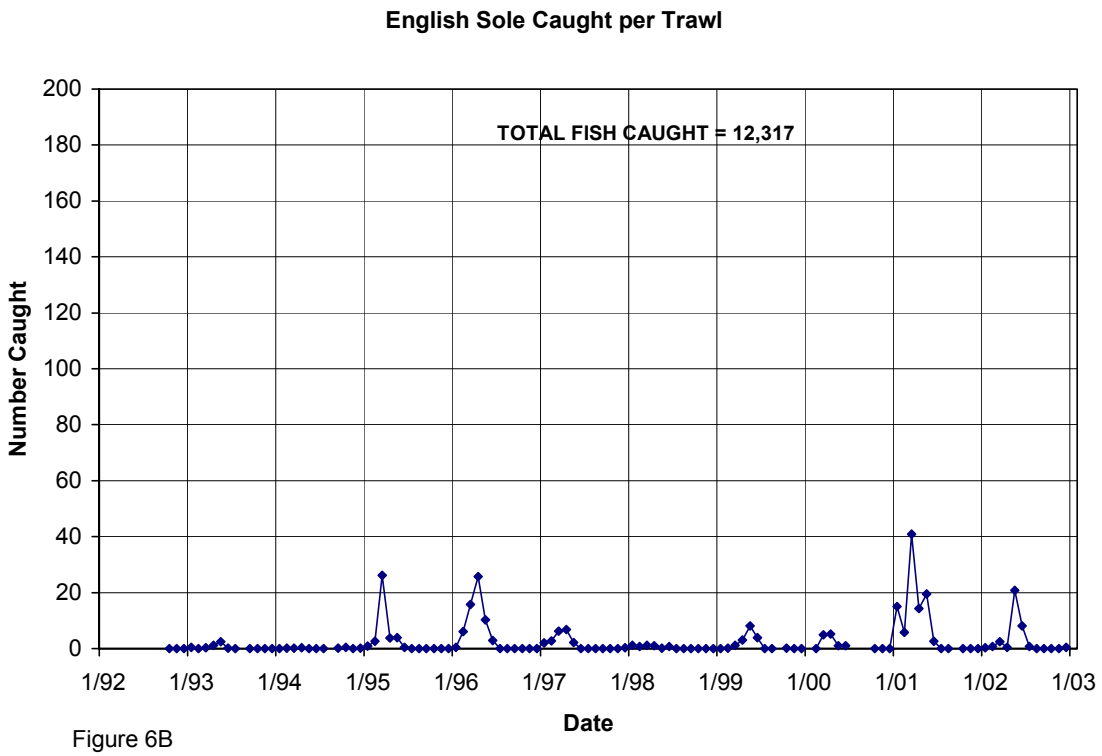

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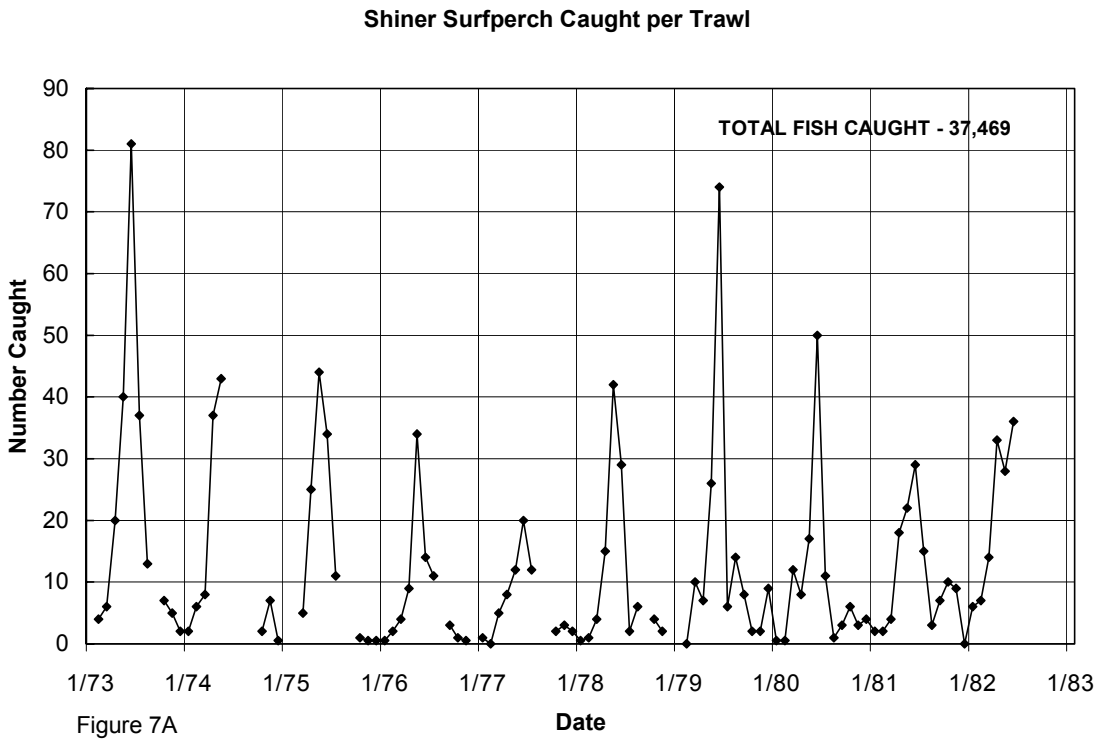

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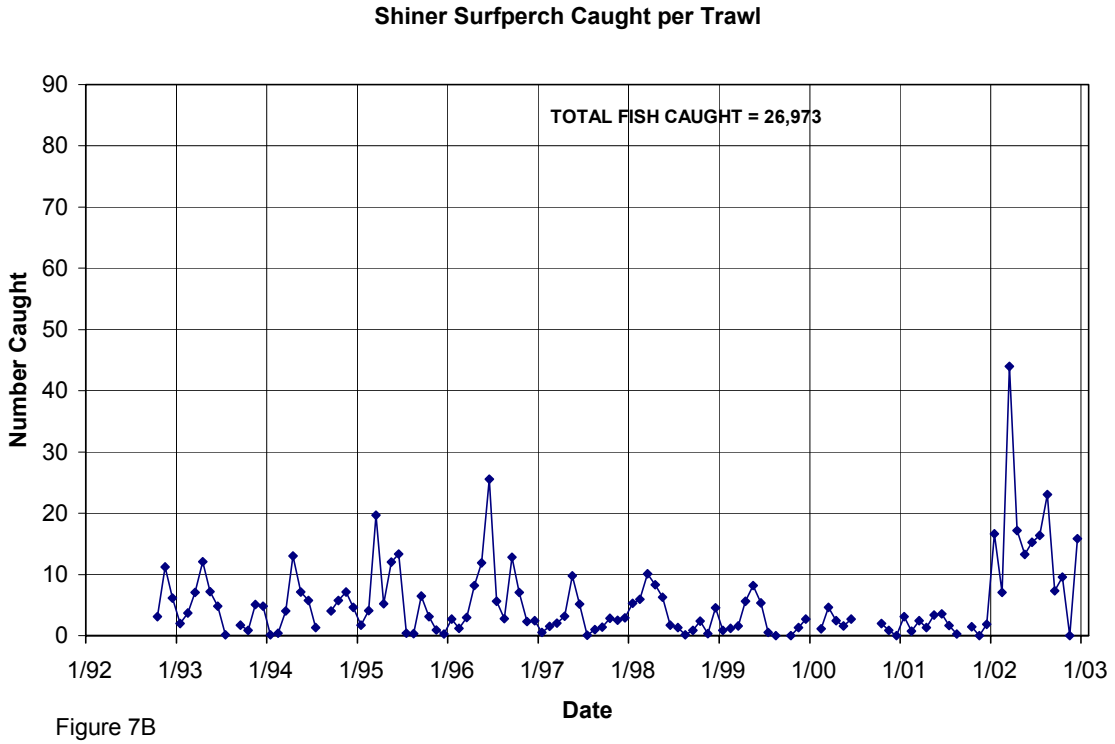

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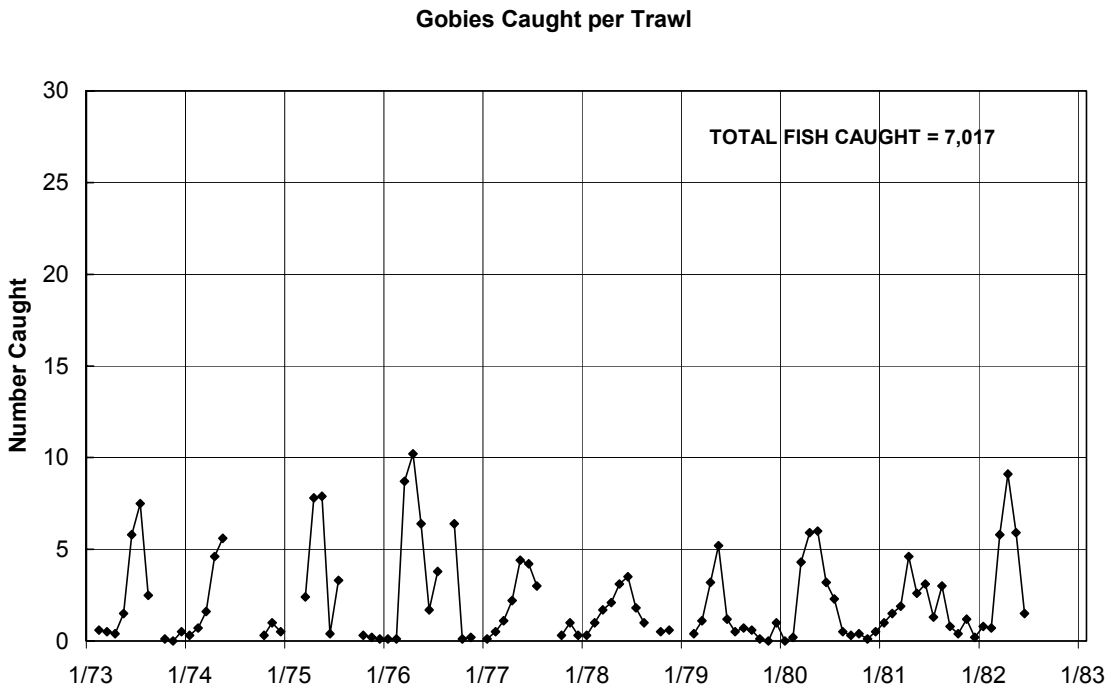

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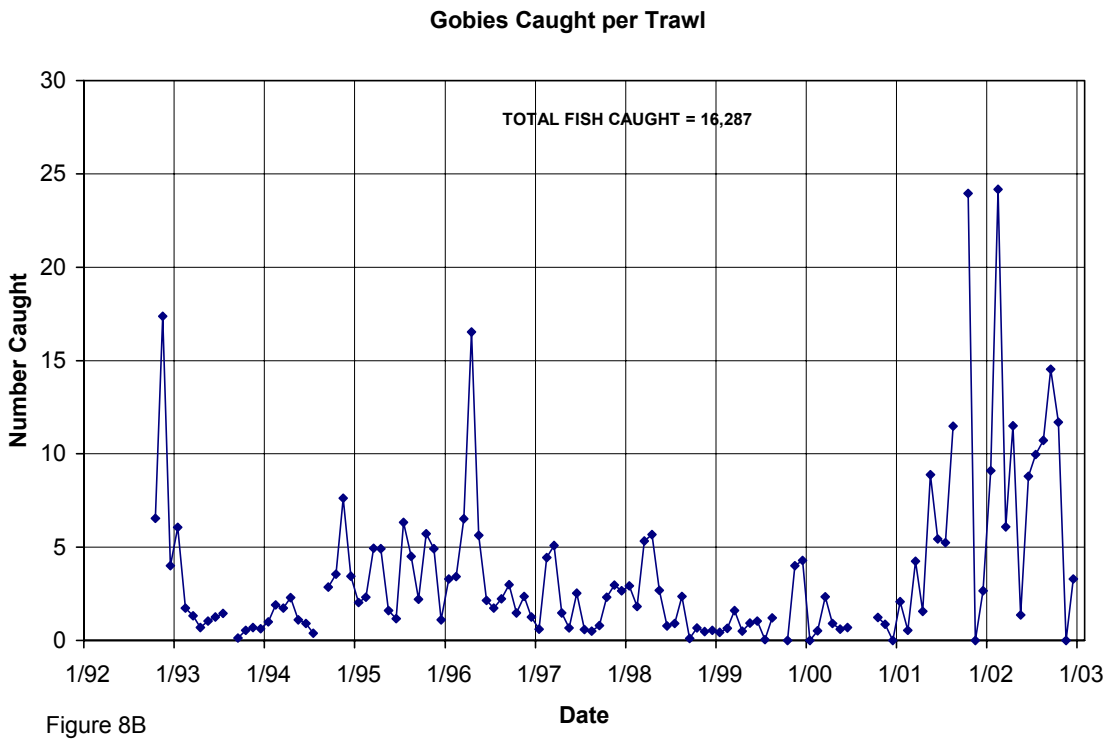

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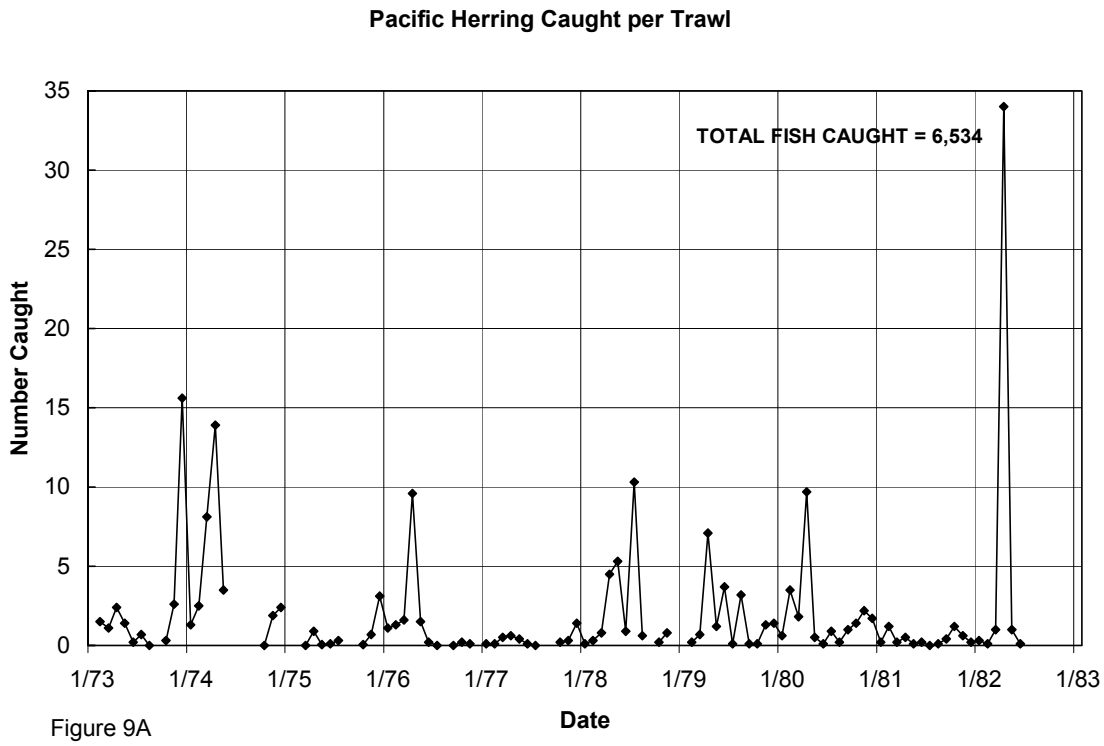

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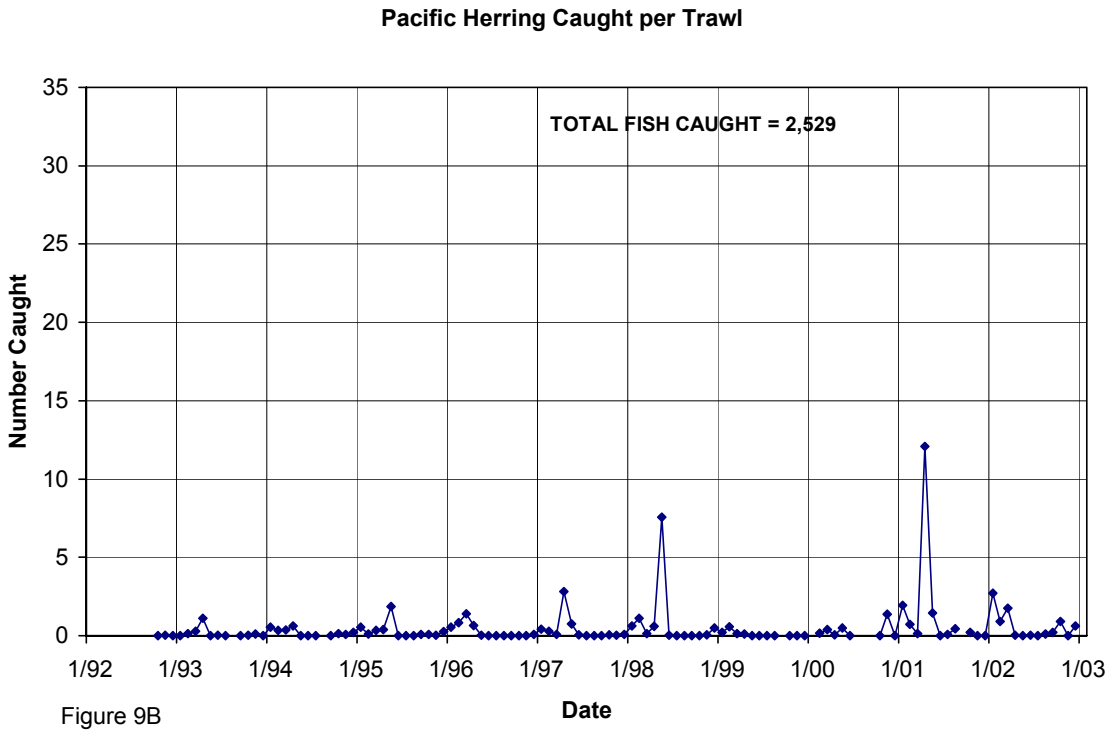

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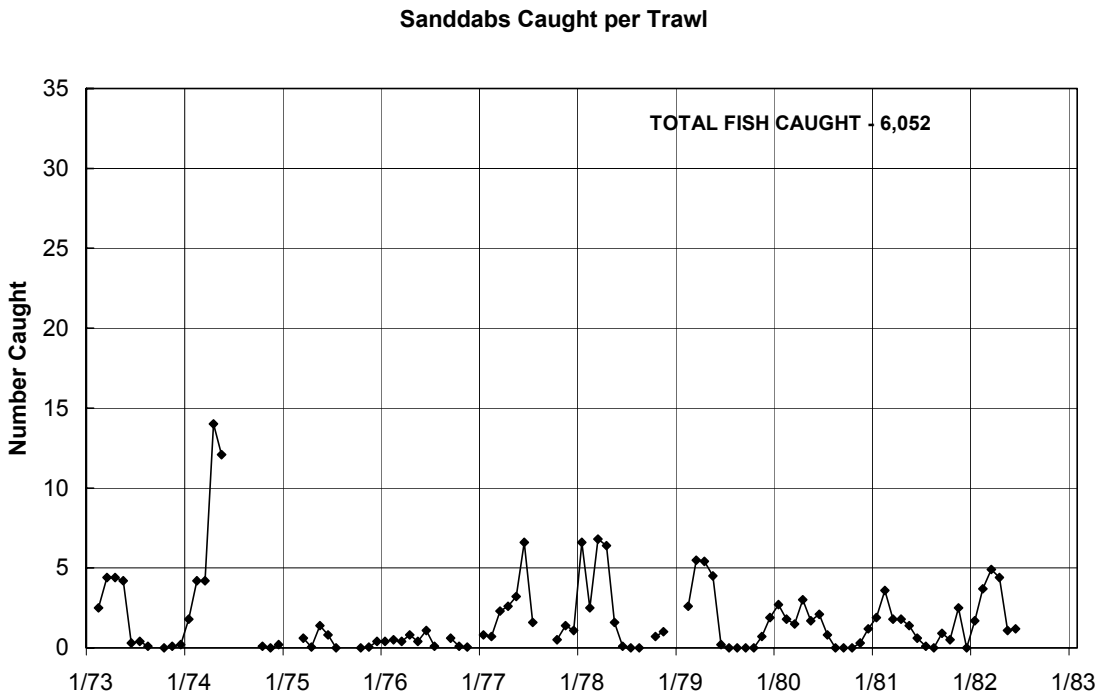

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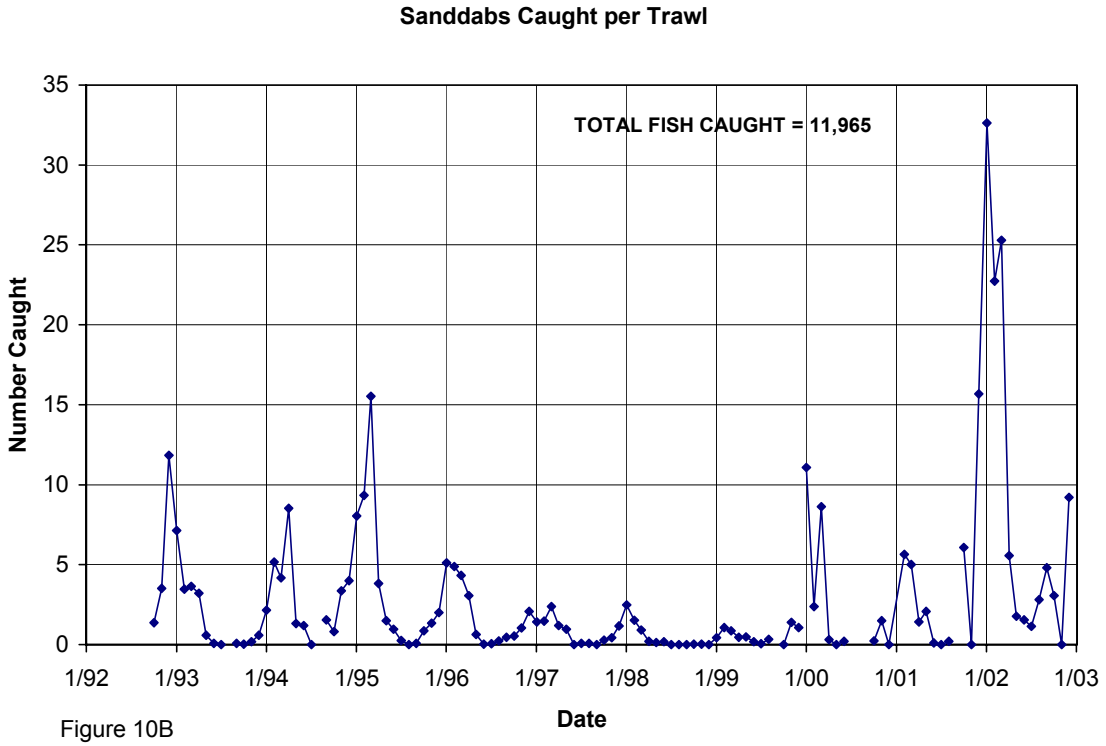

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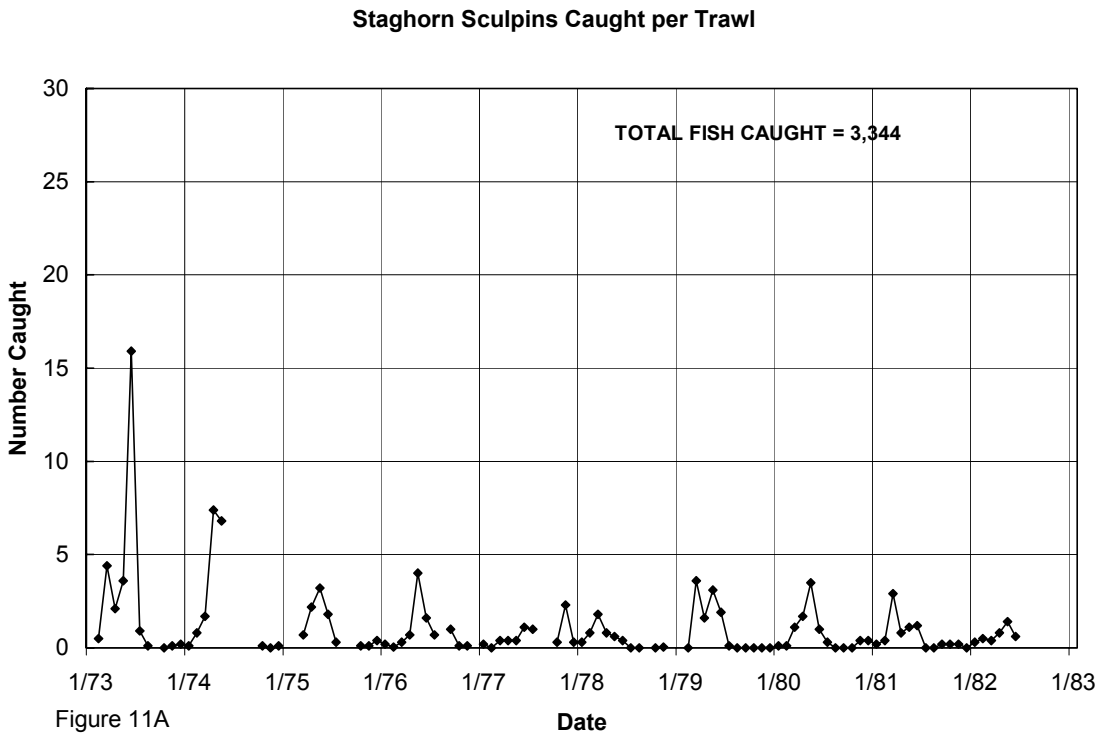

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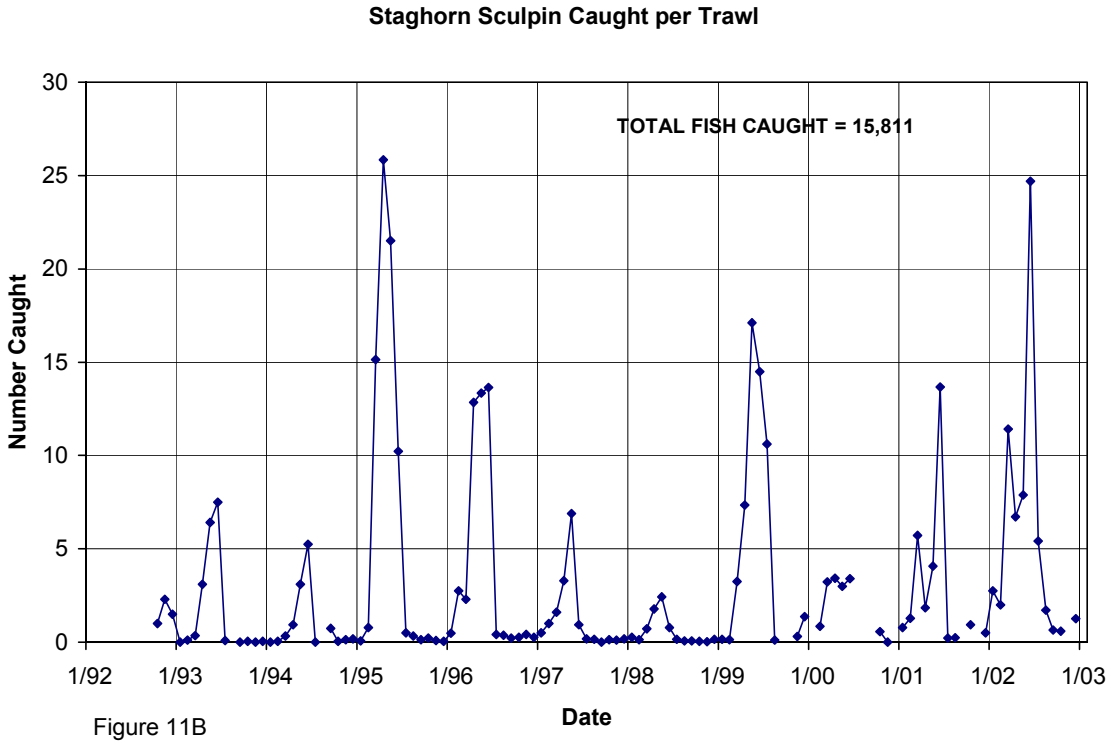

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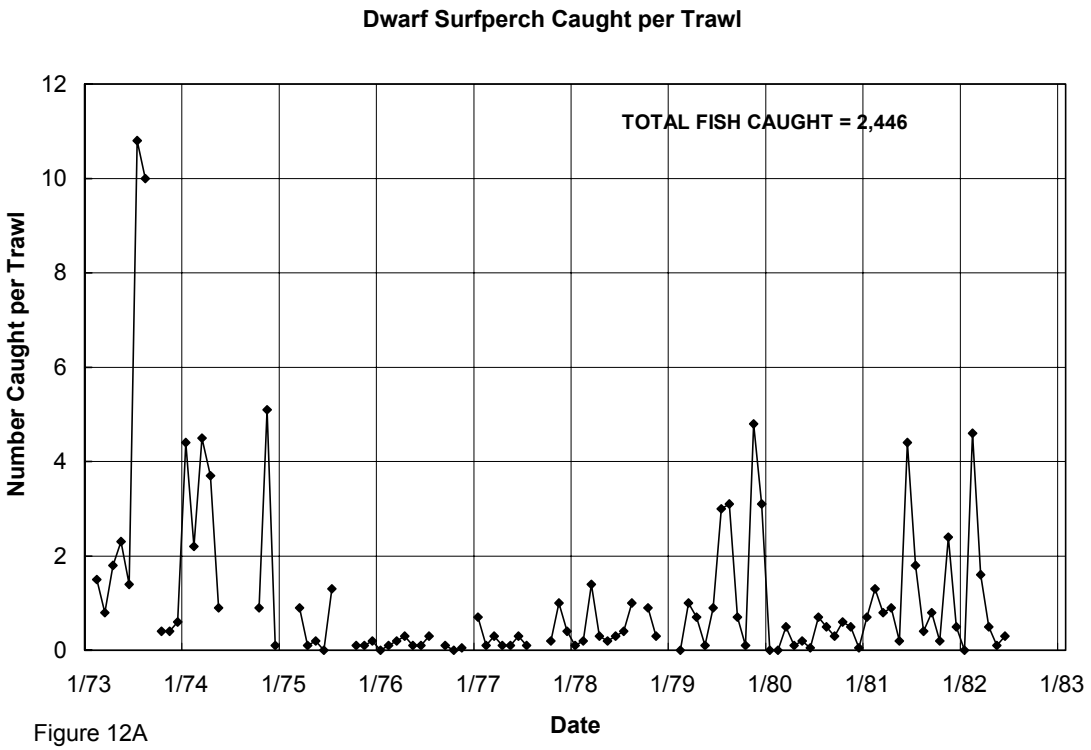

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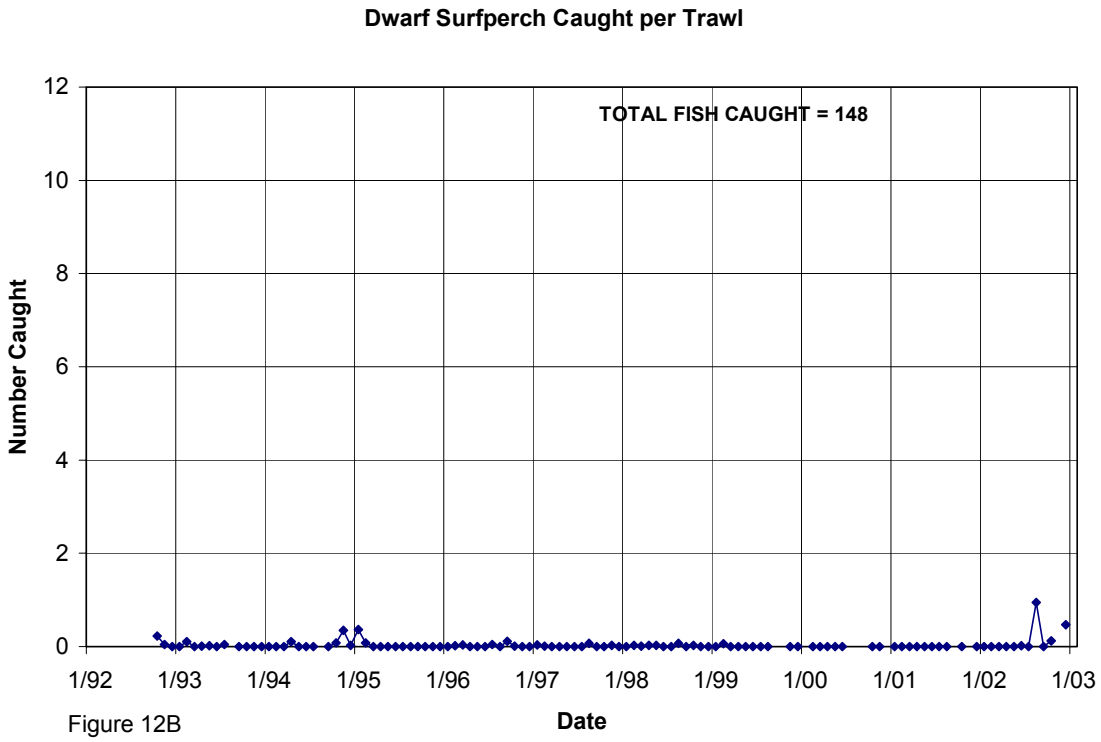

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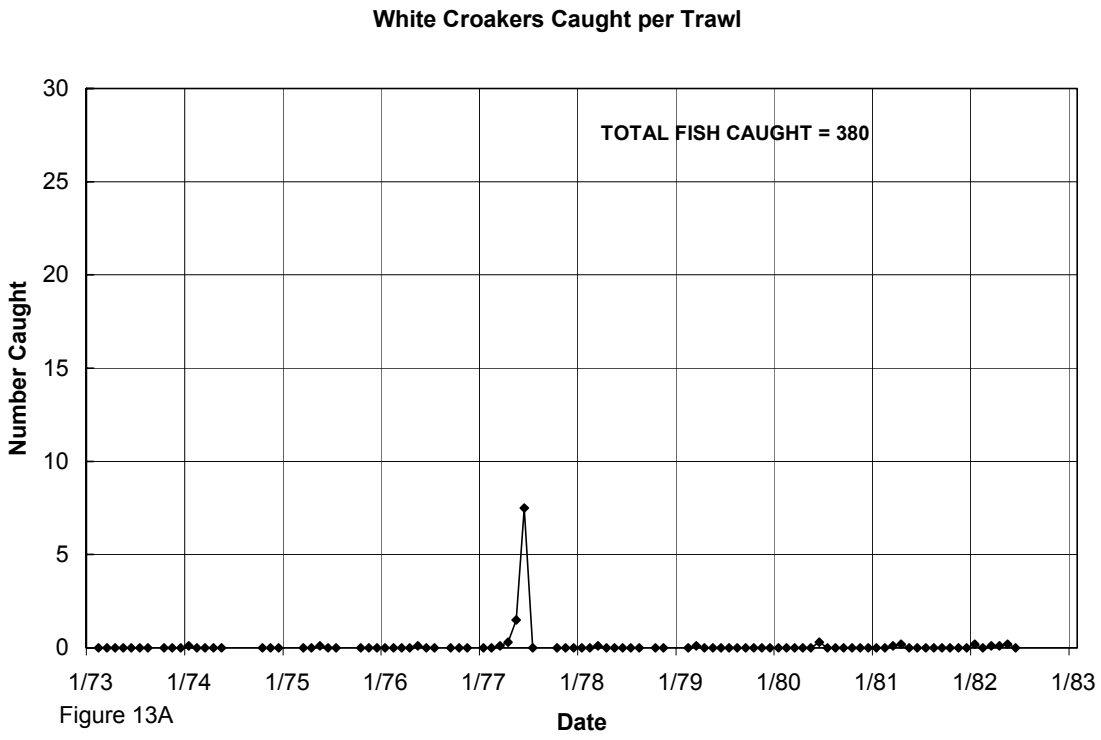

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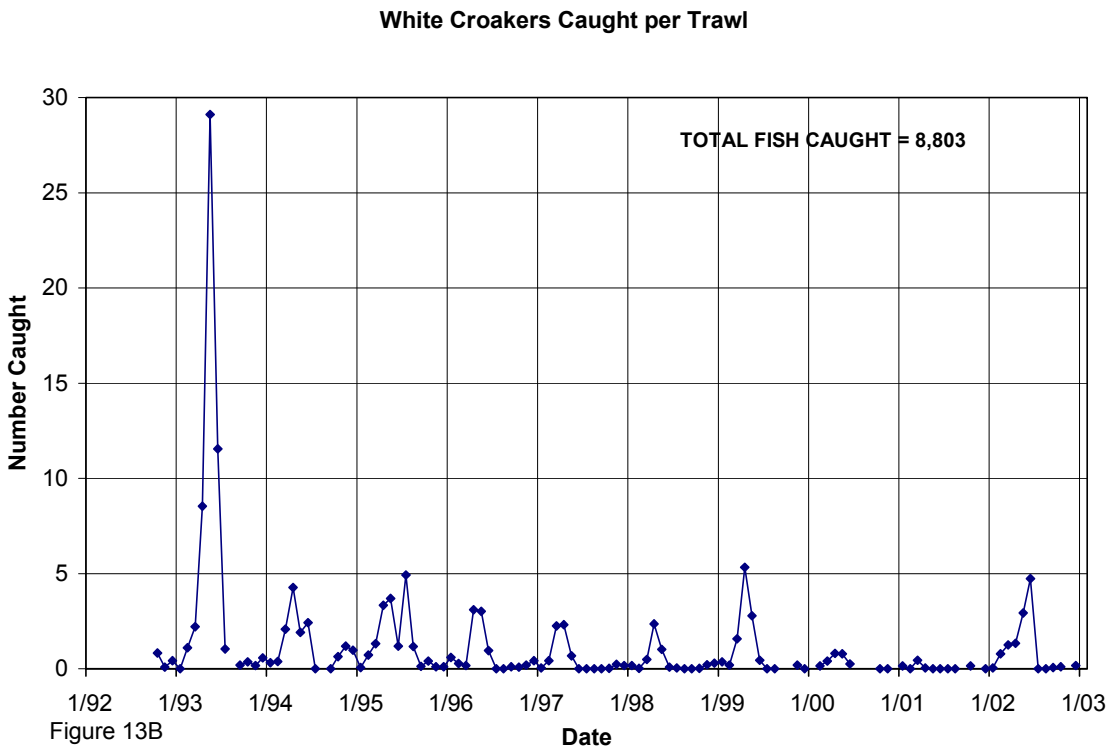

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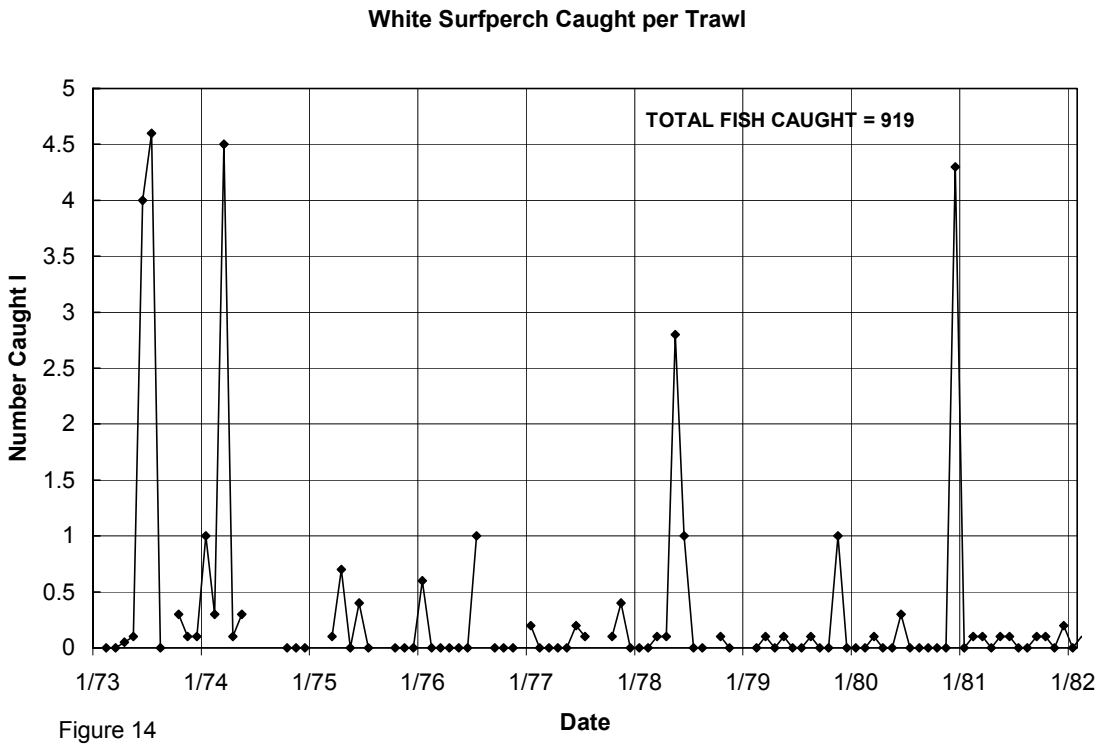

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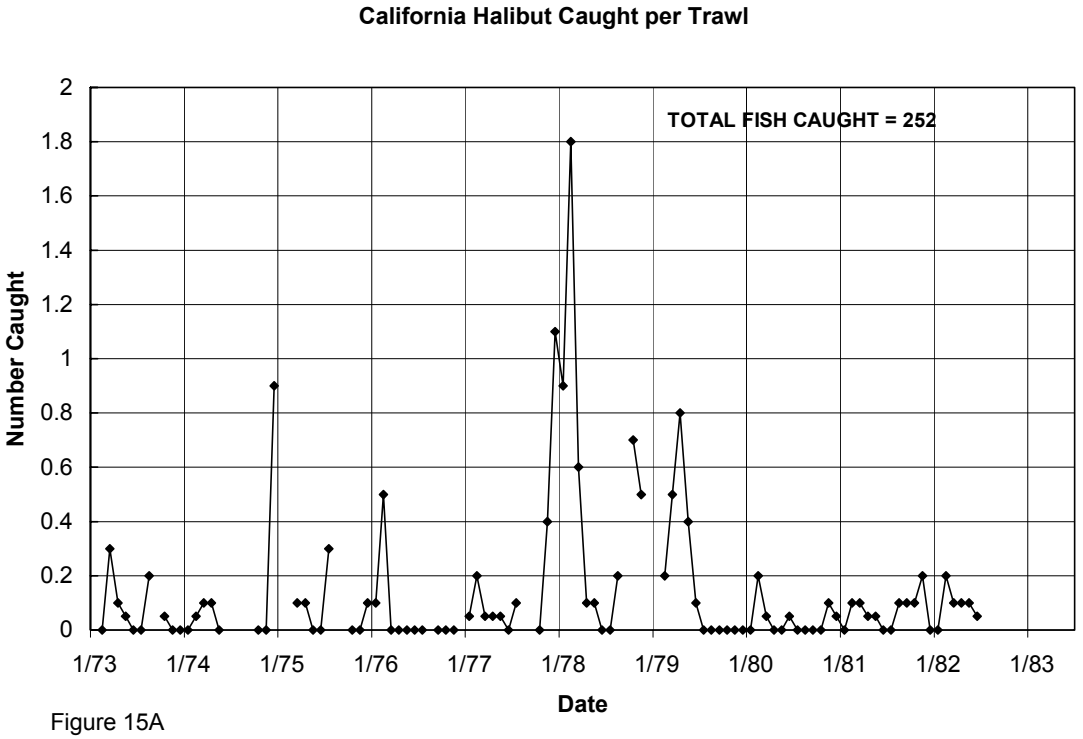

Figure 15A

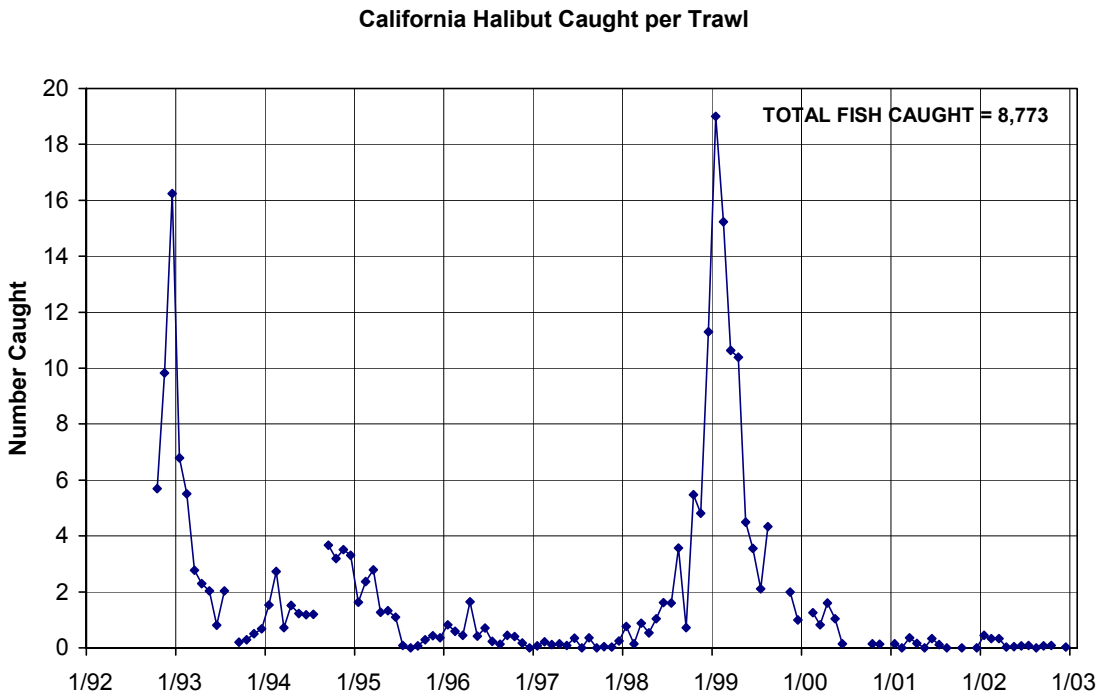

Figure 15B

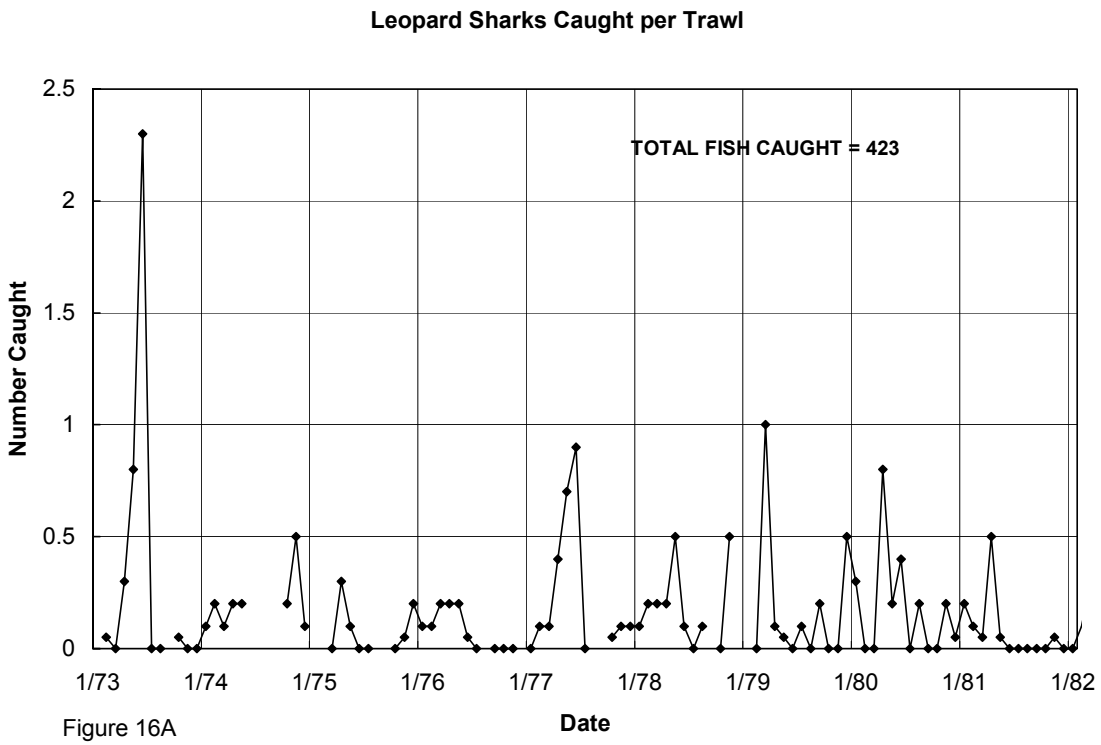

Figure 16A

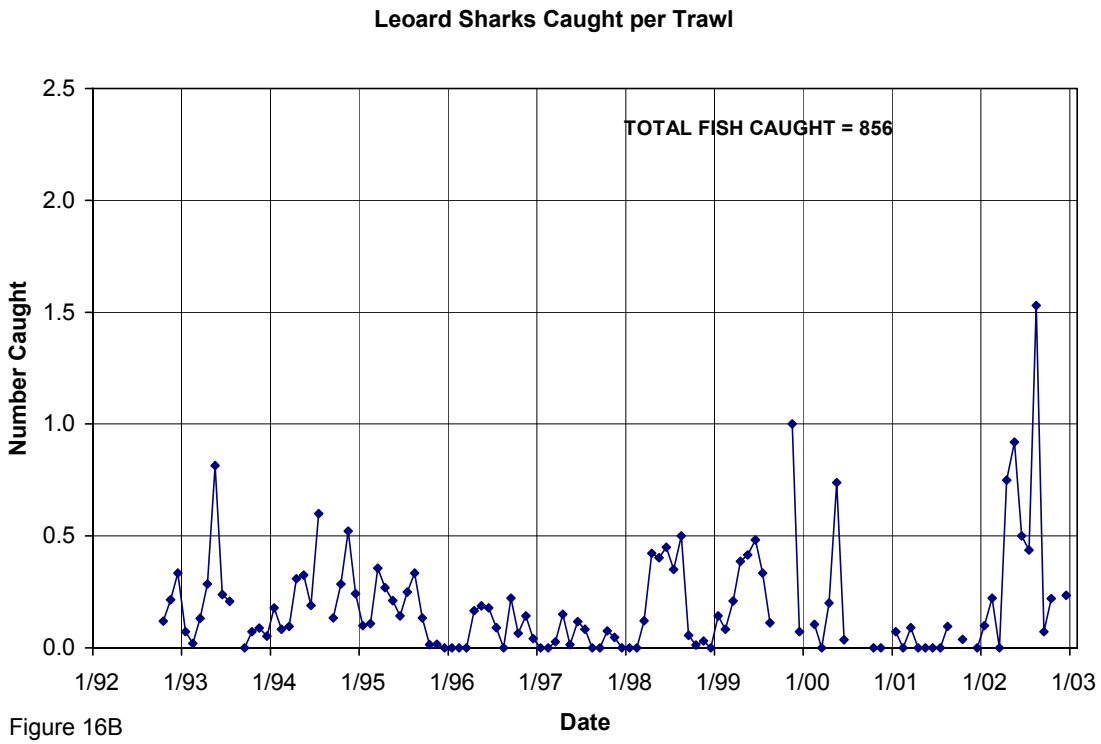

Figure 16B

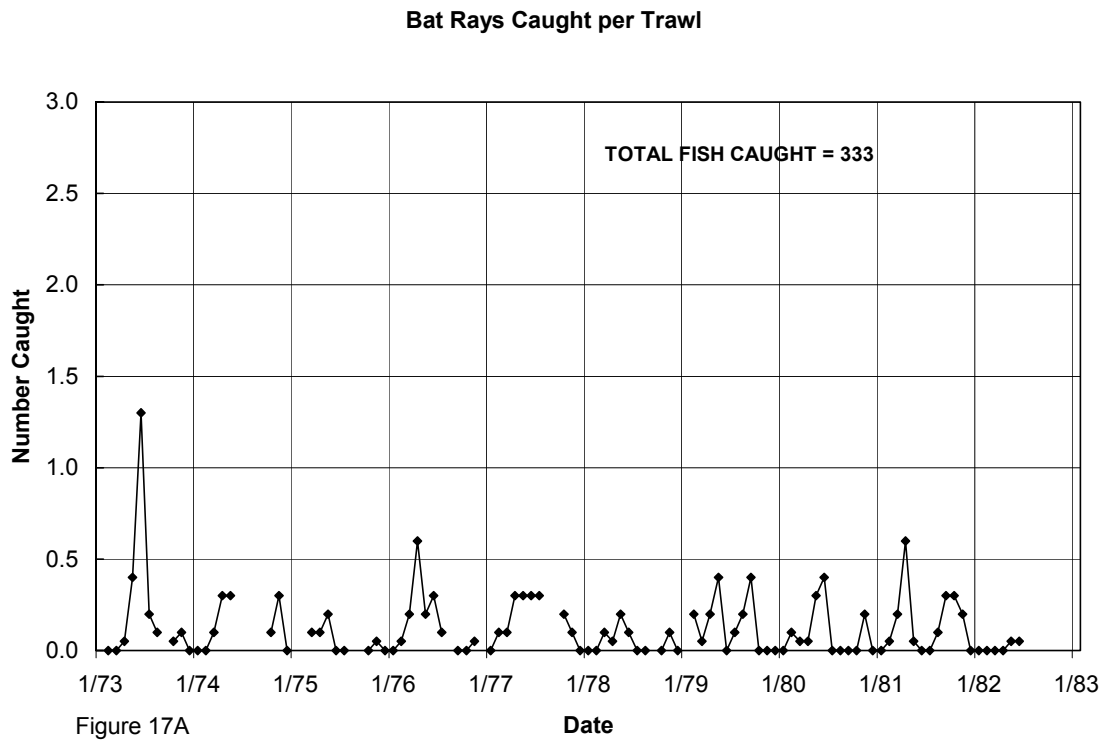

Figure 17A

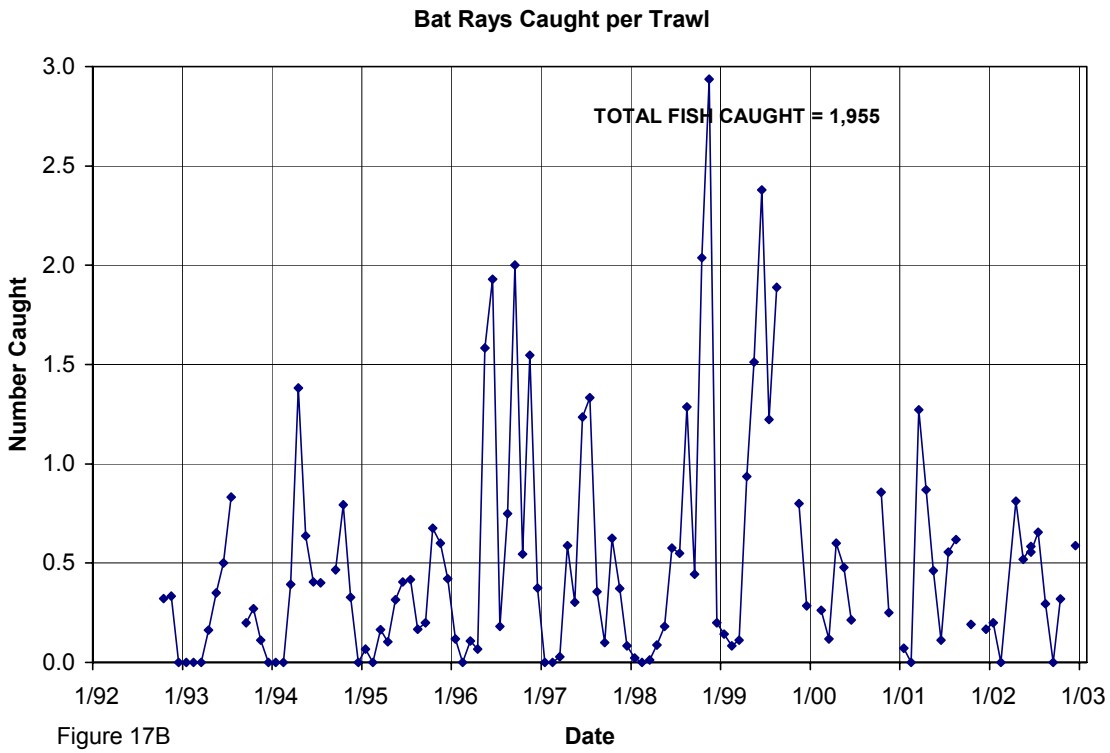

Figure 17B

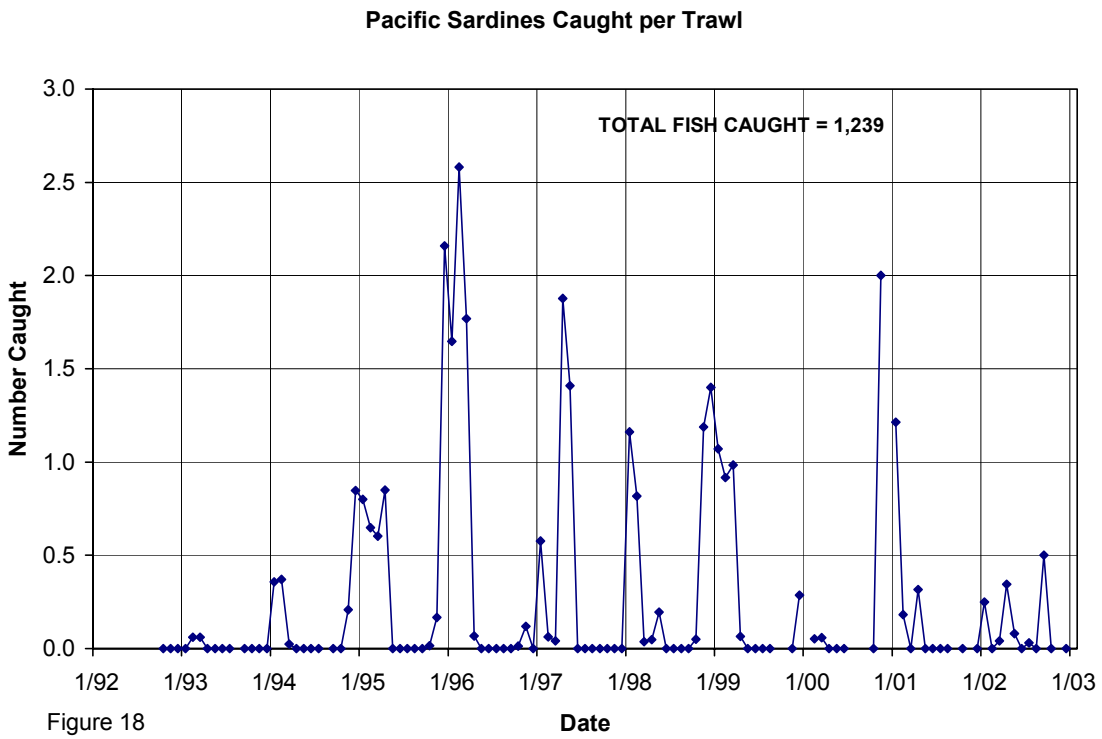

Figure 18