Pacific Science, vol. 54, no. 2: 127–136

Larval Feeding of *Scomber japonicus* (Pisces: Scombridae) in the Gulf of California and Its Relation to Temperature and Chlorophyll Satellite Data[1]

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ABSTRACT: Feeding habits of *Scomber japonicus* larvae in the central part of the Gulf of California during April 1984 and 1985 are described and compared. Satellite images of temperature and chlorophyll monthly average showed that the central gulf during April 1984 was relatively warmer but with lower chlorophyll concentration than during April 1985. Feeding incidence was lower in larvae collected in April 1984 than in larvae in April 1985. Prey size consumed was larger in larvae in 1984 than in larvae in 1985. The cladoceran *Penilia* sp., copepod nauplii, and appendicularians were the dominant prey in the diet of larvae in 1984. In 1985 diatoms and copepod nauplii were the dominant prey. The high incidence of diatoms in *S. japonicus* larvae collected in 1985, a cold year, corresponded to the high chlorophyll concentration observed by satellite. Diatoms were not an important component in the larval diet in 1984, when the chlorophyll concentration was low. A high incidence of the cladoceran *Penilia* sp. in the larval gut in 1984 coincided with cladoceran blooms recorded in years affected by El Niño events. Interannual difference in feeding habits of *S. japonicus* larvae can be associated with changes in environmental conditions, such as temperature and chlorophyll concentration.

THE CHUB MACKEREL *Scomber japonicus* inhabits the Gulf of California all year (Collete and Nausen 1983). It is captured from the end of winter to the middle of summer, in association with Pacific sardine *Sardinops sagax* capture (Névarez et al. 1993). Chub mackerel populations have shown large fluctuations associated with environmental variations over time, as have other species of small pelagics (e.g., Lluch-Belda et al. 1986, Cisneros-Mata et al. 1997).

The ability of a fish to find sufficient food in its early life-history stages can determine recruitment success (e.g., Hjort 1914, Lasker 1975). Therefore, knowledge of larval feeding ecology is essential to understanding variability in their early life history and recruitment (Last 1980). Feeding strategies of fish larvae are complex and depend on several factors of different nature and scale, such as optimal temperature and food availability in first-feeding larvae (Hjort 1914, Hunter 1981), and morphological and physiological characteristics of the larvae and prey (e.g., Govoni et al. 1983, Sánchez-Velasco 1998).

Temperature and phytoplankton pigment concentration are important measurements to describe the general surface environment (Hammann et al. 1988). Variations in this environment affect food availability and consequently the diet composition of fish in planktonic phases (e.g., Hunter and Kimbrell 1980, Peterson and Ausubel 1984). In the Gulf of California, temperature and food availability are associated with the variability of seasonal upwelling and tidal-mixing processes, interannual effects of El Niño and non–El Niño events, among other physical events (e.g., Roden and Groves 1959, Robles-Pacheco and Christensen 1984, Badan-Dangon et al. 1985). Variations in these processes may be detected by NOAA-AVHRR and Nimbus-CZCS satellite data with relative accuracy (Cervantes-Duarte

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et al. 1993, Santamaría-del-Angel et al. 1994*a,b*).

There are few studies of the early life stages of the chub mackerel in the Gulf of California. Moser et al. (1974) studied ichthyoplankton distribution, including *S. japonicus* larvae, and Esqueda-Escárcega (1995) analyzed the spatial and temporal distribution of *S. japonicus* larvae, recording strong interannual variation in larval abundance. From these studies, the need to understand the trophic processes that affect larval survival has been recognized. Our aim was to describe and compare the feeding habits of *Scomber japonicus* larvae in the Gulf of California during April 1984 and April 1985. Differences in feeding incidence and diet composition are discussed in relation to interannual changes in temperature and chlorophyll, detected by satellite images.

MATERIALS AND METHODS

Satellite Data

NOAA-AVHRR and Nimbus-7 CZCS monthly average images of April 1984 and 1985, with a spatial resolution of 18 × 18 km, were obtained from the Jet Propulsion Laboratory (JPL), Pasadena, California. Images were processed by Ermapper Image Processing System. Sea-surface temperature was computed from the AVHRR data in accordance with the formula supplied by the JPL, SST = 0.15*DN-2.1, where DN = data value in file. Phytoplankton pigment concentration was calculated from the CZCS data using the formula $PC = 10^{(0.012*DN-1.4)}$.

Field Data

Fish larvae used in this study were collected in the central part of the Gulf of California during two oceanographic cruises, GOLCA 8404 (April 1984, 12 positive stations) and 8504 (April 1985, 11 positive stations) (Figure 1). The sampling was by a double-oblique plankton tow following a circular course, using a 60-cm bongo net with a 505-μm mesh size. Oblique tows were made from a depth of 200 m to the surface, or from 10 m above the bottom where the water was shallower. Each sample was fixed immediately after capture in 4% formaldehyde solution buffered with sodium borate.

Larval Feeding Analysis

Larvae of *Scomber japonicus* were sorted and identified. All larvae with the stomach in good condition were examined. Standard length (from snout tip to notochord tip in both preflexion and postflexion larvae) and length of the lower jaw (from lower jaw tip to angle end) of each larva were measured under a dissecting microscope with an ocular micrometer. The stomach of each larva was separated and opened lengthwise with acupuncture needles. The prey items were identified to the lowest possible taxon and measured transversally.

All larvae with identifiable prey within their stomach were included in the data analysis. Composition of the diet was summarized as percentage number and frequency of occurrence of prey items. The product of these two factors gave an index of relative dietary importance (Laroche 1982). Analysis of covariance (ANCOVA) was used to compare morphometric relations of larvae and prey between years. Morphometric data were log-transformed [$ln(x+1)$] to homogenize variances. The normality of the data was verified with the Kolmogorov-Smirov test (Sokal and Rolf 1979). An ANCOVA was used for each pair of variables: (a) standard length of larvae and lower jaw length, (b) standard length of larvae and prey width of each item, and (c) lower jaw length and prey width of each item. In the three cases, larvae from 2 to 5.99 mm with identifiable prey in their stomachs were used.

RESULTS

Satellite Data

A synoptic picture of the region in terms of monthly average images of temperature and chlorophyll is shown in Plate I. In gen-

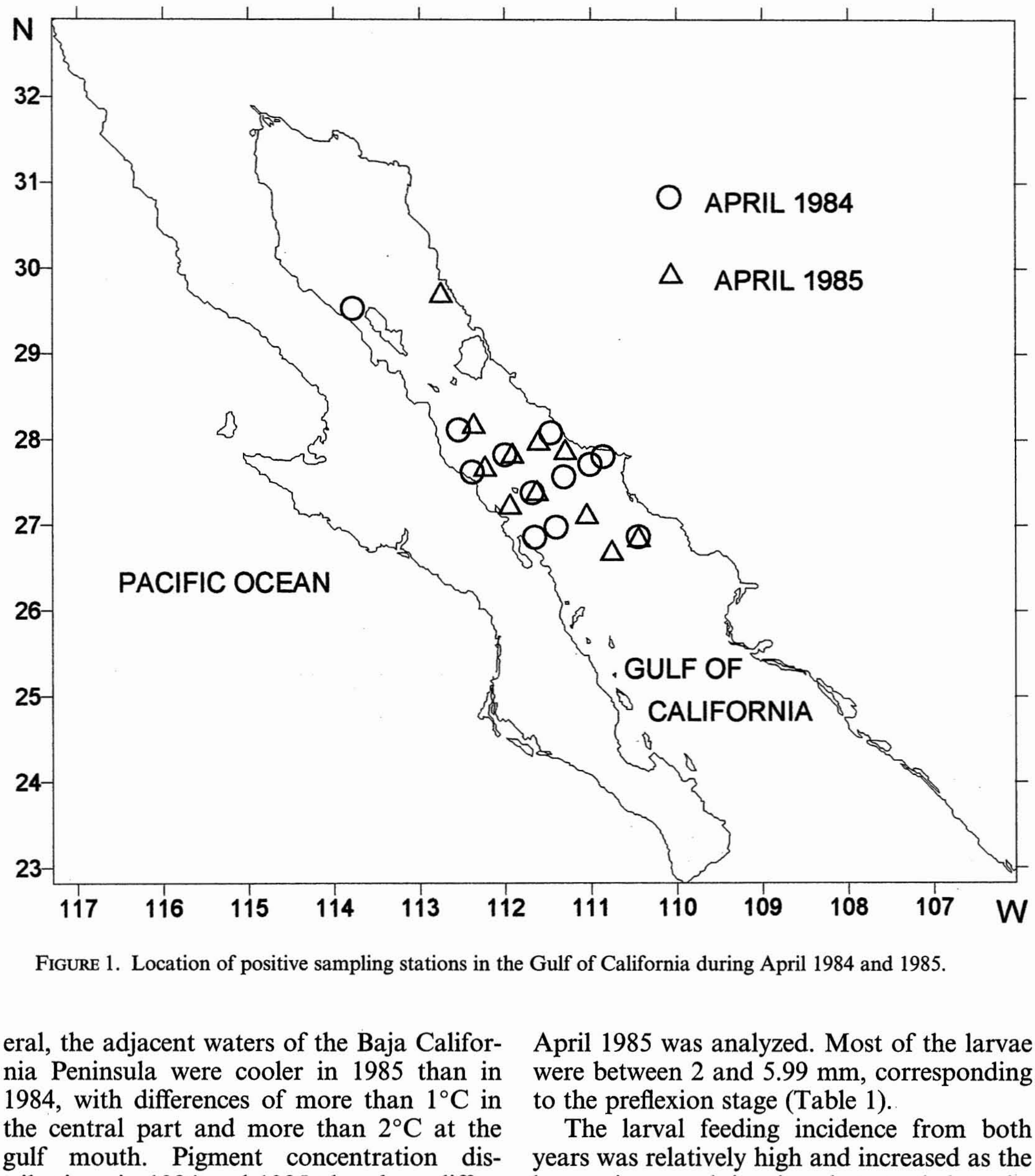

FIGURE 1. Location of positive sampling stations in the Gulf of California during April 1984 and 1985.

eral, the adjacent waters of the Baja California Peninsula were cooler in 1985 than in 1984, with differences of more than 1°C in the central part and more than 2°C at the gulf mouth. Pigment concentration distributions in 1984 and 1985 also show differences. In 1985, an increase of chlorophyll was observed in almost the entire gulf, especially in the northern and central parts, registering values up to 10 mg/m^3.

Larval Feeding Data

A total of 122 larvae of *Scomber japonicus* collected in April 1984 and 100 larvae from April 1985 was analyzed. Most of the larvae were between 2 and 5.99 mm, corresponding to the preflexion stage (Table 1).

The larval feeding incidence from both years was relatively high and increased as the larvae increased in size, but tended to be lower in larvae in April 1984 than in those in April 1985 (Table 1). Larvae from both years consumed prey during day and night (Figure 2).

ANCOVA indicated that the relation of standard length and lower jaw length was not significantly different between the two years and that relative prey size was significantly larger in larvae in 1984 than in 1985

TABLE 1

LENGTH DISTRIBUTION AND FEEDING INCIDENCE OF *Scomber japonicus* LARVAE COLLECTED IN THE GULF OF CALIFORNIA DURING APRIL 1984 AND 1985

LENGTH INTERVAL (mm)	APRIL 1984 LARVAE ANALYZED	APRIL 1984 LARVAE WITH FOOD (%)	APRIL 1985 LARVAE ANALYZED	APRIL 1985 LARVAE WITH FOOD (%)
2.0–2.9	10	60.0	21	80.9
3.0–3.9	26	61.5	39	97.4
4.0–4.9	42	64.2	21	62.0
5.0–5.9	27	62.9	17	88.2
6.0–6.9	11	90.9	2	100.0
7.0–7.9	1	100.0		
8.0–8.9	1	100.0		
9.0–9.9	4	75.0		

($P < 0.001$) (Table 2). Negative values of y intercept did not reflect direct biological meaning because the size of the larvae were > zero (>2 mm of standard length).

A wide trophic spectrum from small larvae to 6.99 mm standard length was seen in both years (Figure 3). The trophic spectrum was similar, but the relative importance of the prey was different (Table 3). Cladoceran *Penilia* sp., copepod nauplii, and appendicularians were the dominant prey in the larval diet in April 1984, and in April 1985 (cold year) diatoms and copepod nauplii were the dominant prey.

DISCUSSION

The general results show that *S. japonicus* larvae tend to feed on a wide trophic spectrum with relativity high feeding incidence during day and night and with increasing prey size throughout their early ontogeny. Chub mackerel larvae are characterized in laboratory experiments by their fast growth, rapid swimming abilities, high metabolism, dependence on increasingly larger prey, and a tendency for cannibalism in larger sizes (Hunter and Kimbrell 1980). These larvae are voracious predators in comparison with other larvae of marine fish species, which are visual predators with relativity low feeding incidence, tending to select specific prey items (e.g., Govoni et al. 1983, Sánchez-Velasco and Norbis 1997).

By comparing the feeding habits of *S. japonicus* larvae from April 1984 and 1985, an evident difference in feeding incidence, diet composition, and prey size consumed was seen. These feeding differences could be associated with the changes in environmental conditions detected by the satellite images of temperature and chlorophyll, which coincided with those reported in the literature. The eastern Pacific system, including the Gulf of California, was affected by El Niño 1982–1983, with 1984 being a transition year in the return to typical conditions of the area. The Gulf of California appeared still to be affected by the heating El Niño. In contrast, 1985 is considered a cold year for the Gulf of California (e.g., Robles-Pacheco and Christensen 1984, Lara-Lara and Valdez-Holguín 1988, Cole and Mclaine 1989, Santamaría-del-Angel et al. 1994*a*). The temperature variations affect the chlorophyll concentrations in the area, but in the northern and central Gulf of California the El Niño and non–El Niño could be masked by upwelling and mixing phenomena associated with the tides (Hammann et al. 1988, Alvarez-Borrego and Lara-Lara 1991). In spite of this, differences in the central gulf between April 1984 and 1985 were detected in CZCS data, coinciding

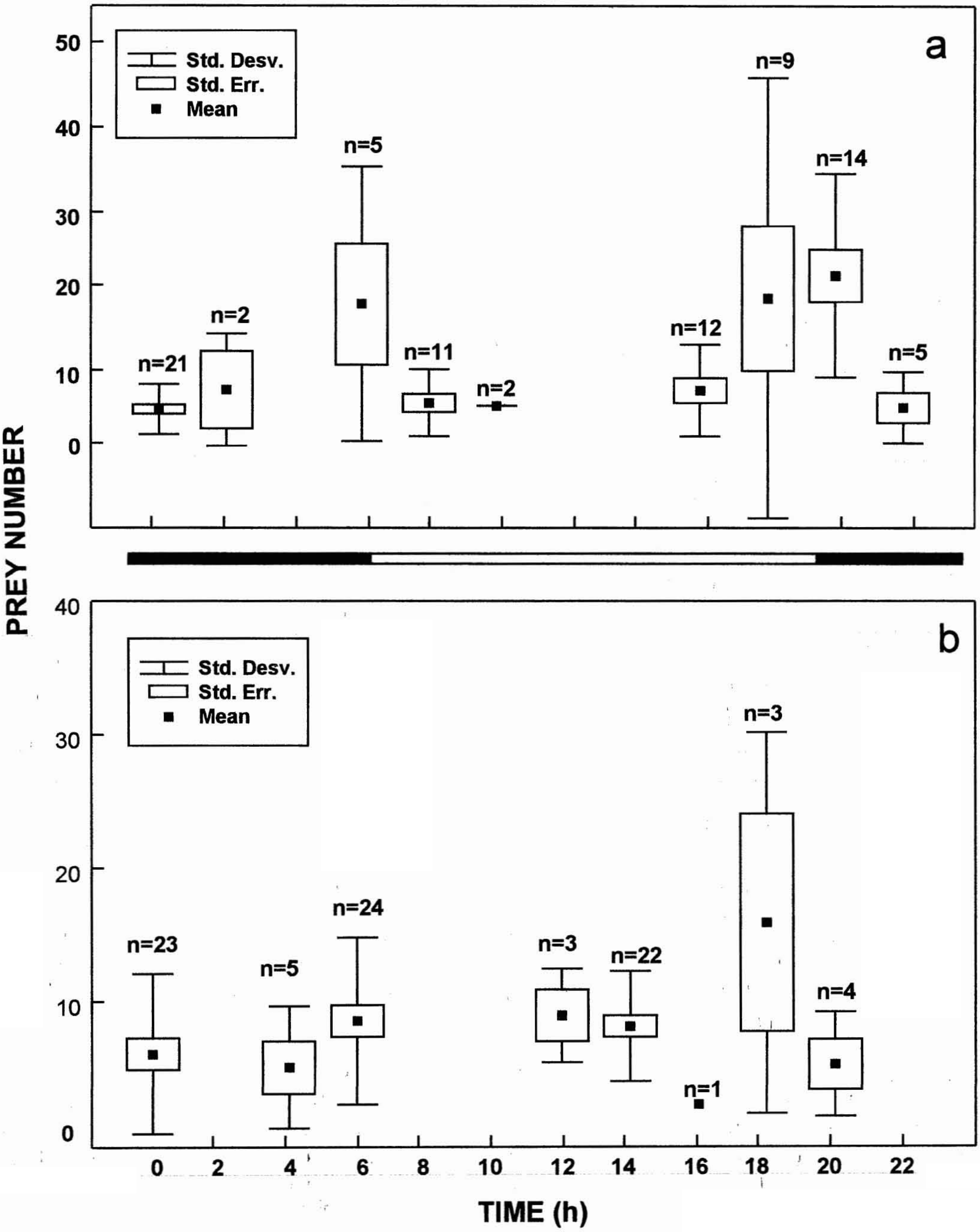

FIGURE 2. Mean and standard deviation of prey number consumed by *Scomber japonicus* larvae collected in the Gulf of California during (*a*) April 1984 and (*b*) April 1985.

TABLE 2

RESULTS OF ANCOVA COMPARING SOME MORPHOMETRIC RELATIONS BETWEEN *Scomber japonicus* LARVAE COLLECTED IN THE GULF OF CALIFORNIA IN APRIL 1984 AND 1985, AND THEIR PREY

CASES ANALYZED	REGRESSION VALUES		ANALYSIS OF COVARIANCE				
	Y INTERCEPT	SLOPE	DF	SUM OF SQUARES	MEAN SQUARE	*F* RATIO	SIGNIFICANCE LEVEL
SL/LJL			1	8.11	8.14	3.27	NS
April 1984	−0.31	0.44					
April 1985	−0.24	0.41					
LJL/PW			1	8.68	13.14	44.57	$P < 0.001$
April 1984	−0.15	0.20					
April 1985	0.05	0.09					
SL/PW			1	13.39	10.73	56.17	$P < 0.001$
April 1984	−0.16	0.19					
April 1985	−0.04	0.08					

Note: SL, standard length (mm); LJL, lower jaw length (mm); PW, prey width (mm). Values were transformed $ln(x + 1)$.

with the results of Santamaría-del-Angel et al. (1994*b*).

The high feeding incidence on diatoms that the *S. japonicus* larvae had in the cold year corresponded to the high chlorophyll concentration observed by the satellite image in that period. It is probable that the high chlorophyll concentration was associated with a great abundance of diatoms in the environment. Although we do not have specific information on the environmental plankton, the larval diet reflected a high availability of them. The diatom bloom can be related to the intensity of upwelling events and tidal mixing processes occurring in the northern and eastern central coast of the gulf during spring (e.g., Roden and Groves 1959, Alvarez-Borrego and Lara-Lara 1991).

In contrast, diatoms were not an important component in the larval diet in the El Niño relaxation year 1984, when the chlorophyll concentration observed in CZCS data was low. But the high incidence of the cladoceran *Penilia* sp. in the larval gut in 1984, a larger prey, coincided with the cladoceran bloom recorded in other warm years. Jiménez-Pérez and Lara-Lara (1988) recorded a cladoceran bloom, *Penilia avirostris,* in the gulf during March 1983, the year affected by El Niño. This cladoceran species was 30% of the zooplankton community and was related to the domination by nannoplankton cells in the phytoplankton biomass. We do not have specific information about the plankton assemblages, but the dominance of cladocerans in the larval diet of *S. japonicus* can be a reflection of the abundance of these zooplankters in the environment.

A similar portion of copepod nauplii was consumed by larvae in both years, which reflected the importance of this kind of prey in the species' diet. This situation is consistent with most studies on larval feeding of marine fish species, such as *Sardinops sagax, Engraulis mordax,* and *Auxis* spp. (Arthur 1976, Hunter 1981, Sánchez-Velasco et al. in press). The fact that the width of prey consumed by *S. japonicus* larvae in 1984 was significantly larger than that in 1985 is related to differences in the amount of cladocerans and diatoms consumed by the larvae in 1984 and 1985, respectively. This circumstance was influenced by interannual variations in the environment, such as surface temperature and pigment concentration, and consequently the availability of prey items for diverse predators including the fish larvae.

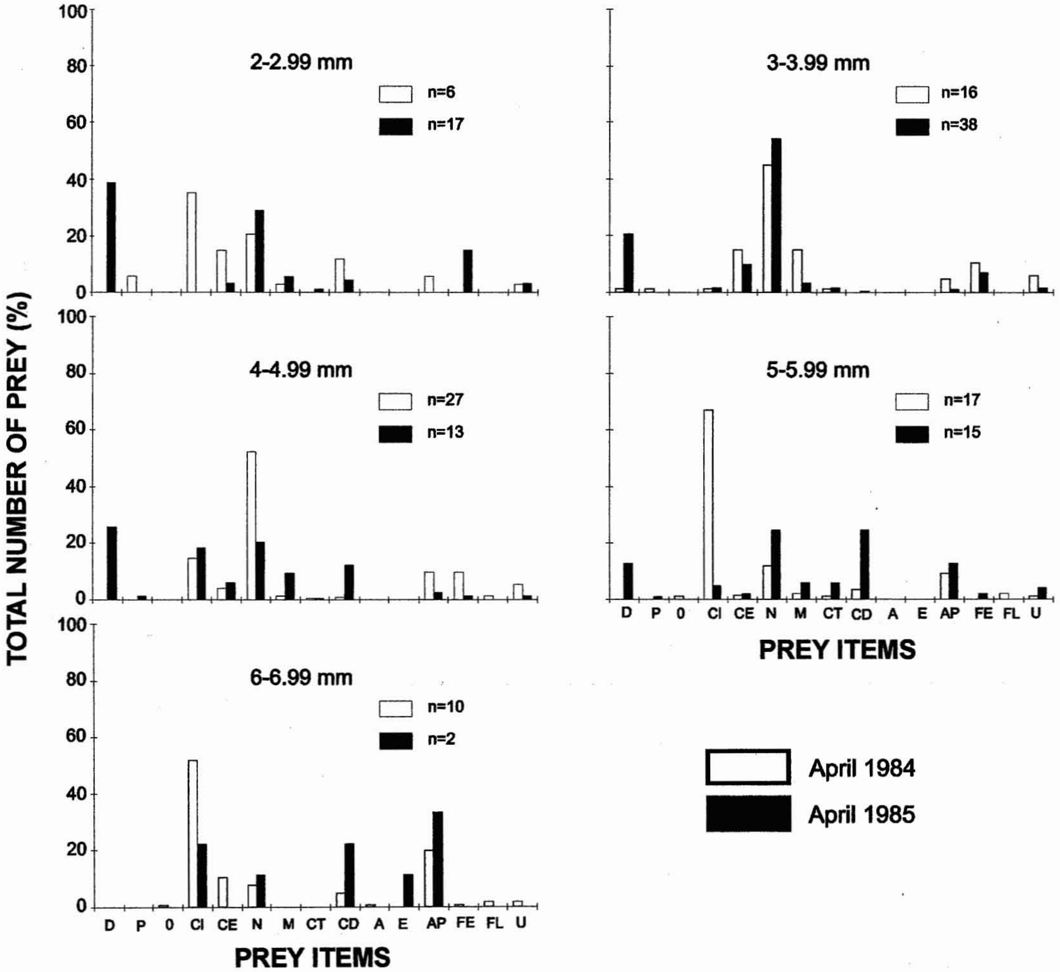

FIGURE 3. Total number of prey recovered from each size class of *Scomber japonicus* larvae collected in the Gulf of California during April 1984 and 1985. *n*, number of larvae examined; D, diatoms; P, Polychaeta; O, Ostracoda; Cl, Cladocera; CE, copepod eggs; N, copepod nauplii; M, copepod metanauplii; CT, copepodites; CD, copepod; A, Decapoda; E, Euphausiacea; AP, Appendicularia; FE, fish eggs; FL, fish larvae; U, prey unidentified.

We concluded that the interannual difference in the feeding habits of *S. japonicus* larvae is associated with environmental changes such as surface temperature and chlorophyll concentration, both detected by satellite data in this study. Intensive studies of marine plankton are expensive and made over years. For this reason, satellite data are important tools to enhance plankton ecology studies, and their spatial and spectral resolutions continue to be improved.

ACKNOWLEDGMENTS

We acknowledge the CICIMAR Plankton Department for providing fish larvae and the NASA Jet Propulsion Laboratory, Pasadena, for the satellite data. We thank Gabriela Esqueda for her technical collaboration on fish larvae dissection, SNI-CONACyT and COFAA-IPN for their financial support, and Ellis Glazier for editing this English-language text.

TABLE 3

DIET COMPOSITION OF *Scomber japonicus* LARVAE COLLECTED IN THE GULF OF CALIFORNIA DURING APRIL 1984 AND 1985, EXPRESSED AS PERCENTAGE FREQUENCY OF OCCURRENCE (F%) IN LARVAL GUT, PERCENTAGE OF TOTAL NUMBER (N%) OF ITEMS IN THE DIET, AND THE PRODUCT (F × N), WHICH WAS USED AS AN INDEX OF RELATIVE IMPORTANCE

	APRIL 1984 (n = 81)[a]			APRIL 1985 (n = 85)[a]		
PREY ITEMS	N%	F%	N% F%	N%	F%	N% F%
Centric diatoms	0.1	1.2	0.1	10.2	76.2	780.2
Pennate diatoms				12.5	92.9	1,158.9
Eucampia zoodiacus				0.2	1.2	0.2
Polychaeta	2.7	28.4	77.6	0.5	3.6	1.7
Ostracoda	0.5	4.9	2.3			
Cladocera						
Penilia sp.	29.8	100.0	2,981.0	5.9	44.0	260.8
Evadne sp.	5.0	51.9	258.6	0.2	1.2	0.2
Copepoda						
copepod eggs	5.5	56.8	310.3	6.6	48.8	320.2
nauplii *Acartia* sp.	0.8	8.6	7.2			
nauplii *Calanus* sp.				0.2	1.2	0.2
nauplii *Centropages* sp.	0.1	1.2	0.1			
nauplii *Eucalanus* sp.	0.5	4.9	2.3			
nauplii *Microsetella* sp.				0.2	1.2	0.2
nauplii *Paracalanus* sp.	2.4	24.7	58.6	1.1	8.3	9.3
nauplii *Pontellopsis* sp.				0.2	1.2	0.2
nauplii *Rhincalanus* sp.	1.2	12.3	14.7			
nauplii unidentified	17.1	100.0	1,710.0	22.0	100.0	2,200.0
metanauplii unidentified	2.6	27.2	71.0	5.4	40.5	220.2
copepodites *Acartia* sp.				0.2	1.2	0.2
copepodites *Paracalanus* sp.				0.3	2.4	0.8
copepodites unidentified	0.6	6.2	3.7	1.4	10.7	15.4
copepod *Calanus* sp.				0.2	1.2	0.2
copepod *Centropages* sp.				0.2	1.2	0.2
copepod *Corycaeus* sp.	0.1	1.2	0.1			
copepod *Euterpina* sp.	0.1	1.2	0.1			
copepod *Eucalanus* sp.	0.1	1.2	0.1			
copepod *Haloptilus* sp.				0.2	1.2	0.2
copepod *Microsetella* sp.				0.2	1.2	0.2
copepod *Oithona* sp.	0.4	3.7	1.3	0.2	1.2	0.2
copepod *Oncaea* sp.	0.2	2.5	0.6			
copepod *Paracalanus* sp.	2.6	27.2	71.0	0.6	4.8	3.0
copepod *Rhincalanus* sp.	0.1	1.2	0.1			
copepod unidentified	1.4	14.8	21.1	6.6	48.8	320.2
Euphausiacea				0.2	1.2	0.2
Decapoda	0.4	3.7	1.3			
Appendicularia	16.7	100.0	1,675.0	3.5	26.2	92.2
Fish eggs	3.6	37.0	132.0	5.9	44.0	260.8
Fish larvae	2.3	23.5	43.0			

[a] n = number of larvae examined with food.

LITERATURE CITED

ALVAREZ-BORREGO, S., and J. R. LARA-LARA. 1991. The physical environment and primary productivity of the Gulf of California. Pages 555–567 *in* B. R. T. Simoneit and J. P. Dauplin, eds. The Gulf and Peninsular Province of the Californias. Am. Assoc. Pet. Geol. Mem.

ARTHUR, D. K. 1976. Food and feeding of larvae of three fishes occurring in the California Current: *Sardinops sagax, Engraulis*

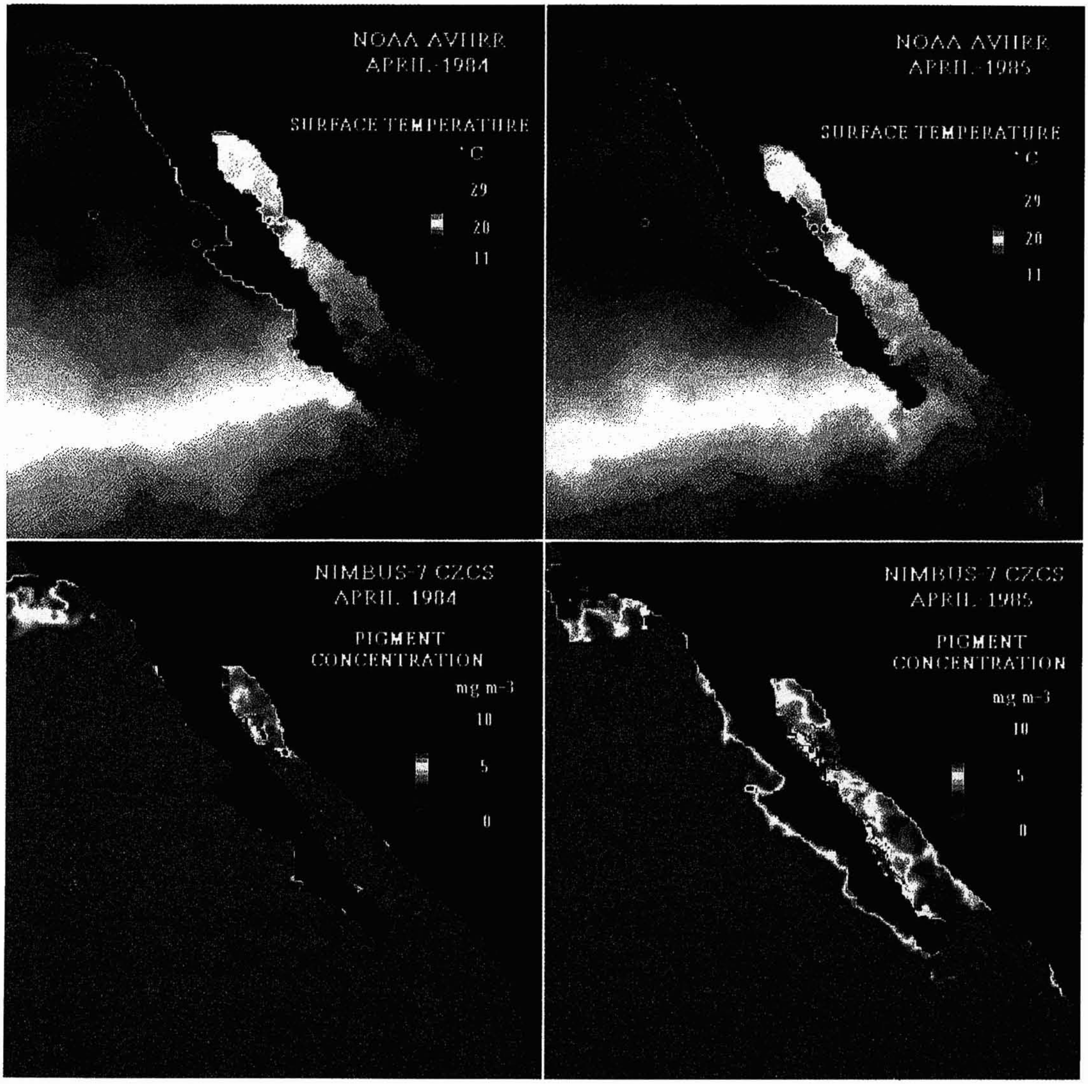

PLATE 1. NOAA-AVHRR and Nimbus-7 CZCS monthly average images showing a synoptic vision of the whole region including the Gulf of California during April 1984 and April 1985.

mordax and *Trachurus symmetricus.* Fish. Bull. 75 : 601–611.

BADAN-DANGON, A. F., J. KOBLINSKY, and T. BAUMGARTNER. 1985. Spring and summer in the Gulf of California: Observations of surface thermal patterns. Oceanol. Acta 8 : 13–22.

CERVANTES-DUARTE, R., G. GAXIOLA-CASTRO, and J. E. VALDEZ-HOLGUÍN. 1993. Relationship between surface chlorophyll and chlorophyll in the euphotic zone of the Gulf of California: Possible application to estimate primary production with data obtained by remote sensors. Cienc. Mar. 19 : 473–490.

CISNEROS-MATA, M. A., M. O. NÉVAREZ-MARTÍNEZ, M. A. MARTÍNEZ-ZAVALA, M. L. ANGUIANO-CARRAZCO, J. P. SANTOS-MOLINA, A. R. GODÍNEZ-COTA, and G. MONTEMAYOR-LÓPEZ. 1997. Diagnosis de la pesquería de pelágicos menores del Golfo de California de 1991 a 1995/96. Invest. Nal. de la Pesca, CRIP Guaymas, Sonora.

COLE, A. D., and D. R. MCLAINE. 1989. Interannual variability of temperature in the upper layer of the North Pacific Eastern Boundary region, 1971–1987. NOAA Tech. Mem. NMFS-SWFC (125): 1–10.

COLLETE, B. B., and C. E. NAUSEN. 1983. FAO species catalogue. Vol. 2. Scombridae of the world. An annotated and ilustrated catalogue of tunas, mackerels, bonitos and related species know to date. FAO Fish. Synop. 2 (125):135.

ESQUEDA-ESCÁRCEGA, G. M. 1995. Spatial and temporal distributions of *Scomber japonicus* larvae in the Sea of Cortez (1984–1988). Sci. Mar. 59 (3–4): 391–397.

GOVONI, J. J., D. E. HOSS, and A. J. CHESTER. 1983. Comparative feeding of three species of larval fishes in the northern Gulf of Mexico: *Brevortia patronus, Leiostomus xanthurus,* and *Micropogonias undulatus.* Mar. Ecol. Prog. Ser. 13 : 189–199.

HAMMANN, M. G., T. R. BAUMGARTNER, and A. BADA-DAGON. 1988. Coupling of the Pacific sardine (*Sardinops sagax caeruleus*) life cycle with the Gulf of California pelagic environment. Calif. Coop. Oceanic Fish. Invest. Rep. 29 : 102–109.

HJORT, J. 1914. Fluctuations in the great fisheries of northern Europe viewed in the light of biological research. Rapp. P.-V. Reun. Cons. Perm. Int. Explor. Mer 20 : 1–228.

HUNTER, J. R. 1981. Feeding ecology and predation of marine postlarvae. Pages 60–77 *in* R. Lasker, ed. Marine fish larvae: Morphology, ecology and relation to fisheries. University of Washington Press, Seattle.

HUNTER, J. R., and C. A. KIMBRELL. 1980. Early life history of Pacific mackerel *Scomber japonicus.* Fish. Bull. 78 : 89–101.

JIMÉNEZ-PÉREZ, J. C., and J. R. LARA-LARA. 1988. Zooplankton biomass and copepod community structure in the Gulf of California during the 1982–1983 El Niño Event. Calif. Coop. Oceanic Fish. Invest. Rep. 29 : 122–128.

LARA-LARA, J. R., and J. E. VALDEZ-HOLGUÍN. 1988. Size fraction biomass and primary productivity in the Gulf of California during spring 1984. Cienc. Mar. 14 (1): 1–14.

LAROCHE, J. L. 1982. Trophic patterns among larvae of five species of sculpins (Family: Cottidae) in a Maine estuary. Fish. Bull. 80 : 827–840.

LASKER, R. 1975. Field criteria for survival of anchovy larvae: The relation between inshore chlorophyll maximum layers and successful first feeding. Fish. Bull. 73 : 453–462.

LAST, J. M. 1980. The food of twenty species of fish larvae in the west-central North Sea. Fish. Res. Tech. Rep. No. 60.

LLUCH-BELDA, D., F. J. MAGALLÓN, and R. A. SCHWARTZLOSE. 1986. Large fluctuations in the sardine fishery in the Gulf of California: Possible causes. Calif. Coop. Oceanic Fish. Invest. Rep. 27 : 136–140.

MOSER, G. H., E. H. AHLSTROM, D. KRAMER, and G. E. STEVENS. 1974. Distribution and abundance of fish eggs and larvae in the Gulf of California. Calif. Coop. Oceanic Fish. Invest. Rep. 17 : 112–128.

NÉVAREZ, M. M., R. MORALES, M. A. MARTÍNEZ, J. P. SANTOS, and M. A. CISNEROS. 1993. Pesquerías de pelágicos menores en el Golfo de California. Temporada 1990/1991. Invest. Nal. de la Pesca, CRIP Guaymas, Sonora.

PETERSON, W. T., and S. AUSUBEL. 1984. Diets and selective feeding by larvae of Atlantic mackerel *Scomber scombrus* on zooplankton. Mar. Ecol. Progr. Ser. 17:65–75.

ROBLES-PACHECO, J. M., and N. CHRISTENSEN. 1984. Effects of the 1982–1983 "El Niño" on the Gulf of California. EOS–Trans. Am. Geophys. Union 64:52.

RODEN, G. I., and G. W. GROVES. 1959. Recent oceanographic investigation in the Gulf of California. J. Mar. Res. 18:10–35.

SÁNCHEZ-VELASCO, L. 1998. Diet composition and feeding habits of fish larvae of two co-ocurring species (Pisces: Callionymidae and Bothidae) in the North-western Mediterranean. ICES J. Mar. Sci. 55:1–11.

SÁNCHEZ-VELASCO, L., and W. NORBIS. 1997. Comparative diets and feeding habits of *Boops boops* and *Diplodus sargus* larvae, two sparid fishes co-ocurring in the Northwestern Mediterranean (May 1992). Bull. Mar. Sci. 61 (3): 821–835.

SÁNCHEZ-VELASCO, L., I. CONTRERAS-ARREDONDO, and G. ESQUEDA-ESCÁRCEGA. In press. Diet composition of *Euthynnus lineatus* and *Auxis* sp. larvae (Pisces: Scombridae) in the Gulf of California. Bull. Mar. Sci.

SANTAMARÍA-DEL-ANGEL, E., S. ALVAREZ-BORREGO, and F. E. MÜLLER-KRAGER. 1994*a*. Gulf of California biogeographic regions based on coastal zone color scanner imagery. J. Geophys. Res. 99 (C4): 7411–7421.

———. 1994*b*. The El Niño 1982–1984 in the Gulf of California as seen in the coastal zone color scanner imagery. J. Geophys. Res. 99 (C4): 7423–7431.

SOKAL, R. R., and F. J. ROLF. 1979. Biometría: Principios y métodos estadísticos en la investigación biológica. Ed. H. Blume, España.