THE EFFECTS OF THE 1992 EL NIÑO ON THE FISHERIES OF BAJA CALIFORNIA, MEXICO

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ABSTRACT

The 1992 El Niño affected the landings and distribution of several commercial and sport fisheries of Baja California, Mexico. Pacific mackerel, yellowtail, swordfish, and giant squid showed clear changes in seasonality (early fishing seasons). Increased landings of tropical roosterfish, dolphin, and marlin were reported in the recreational fisheries. Increased landings of northern anchovy and Pacific mackerel, and decreased landings of yellowtail and swordfish in Baja California waters may have been due to changes in availability under warm El Niño conditions.

INTRODUCTION

The state of Baja California is located in the northwestern part of Mexico (figure 1). Its fisheries exploit resources from the Pacific Ocean and the Gulf of California. In 1991, landings in Baja California were 231,319 MT, or 15.6% of the total Mexican production, and second only to the state of Sonora (25.4%; Anonymous 1992). The most important species in the total landings were yellowfin tuna (*Thunnus albacares*), skipjack tuna (*Euthynnus pelamis*), giant kelp (*Macrocystis pyrifera*), Pacific mackerel (*Scomber japonicus*), Pacific sardine (*Sardinops sagax caeruleus*), and red sea urchin (*Strongylocentrotus fransiscanus*). The tuna species, however, are mostly caught in waters south of state limits.

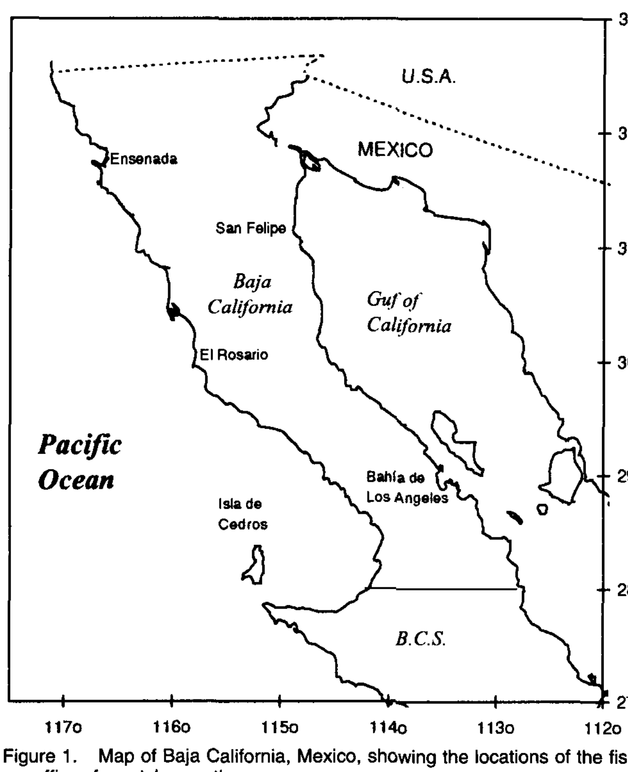


Figure 1. Map of Baja California, Mexico, showing the locations of the fishery offices for catch reporting.

The western coast of Baja California is part of the California Current system. In this system an association between the California Current and prevailing northerly winds produces upwelling along the U.S. Pacific coast, from the Canadian border to Baja California and beyond (Mann and Lazier 1991). Upwelling off the Pacific shore of the Baja California peninsula is strongest during spring and summer on the southern sides of land extensions (Hubbs and Roden 1964).

The fish fauna of the California Current changes dramatically under El Niño Southern Oscillation (ENSO) conditions (Hayward 1993). Pearcy and Schoener (1987) reported that the very strong 1982–83 El Niño was implicated in northern range extensions and shifts in population distributions of many species of marine organisms from Oregon to Alaska during 1983. Radovich (1960) discussed the redistribution of fishes during the 1957–58 El Niño event.

In the North Pacific basin as a whole, an ENSO episode has been associated with a counterclockwise range extension; many species have been reported farther north than usual on the west coast of North America, and farther south than usual on the coast of Japan (Mann and Lazier 1991). These changes in distribution, especially for the southern species typically found in warm waters, are presumably due to a combination of advection and a changed habitat structure (Hayward 1993).

For some fisheries, especially pelagic fisheries, El Niño can be catastrophic (Cushing 1982; Smith 1985). But warm periods benefit commercial and recreational fisheries for some species off southern California. During El Niño conditions, subtropical and tropical species such as yellowtail (*Seriola dorsalis*), California barracuda (*Sphyraena argentea*), Pacific bonito (*Sarda chiliensis*), skipjack tuna, yellowfin tuna, and dolphin (*Coryphaena* *hippurus*) become more available to northern fisheries (Radovich 1960; Squires 1987).

Although the 1983–84 El Niño event was characterized as the strongest of the century (Norton et al. 1985), the period from 1991 to 1993 was one of the longest continuously warm episodes recorded, and was only the third time during the 1900s that mature ENSO conditions were observed in consecutive winter and spring seasons; previous periods were 1911–13 and 1939–41 (Bell and Halpert 1995).

Earlier workers focused on El Niño effects on the distribution of fish in the California Current north of the U.S.–Mexico border. In this paper we review and summarize the monthly landings data reported from different fisheries in the state of Baja California, Mexico, from 1984 to 1993, and use changes in monthly and annual landings to qualitatively examine how the 1992 El Niño may have affected resource availability in time and space.

METHODS AND MATERIALS

Daily surface temperature data from Scripps Pier, La Jolla, Calif. (32°52.0'N, 117°15.5'W) were analyzed for 1980–93 to represent the development and relaxation of El Niño near the Baja California coast. Monthly means were calculated, and the monthly time series was adjusted for seasonality; a smoothed trend cycle was determined with a Henderson curve moving average (Statsoft 1994).

Monthly commercial landing records for Baja California during 1984 and 1993 were reviewed from logbooks, inspection sheets, and data files maintained at the Baja California Fisheries Delegation of the ex-Secretary of Fisheries (Ave. Lopez Mateus, Ensenada, Baja California). Monthly data for previous years were not available. Commercial vessels are required to keep a fishing log and inform the local fisheries office of their landings. Inspectors also collect information from small-boat operators who fish along the coast.

Official fisheries offices are at Tijuana (0.08% total state landings during 1984–93), Ensenada (94.58%), El Rosario (1.81%), and Isla de Cedros (2.27%) on the Pacific coast, and at Mexicali (0.12%), San Felipe (0.85%), and Bahía de Los Angeles (0.29%) in the Gulf of California (figure 1). We did not include data from Tijuana and Mexicali in our study because those reports include freshwater species and fish landed but not reported at the other offices; we do not expect this to produce a significant bias in the data.

We examined the database for inconsistencies in common names and in data reporting. For example, in some years, it was clear that certain sport species were not reported officially at all, but the sport fisheries logbooks did record catches. Our annual data are based on the sum of the corrected monthly data in our combined database, and may differ from the official reports in FAO and Mexican fisheries yearbooks because they may not have used the same criteria for data correction from monthly records, or the same common name–species name equivalencies. It was clear that errors due to changes in common name from one region to another increase when data summary is carried out far from the geographic region where fish are landed (for example, Mexico City or Rome). Furthermore, for yearbooks, landings are converted to live weight; in this paper we report landed weight.

Qualitative data from the sport fisheries at Ensenada were collected through interviews with four vessel operators and two seamen who move between the twelve vessels of the Ensenada sport fleet. Raw data sheets for commercial landings were reviewed to find tropical species that may have been specified as "others" in the data summary sheets and files.

We reviewed the monthly landings during 1984–93 to investigate the possibility of changes in seasonality. The monthly time series for several species had large gaps, which made seasonal analysis impossible. For 1992 no landings were reported for the California barracuda (*Sphyraena argentea*), and although an El Niño effect on this species has been reported in other works, analysis was not possible. Species regulated with strict fishing seasons were also not analyzed (e.g., lobsters, sea urchin, abalone).

Fishing effort data were not available, so we were unable to estimate catch per unit of effort as an index of relative abundance.

RESULTS AND DISCUSSION

Figure 2 shows the seasonally adjusted time series of monthly average SST at Scripps Pier, and the final Henderson curve trend cycle. Although SST off Baja and southern California did not warm as much as during the 1983–84 El Niño event, the 1992 El Niño was

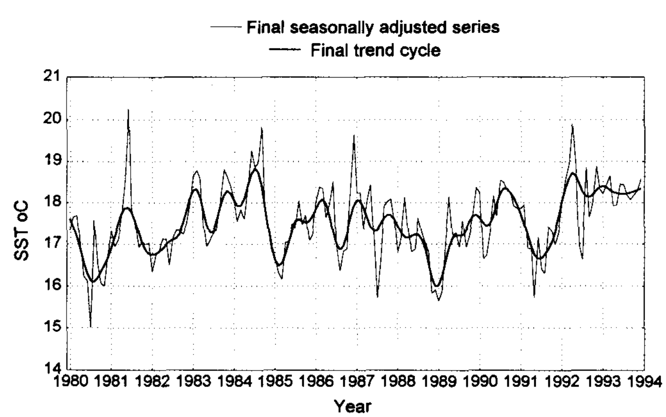


Figure 2. Mean monthly SST at Scripps Pier, La Jolla, Calif., adjusted for seasonality. The *heavy line* is the Henderson curve final trend cycle.

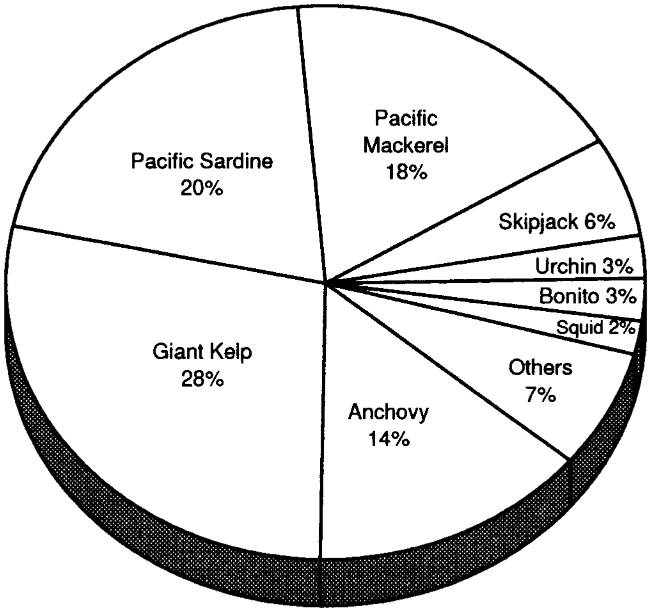


Figure 3. Species composition for the Baja California fisheries, 1989–93.

the strongest since then, with average monthly SST above 18°C, conditions which continued into 1994.

After combining all data sources, correcting for duplicated and synonymous species common names, and eliminating freshwater and newly cultured species, we had 99 marine species for analysis.

We determined the species composition for the five-year period (1989–93) to show the current status of the Baja California fisheries. We eliminated yellowfin tuna from the total because, although Ensenada has been an important port for tuna landings, fishing is done in waters south of the state boundary. Thus during 1989–93 giant kelp represented the greatest landed biomass (28%), followed by Pacific sardine (20%) and Pacific mackerel (18%). Northern anchovy, previously the most important fishery, decreased rapidly after 1989 and represented only 14% (figure 3).

During 1992, the landings of several species increased while others decreased, as occurs each year, and few patterns with El Niño were found. This may be partly due to the shortness of the time series relative to the occurrence of an El Niño event, and to the lack of effort data. Monthly data for previous years were not available. Table 1 shows the yearly landings from 1984 to 1993 for 13 selected species, in alphabetical order.

Species with Increased Landings

The landings of giant kelp ("sargazo"; *Macrosystis pyrifera*) surprisingly increased during 1992, although it is known that this cold-water species can be severely affected by El Niño (Dayton and Tegner 1990). Kelp landings decreased during 1984 and 1987, suggesting an El Niño effect not observed during 1992. We feel that this result is an artifact of a one-vessel fleet that cannot fully exploit the available kelp beds along the coast of Baja California. Unusual beaching of kelp (observed during 1983–84) was not reported during this period, and there is no evidence that survival was affected.

The northern anchovy ("anchoveta"; *Engraulis mordax*), almost nonexistent since 1989, increased from 340 MT in 1991 to 1785 MT in 1992. We included this species because the change in landings was remarkable. The northern anchovy is a temperate species that prefers cooler waters, so the observed increase in 1992 may be due to concentration in areas of local upwelling. Hammann and Cisneros-Mata (1989) suggested distribution changes due to the La Niña event of 1985 as a mechanism for the northern anchovy to expand its range into the Gulf of California.

Although the Pacific sardine ("sardina monterrey"; *Sardinops sagax caeruleus*) increased during 1992, the recent population recovery already described by several authors (Barnes et al. 1992; Lluch-Belda et al. 1992; Wolf 1992) is sufficient explanation. Landings also increased in California (CDFG 1994).

TABLE 1
Yearly Landings for Selected Marine Resources in Baja California, Mexico, 1984–1993 (Metric Tons)

Species	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
California sheepshead	31.35	4.64	6.55	11.29	18.05	9.19	14.18	12.36	33.06	19.49
Giant kelp	12,673.00	27,823.00	36,502.00	23,147.00	33,624.00	34,247.00	39,575.57	29,931.30	39,919.00	31,245.00
Giant squid	35.82	8.50	19.86	10.52	1,331.77	856.59	2,663.85	6,331.81	1,663.19	1.27
Marine snails	5.65	0.14	1.45	0.60	39.68	142.81	119.18	66.44	150.33	104.48
Northern anchovy	101,547.35	118,045.91	93,053.15	129,662.03	123,804.87	84,653.40	48.86	340.36	1,784.84	144.64
Pacific mackerel	2,106.31	7,355.39	9,114.33	3,295.37	8,946.99	16,134.64	39,502.80	18,690.05	24,529.28	10,639.48
Pacific sardine	1,521.10	8,747.47	3,273.00	5,121.13	2,563.00	7,546.24	13,248.65	30,077.14	34,866.35	38,917.91
Pismo clam	658.21	70.34	91.75	171.17	615.94	588.99	499.87	797.25	929.87	228.27
Red sea urchin	157.04	744.82	3,296.91	2,929.91	6,737.00	4,643.73	3,493.80	2,598.71	2,397.65	2,746.50
Sea bass	45.12	56.09	60.77	45.68	97.76	54.35	33.96	36.96	17.30	35.11
Striped mullet	204.17	238.77	159.39	172.38	367.84	251.21	72.02	94.68	35.73	92.87
Swordfish	37.44	2.15	286.76	425.46	633.76	406.84	632.68	829.69	554.26	384.64
Yellowtail	938.76	389.21	353.49	456.42	1,849.31	519.07	253.19	174.64	113.87	133.81

Pacific mackerel ("macarela"; *Scomber japonicus*) landings, after having fallen off during 1991, increased sharply during 1992 and decreased during 1993. Landings in California have decreased since 1990 (CDFG 1994), and the population biomass has decreased to less than 100,000 short tons since 1982 because of low recruitment (Jacobson et al. 1994). Increased landings in Mexico during 1992 may have been due to increased availability as a response to the warm El Niño conditions.

The Pismo clam ("almeja pismo"; *Tivela stultorum*), California sheepshead ("vieja"; *Semicossyphus pulcher*), and marine snails ("caracol panocha" and "caracol chino") increased in landings, with effort apparently similar to that of previous years. Limpets and snails are mostly used as bait for the lobster ("langosta") fishery. Although these increased landings were striking, it is difficult to attribute them to El Niño conditions with the information available.

In the 1992 recreational fishery, higher landings were found for roosterfish ("pez gallo"; *Nematistius pectoralis*), dolphin ("dorado"; *Coryphaena hippurus*), and (mostly striped) marlin ("marlin"; *Tetrapturus audax*). These species are not clearly documented in the database, but are reported in port interviews and private logs. The incidence of tropical, migratory, large pelagic species in temperate waters during an El Niño event has been previously documented (Radovich 1960; Squires 1987).

Species with Decreased Landings

Landings of the red sea urchin (*Strongylocentrotus fransiscanus*) decreased during 1992. Landings also decreased during the 1984 and 1987 El Niño events, suggesting a connection with El Niño. Table 1 shows that kelp and sea urchin landings generally fluctuate together; sea urchin is one of the major grazers on giant kelp (Leighton 1971). It may be that the kelp was affected by El Niño, as suggested by the decrease in sea urchin landings, and that the one-vessel landing data for kelp do not reflect abundance.

Giant squid ("calamar gigante"; *Dosidicus gigas*) landings decreased during 1992, although during the previous two years large effort was carried out through an experimental fisheries program. This decrease is most likely due to permit problems, which closed the fisheries in late 1992. On the other hand, effort for yellowtail ("jurel"; *Seriola dorsalis*) appeared constant, and the decreased landings may be due to El Niño.

Swordfish ("pez espada"; *Xiphias gladius*) landings also decreased in 1992, and continued to do so during 1993. This relatively recent fishery suffered rapid increases in effort, and it is difficult to separate the effects of fishing effort from the environment. Nevertheless, decreased landings of this species have been reported during El Niño conditions as a result of loss to northern waters (Schoener and Fluharty 1985). Because of the closeness of the U.S.–Mexico border, this may be an important factor for Baja California fisheries. It is noteworthy that swordfish landings in California increased during 1992 and 1993 (CDFG 1994), suggesting that an El Niño effect on the fisheries cannot be eliminated as a contributing factor to decreased landings in Mexico.

Striped mullet ("lisa"; *Mugil cephalus*) and sea bass ("cabrilla"; *Paralabrax* spp.) landings all decreased during 1992 with no apparent changes in effort. No trends with other recent El Niño events are apparent, and in the case of striped mullet, landings have decreased since 1988, suggesting that the 1992 change for these species can be explained as normal interannual variation of exploited resources.

Seasonal Changes

From the entire database, we found a seasonal effect suggesting a relation to El Niño in only five species. Landings at ports other than Ensenada were too sporadic to allow monthly analysis, except for yellowtail.

During 1992, monthly Pacific sardine landings at Ensenada were much lower than usual until September (figure 4). Although the data suggest important changes in seasonality, large imports of low-priced fish meal from Chile caused significant reduction in fishing effort for sardine during this period. Thus the data can be explained by a market situation, and not by the El Niño event.

Figure 5 shows the monthly landings of Pacific mackerel at Ensenada during 1989–93. Normally, Pacific mackerel are caught off Baja California in summer; in

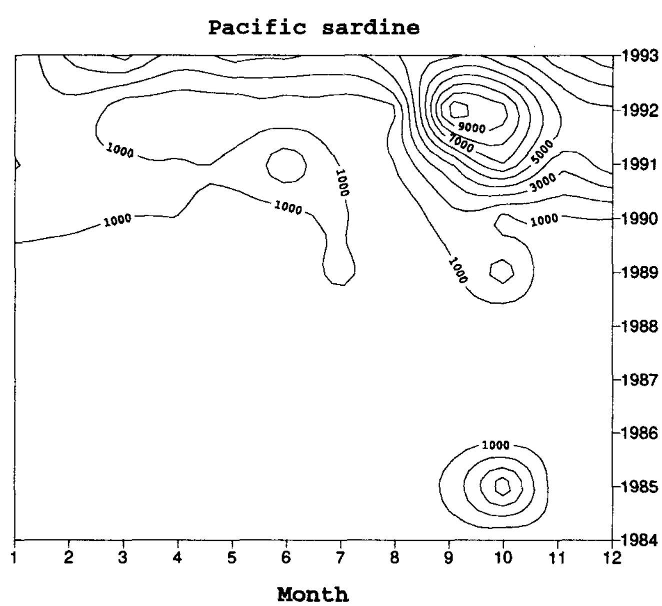
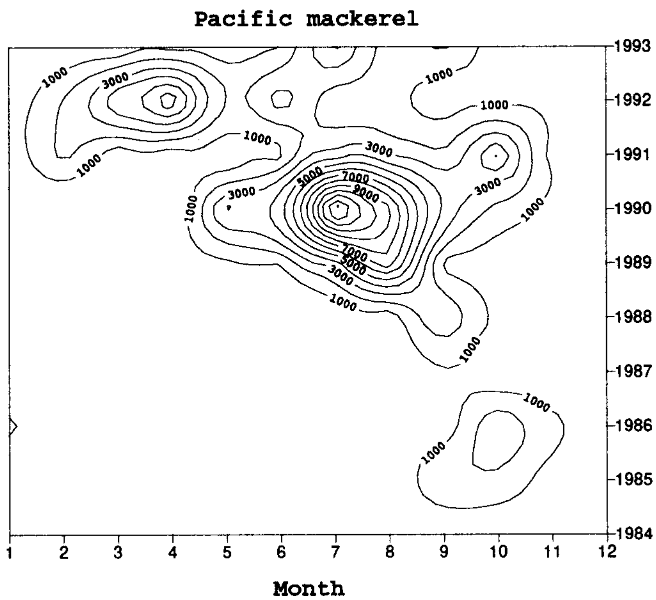


Figure 4. Plot of monthly landings (1000 MT contours) of Pacific sardine in Ensenada, Baja California, 1984–93.



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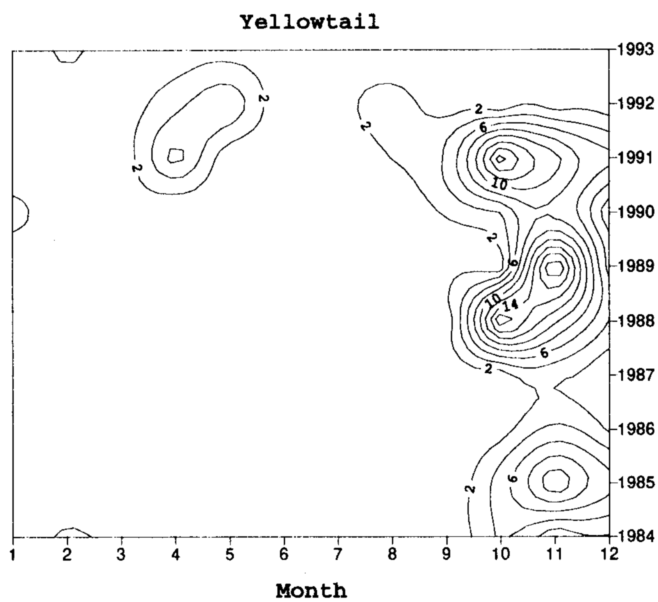

Figure 6. Plot of monthly landings (2 MT contours) of yellowtail in El Rosario, Baja California, 1984–93.

1992, however, catches were in spring. We suggest that both the higher yearly catch and early fishing season in 1992 were influenced by the warmer waters of the El Niño event.

We studied monthly landings of yellowtail in two different localities off the Pacific Baja California coast. Normally, yellowtail are caught in winter (Oct.–Dec.). For 1991–92 we found a clear change in seasonal pattern at El Rosario; landings were made in April and May (figure 6). In Ensenada, farther north, a change in sea-

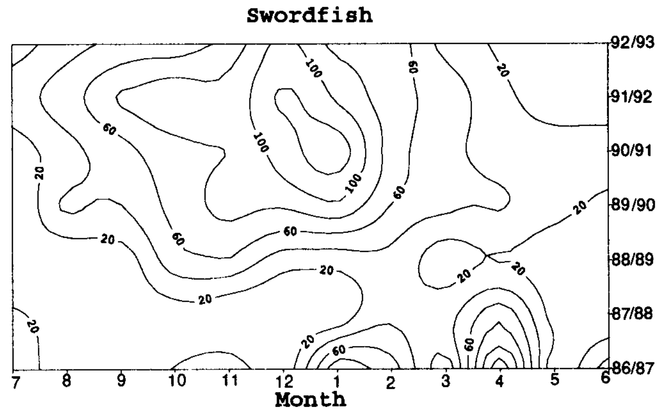

Figure 7. Plot of monthly landings (20 MT contours) of swordfish in Ensenada, Baja California, 1986/87–1992/93 fishing seasons.

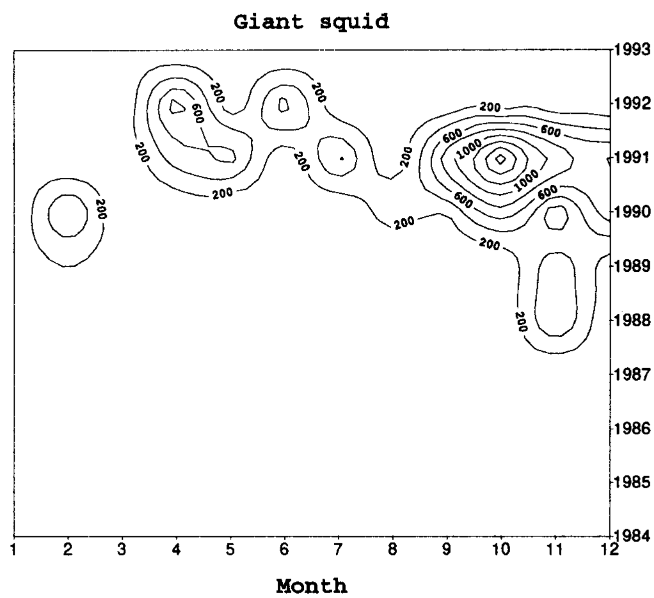

Figure 8. Plot of monthly landings (200 MT contours) of giant squid in Ensenada, Baja California, 1984–93.

sonality was not apparent. This demonstrates a latitudinal effect of El Niño on yellowtail.

Figure 7 shows monthly landings of swordfish. During 1986–88, catches were mostly in April, with lesser activity in January and February. During these years, the swordfish fleet was composed of longline vessels. Beginning in 1988, the fleet changed to drift gill net vessels, and December and January were the months of highest catches. The normal fishing season with this new fleet is October–March, but during 1991–92, catches were registered as early as August. This early fishing season further suggests the influence of El Niño on swordfish availability, and decreased landings because fish move to northern waters.

The early fishing season for giant squid in 1992 is clearly seen in figure 8. Peak landings usually are made

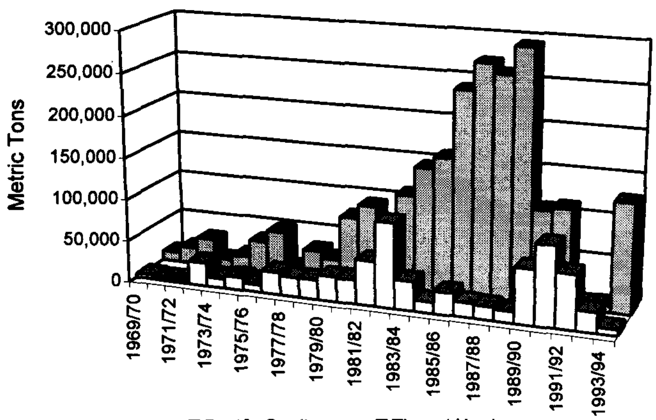

Figure 9. Landings of Pacific sardine and thread herring (MT) in the Gulf of California during the 1969/70–1993/94 fishing seasons.

in October (as in 1991), but in 1992, giant squid were caught from April to June. Ehrhardt et al. (1983) reported that giant squid are usually oceanic and move toward the shore and migrate northward during summer warming. Baja California is close to the northern distribution limit (Ehrhardt et al. 1986), and the normal fall fishing season off Baja California reflects the thermally related migration pattern. We suggest that the early warming under El Niño conditions increased spring availability of giant squid in 1992.

Gulf of California

The major fisheries of the Gulf of California are for the small pelagic species (sardine, anchovy, mackerel). Although we did not analyze the data from all other fisheries, the small pelagics show an interesting trend between the temperate Pacific sardine and the tropical thread herring (*Opisthonema* spp.). During cool periods, Pacific sardine have dominated the fisheries in the gulf, whereas during El Niño years, tropical thread herring are more available (figure 9); note especially the 1972–73, 1983–84, and 1991–92 events. Although data were not available, increased captures of yellowfin tuna were reported in the Gulf of California during the 1992 El Niño event.

CONCLUSIONS

In this paper we have provided a qualitative examination of trends in fisheries landings for the state of Baja California, Mexico, during the 1992 El Niño event. El Niño can affect fisheries by changing the short-term availability to the fleets, or by longer-term changes in recruitment; we have addressed only short-term availability in this paper. El Niño events can have profound economic effects, especially when changes in seasonal availability find the fleet unprepared, or when low catches correspond to periods of low market demand. Economic impact can be minimized by enhancing our knowledge of the relation between fish movements and ocean conditions; we hope that this paper contributes in that sense.

In order to better understand the relation between fish movement and behavior under El Niño conditions, more rigorous analysis is necessary in future studies. Yearly changes due to El Niño may be clear only after catch data are standardized with fishing effort, and after a much longer time series that includes several El Niño events is analyzed. Such data, unfortunately, are available for only a few species.

Recognizing that short-term fisheries management policies are also affected by an El Niño event, one must consider the importance of larger-scale analyses that treat El Niño as a normal part of an oscillating environment. Fisheries operational support in near real time, for example, with satellite imagery of sea-surface temperature, is an important tool, as is the capability to predict oceanographic events such as El Niño, to minimize error caused by not coupling fishing efforts to changes in resource availability or population production.

Additional complications arise when political and economic constraints are put upon the fisheries industry. For example, Pacific mackerel and swordfish move between Baja California and California, each of which has different management policies; the availability of both species appears to be affected by El Niño. Monthly and interannual fluctuations in interest rates and market conditions are also important realities that must be considered in a holistic analysis of medium- to long-term environmental change and its relation to fisheries, before final recommendations can be made.

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