Fish larvae from the Gulf of California*

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SUMMARY: Taxonomic composition of fish larvae was analysed from 464 plankton samples obtained during 10 oceanographic surveys in the Gulf of California between 1984 and 1988. We identified 283 taxa: 173 species, 57 genera, and 53 families. Tropical and subtropical species predominated except during the winter, when temperate-subarctic species were dominant. The most abundant species were the mesopelagic *Benthosema panamense*, *Triphoturus mexicanus* and *Vinciguerria lucetia*, but the coastal pelagic species *Engraulis mordax*, *Opisthonema* spp., *Sardinops caeruleus* and *Scomber japonicus* were also prominent. The taxonomic composition of the ichthyoplankton shows the seasonality of the Gulf as well as environmental changes that occurred between the 1984-1987 warm period and the 1956-1957 cool period previously reported. The presence of *E. mordax* larvae as one of the most abundant species in the Gulf provides evidence of the reproduction of this species two years before the development of the northern anchovy fishery and the decline of the sardine fishery in the Gulf of California.

Key words: fish larvae, ichthyoplankton, Gulf of California.

RESUMEN: LARVAS DE PECES DEL GOLFO DE CALIFORNIA. – Se analizó la composición taxonómica de las larvas de peces capturadas en 464 arrastres de plancton obtenidos durante 10 cruceros oceanográficos en el Golfo de California entre 1984 y 1988. Se identificaron 283 taxones: 173 especies, 57 géneros y 53 familias. Los organismos de afinidad tropical y subtropical fueron los más numerosos excepto durante el invierno, periodo en el que las especies templado-subárticas fueron dominantes. Las especies más abundantes fueron los mesopelágicos *Benthosema panamense*, *Triphoturus mexicanus* y *Vinciguerria lucetia*, pero las especies pelágico-costeras como *Engraulis mordax*, *Opisthonema* spp., *Sardinops caeruleus* y *Scomber japonicus* fueron también importantes por el número de organismos recolectados. La composición taxonómica del ictioplancton refleja la variabilidad estacional del Golfo, así como los cambios ocurridos entre el periodo cálido de 1984-1987 y el periodo frío de 1956-1957 previamente registrado en la literatura. La presencia de larvas de *E. mordax* como una de las especies más abundantes en el Golfo, aporta evidencia de la reproducción de esta especie dos años antes del desarrollo de la pesquería de la anchoveta norteña y el desplome de la pesquería de sardina del Golfo de California.

Palabras clave: larvas de peces, ictioplancton, Golfo de California.

INTRODUCTION

The Gulf of California is a semi-enclosed system bordered on the west by the Baja California peninsula and on the east by the Mexican mainland. To the south it connects to the Pacific Ocean through a 200 km wide mouth (Fig. 1). The Gulf has one of the most diverse and highly endemic ichthyofaunas of the eastern Pacific, which supports its designation as a separate zoogeographic province from the Panamic province, in which it is usually included due to its high proportion of tropical species (Walker, 1960;

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Thomson *et al.,* 1979). Although Ekman (1953) first suggested that the Gulf of California ecosystem represents a distinct zoogeographic province, it was not until Briggs (1974) that it received formal status as the Cortez province, which borders to the south with the Mexican province on a line drawn between Cabo San Lucas and Mazatlán. The Cortez province is characterised by a relict Pleistocene temperate-subarctic fauna located north of Tiburón and Angel de la Guarda Islands that was apparently native from the San Diego province and by a tropical-subtropical fauna found primarily in the south. Both the northern and southern faunas merge in the central region, forming a zone of high spatial and temporal faunistic contrast (Castro-Aguirre *et al.*, 1995).

Even though the fish fauna of the Gulf of California is one of the best studied of the eastern Pacific, only a small number of studies have addressed the early life histories of the fishes. Most previous ichthyoplankton studies have been oriented towards species with commercial value, such as the Pacific sardine and the northern anchovy (Green-Ruiz and Hinojosa-Corona, 1997). Except for the work of Moser *et al*. (1974), no one has addressed the composition of the ichthyoplankton of the Gulf, primarily because little was known of the taxonomy of the fish larvae. Richards (1985) and Kendall and Matarese (1994) reported that larvae have been described for nearly 10% of the fish species worldwide, but in the eastern tropical Pacific region this proportion is even lower, as reflected in the work of Moser *et al.* (1974), who found that more than 60% of the fish larvae of the Gulf were identifiable only to family. Since 1951 the California Cooperative Oceanic Fisheries Investigations program (CalCOFI) has conducted ichthyoplankton research in the California current region, allowing more detailed analyses of ichthyoplankton composition and abundance in the California and western coast of Baja California (e.g. Loeb *et al.*, 1983; Moser *et al.*, 1987; Moser and Smith, 1993), and a wide taxonomic knowledge that includes many species found in the Gulf of California (Moser, 1996).

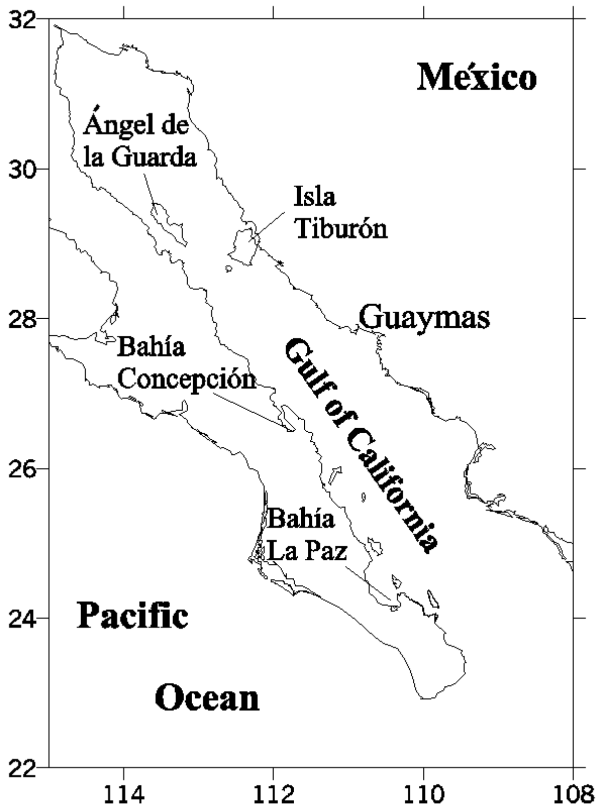

FIG. 1. – Study area.

Progress in the identification of the fish larvae inhabiting the Gulf of California has allowed a more detailed analysis of the ichthyoplankton in terms of species composition, distribution patterns, species assemblages, and how fish larvae are affected by environmental changes, resulting in a better understanding of the ecosystem. This work is the first in a series whose objective is to characterise the larval fish communities of the Gulf of California. Here we draw up the taxonomic list and compare our findings with those of Moser *et al.* (1974).

MATERIALS AND METHODS

Ten oceanographic surveys were conducted in the Gulf of California during April, July and November-December 1984, April 1985, June, July and August 1986, September and November 1987, and February 1988 (Fig. 2). Each cruise was named with the acronym GOLCA (for Golfo de California) and four digits, the first two indicating the year and the last two the month of sampling. Therefore GOLCA 8404 refers to sampling in the Gulf of California in April 1984.

A total of 464 plankton samples were obtained with oblique tows using Bongo nets with 333- and 505-µm mesh size following the sampling methodology detailed by Smith and Richardson (1979). Fish larvae were removed from samples and stored in 2% formalin buffered with a saturated solution of sodium borate. Only the larvae from the 505-µm mesh net were analysed; these were identified to the lowest possible taxon using Moser (1996). Larvae of each taxon were counted and their abundances stan-

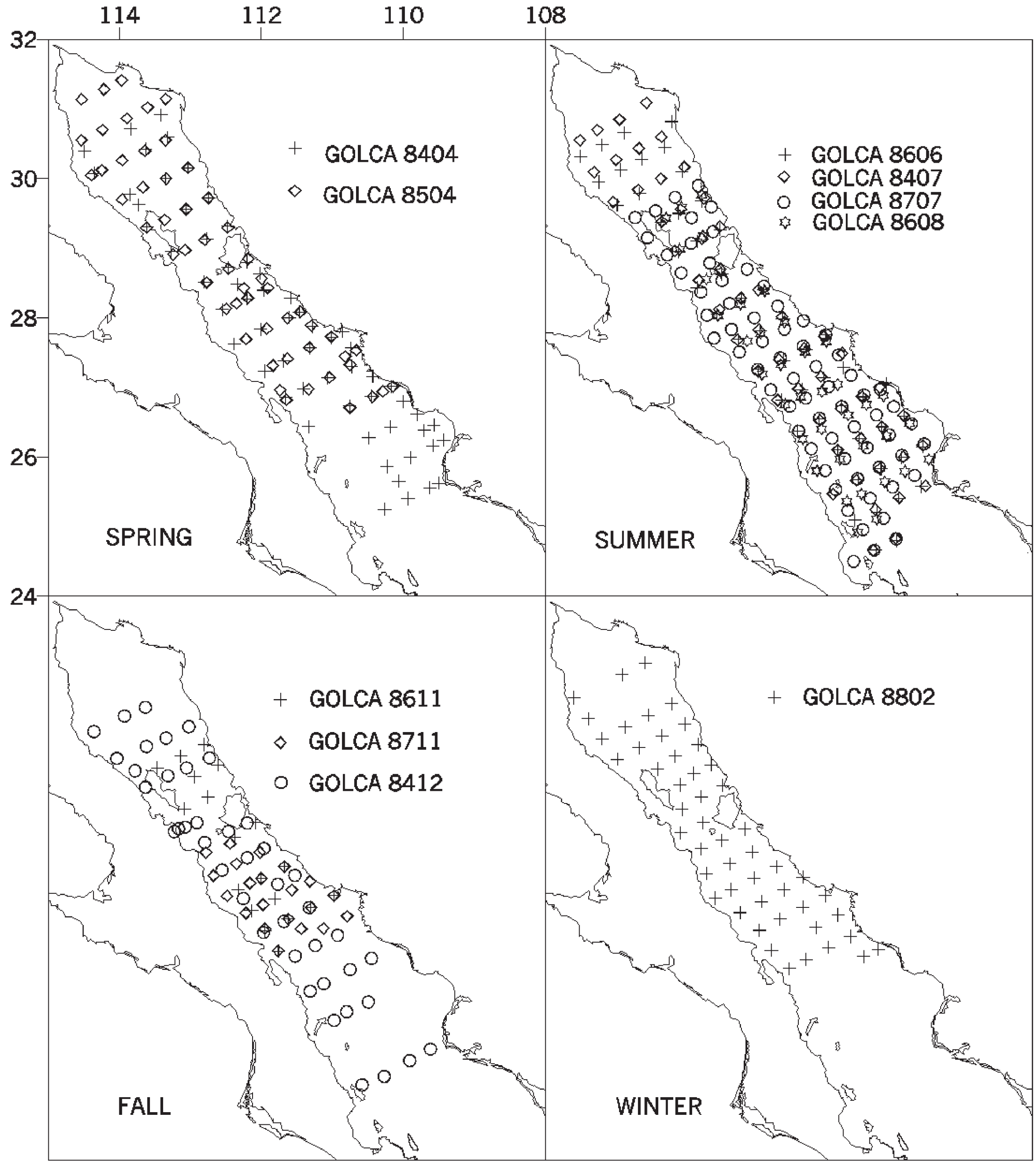

FIG. 2. – Sampling stations.

dardised to 10 m^2 of sea surface following Smith and Richardson (1979). The taxonomic organization of fish larvae is that of Eschmeyer *et al*. (1983) and Moser (1996); species are listed alphabetically within each family. Habitat and affinity data for each species were taken from Moser (1996). For purposes of examining the seasonal distribution of each taxon, cruises occurring in April (GOLCA 8404 and 8504) were assigned to the spring period, June through September to the summer period (GOLCA 8407, 8606, 8608 and 8709), November and December to the fall period (GOLCA 8412, 8611 and 8711), and February to the winter period (GOLCA 8802).

RESULTS

A total of 283 taxa were identified, of which 173 were identified to species, 57 to genus, and 53 to family (Table 1). In most cases, larvae that could not be identified to species were identified to types

TABLE 1. – Systematic list of the fish larvae collected in the Gulf of California during 1984-1988 with the percent abundance (%). Faunistic affinity (FA): tropical (tr); subtropical (st); temperate (tm); subarctic (sa); wide distribution in the eastern Pacific (wd). Habitat (Hab): shallow demersal (sd); deep demersal (dd); coastal pelagic (cp); ocean epipelagic (op); mesopelagic (mp); and bathypelagic (bp).

Taxon	%	(FA)-(Hab)
O. Elopiformes		
F. Elopidae		
Elops affinis Regan 1909	<0.1	(tr/st)-(cp)
O. Albuliformes		
F. Albulidae		
Albula type 1 (*A vulpes*?)	0.7	(tr)-(sd)
O. Notacanthiformes		
F. Notacanthidae		
Notacanthidae	<0.1	-(dd)
O. Anguilliformes		
F. Muraenidae		
Anarchias type 1	<0.1	(sd)
Gymnothorax type 1	<0.1	(tr/st)-(sd)
Uropterygius type 1	<0.1	(sd)
Muraenidae type 1	<0.1	(sd)
F. Ophichthidae		
Myrophis vafer Jordan & Gilbert 1882	<0.1	(tm/st)-(sd)
Ophichthus triserialis (Kaup 1856)	<0.1	(tr/st)-(sd)
Ophichthus zophochir (Jordan & Gilbert 1882)	0.1	(tr/st)-(sd)
Ophichthus type 1	<0.1	-(sd)
Ophichthidae type 1	<0.1	-(sd)
F. Congridae		
Ariosoma gilberti (Ogilby 1898)	<0.1	(tr/st)-(sd)
Bathycongrus macrurus (Gilbert 1891)	<0.1	(tr)-(sd)
Chiloconger type 1	<0.1	(tr/st)-(sd)
Gnathophis cinctus (Garman 1899)	<0.1	(tm/st)-(sd)
Paraconger type 1	<0.1	(tr/st)-(sd)
Congridae type1	<0.1	-(sd)
F. Derichthyidae		
Derichthyidae type 1	<0.1	-(mp)
F. Nemichthyidae		
Nemichthyidae type 1	<0.1	-(mp)
F. Serrivomeridae		
Serrivomeridae	<0.1	(bp)
F. Nettastomatidae		
Hoplunnis sicarius (Garman 1899)	<0.1	(tr)-(sd)
Hoplunnis type 1	<0.1	(tr)-(sd)
F. Cyematidae		
Cyematidae type 1	<0.1	-(mp)
O. Clupeiformes		
F. Clupeidae		
Etrumeus teres (DeKay 1842)	1.0	(wd)-(cp)
Harengula thrissina (Jordan & Gilbert 1882)	0.1	(tr)-(cp)
Opisthonema sp. (*libertate*?)	5.5	(tr)-(cp)
Sardinops caeruleus (Girard 1856)	3.6	(tm/sa)-(cp)
Clupeidae	<0.1	-(cp)
F. Engraulidae		
Engraulis mordax Girard 1854	17.6	(tm)-(cp)
Engraulidae type 1	2.5	-(cp)
O. Salmoniformes		
S.O. Argentinoidei		
F. Argentinidae		
Argentina sialis Gilbert 1890	0.1	(tm)-(dd)
F. Bathylagidae		
Bathylagus pacificus Gilbert 1890	<0.1	(tm/sa)-(mp)
Bathylagus wesethi Bolin 1938	<0.1	(tm)-(mp)
Leuroglossus stilbius Gilbert 1890	1.6	(tm)-(mp)
F. Microstomatidae		
Microstomatidae type 1	<0.1	-(mp)
O. Stomiiformes		
F. Gonostomatidae		
Diplophos proximus Parr 1931	<0.1	(tr)-(mp)
F. Phosichthyidae		
Ichthyococcus irregularis Rechnitzer & Böhlke 1958	<0.1	(wd)-(mp)
Vinciguerria lucetia (Garman 1899)	6.8	(tr)-(mp)
F. Stomiidae		
Stomias atriventer Garman 1899	<0.1	(tr/st)-(mp)
F. Melanostomiidae		
Melanostomiidae type 1	<0.1	-(mp)
O. Aulopiformes		
S.O. Aulopoidei		
F. Aulopidae		
Aulopus bajacali Parin & Kotlyar 1984	<0.1	(tr)-(dd)
F. Scopelarchidae		
Scopelarchoides nicholsi (Parr 1929)	<0.1	(tr)-(mp)
Scopelarchus guentheri Alcock 1896	<0.1	(tr/st)-(mp)
Scopelarchidae type 1	<0.1	-(mp)
S.O. Alepisauroidei		
F. Synodontidae		
Synodus lucioceps (Ayres 1855)	<0.1	(tm)-(sd)
Synodus spp.	0.1	(tr)-(sd)
F. Paralepididae		
Lestidiops neles (Harry 1953)s	<0.1	(tr)-(mp)
Lestidiops type 1	<0.1	-(mp)
O. Myctophiformes		
F. Neoscopelidae		
Neoscopelidae type 1	<0.1	-(bp)
F. Myctophidae		
Ceratoscopelus townsendi (Eigenmann & Eigenmann 1889)	<0.1	(wd)-(mp)
Diaphus pacificus Parr 1931	0.2	(tr)-(mp)
Lampanyctus parvicauda Parr 1931	<0.1	(tr)-(mp)
Nannobrachium idostigma (Parr 1931)	<0.1	(tr/st)-(mp)
Nannobrachium type 1	<0.1	-(mp)
Triphoturus mexicanus (Gilbert 1890)	7.1	(st)-(mp)
Benthosema panamense (Tåning 1932)	34.2	(tr)-(sd)
Diogenichthys laternatus (Garman 1899)	3.5	(tr)-(mp)
Gonichthys tenuiculus (Garman 1899)	<0.1	(tr/st)-(mp)
Hygophum atratum (Garman 1899)	0.2	(tr)-(mp)
Myctophidae type 1	<0.1	-(mp)
O. Gadiformes		
F. Bregmacerotidae		
Bregmaceros bathymaster Jordan & Bollman 1890	0.2	(tr/st)-(cp)
Bregmaceros type 1	<0.1	(tr)-(cp)
Bregmacerotidae type 1	<0.1	-(cp)
F. Macrouridae		
Caelorinchus scaphopsis (Gilbert 1890)	<0.1	(tm)-(bp)
Nezumia type 1	<0.1	(bp)
F. Moridae		
Physiculus nematopus Gilbert 1890	<0.1	(tr)-(mp)
F. Merlucciidae		
Merluccius productus (Ayres 1855)	0.7	(tm/sa)-(dd)
O. Ophidiiformes		
S.O. Ophidioidei		
F. Ophidiidae		
Cherublemma emmelas (Gilbert 1890)	<0.1	(tr)-(dd)
Chilara taylori (Girard 1958)	<0.1	(tm/sa)-(dd)
Lepophidium negropinna Hildebrand & Barton 1949	<0.1	(tr)-(sd)
Lepophidium stigmatistium Gilbert 1890	<0.1	(st)-(dd)
Lepophidium type 1	<0.1	(tr)-(sd)
Ophidion scrippsae (Hubbs 1916)	<0.1	(tm)-(sd)
Ophidion type 1	<0.1	-(sd)
Ophidiidae	<0.1	
F. Carapidae		
Encheliophis dubis (Putman 1874)	<0.1	(tr)-(sd)
Encheliophis type 1	<0.1	
Echiodon exsilium Rosenblatt 1961	<0.1	(tr)-(dd)
Carapidae	<0.1	
F. Bythitidae		
Bythitidae type 1	<0.1	
O. Lophiiformes		
S.O. Lophioidei		
F. Lophiidae		
Lophiodes spilurus (Garman 1899)	<0.1	(wd)-(dd)
Lophiodes type 1	<0.1	

TABLE 1 (Cont.). – Systematic list of the fish larvae collected in the Gulf of California during 1984-1988 with the percent abundance (%). Faunistic affinity (FA): tropical (tr); subtropical (st); temperate (tm); subarctic (sa); wide distribution in the eastern Pacific (wd). Habitat (Hab): shallow demersal (sd); deep demersal (dd); coastal pelagic (cp); ocean epipelagic (op); mesopelagic (mp); and bathypelagic (bp).

Taxon	%	(FA)-(Hab)
Lophiidae type 1	<0.1	
S.O. Antennarioidei		
F. Antennariidae		
Antennarius avalonis Jordan & Starks 1907	<0.1	(tr/st)-(sd)
Antennarius type 1	<0.1	
S.O. Ogcocephalioidei		
F. Ogcocephalidae		
Zalieutes elater (Jordan & Gilbert 1882)	<0.1	(tr/st)-(dd)
S.O. Ceratioidei		
F. Melanocetidae		
Melanocetidae type 1	<0.1	(tr/st)-(bp)
F. Oneirodidae		
Oneirodes type 1	<0.1	-(bp)
Oneirodidae type 1	<0.1	-(bp)
F. Gigantactinidae		
Gigantactis type 1	<0.1	-(bp)
F. Linophrynidae		
Borophryne apogon Regan 1925	<0.1	-(tr)-(bp)
O. Atheriniformes		
F. Atherinidae		
Atherinidae type 1	<0.1	-(cp)
O. Beloniformes		
F. Hemiramphidae		
Hyporhamphus rosae (Jordan & Gilbert 1880)	<0.1	(tr/st)-(cp)
Oxyporhamphus micropterus (Valenciennes 1847)	<0.1	(tr/st)-(cp)
Hemiramphidae type 1	<0.1	
F. Exocoetidae		
Cheilopogon pinnatibarbatus(Cooper 1863)	<0.1	(tm/sa)-(cp)
Fodiator acutus (Günther 1866)	<0.1	(tr/st)-(cp)
Hirundichthys rondeletii (Valenciennes 1846)	<0.1	(tr/st)-(cp)
Hirundichthys spp.	<0.1	(tr/st)-(cp)
Prognichthys tringa Breder 1928	<0.1	(tr)-(cp)
Exocoetidae type 1	<0.1	(tr/st)-(cp)
O. Lampridiformes		
F. Trachipteridae		
Zu cristatus (Bonelli 1819)	<0.1	(tr/st)-(cp)
Trachipteridae type 1	<0.1	
O. Beryciformes		
S.O. Berycoidei		
F. Holocentridae		
Myripristis leiognathos Valenciennes 1855	<0.1	(tr)-(sd)
Myripristis spp.	<0.1	(tr/st)-(cp)
S.O. Stephanoberycoidei		
F. Melamphaidae		
Melamphaes spp.	<0.1	-(mp)
Scopelogadus bispinosus (Gilbert 1915)	<0.1	(tr)-(mp)
F. Mirapinnidae		
Mirapinnidae type 1	<0.1	-(mp)
O. Syngnathiformes		
F. Fistulariidae		
Fistularia commersonii Rüppell 1838	<0.1	(tr)-(sd)
Fistularia corneta Gilbert & Starrks 1904	<0.1	(tr)-(sd)
F. Syngnathidae		
Syngnathus type 1	<0.1	-(sd)
O. Scorpaeniformes		
S.O. Scorpaenoidei		
F. Scorpaenidae		
Sebastes macdonaldi (Eigenmann & Beeson 1893)	0.2	(tm)-(dd)
Sebastes spp.	<0.1	(tm/sa)-
Pontinus sierra (Gilbert 1890)	<0.1	(tr/st)-(dd)
Pontinus spp.	<0.1	(tr)-(sd)
Scorpaena guttata Girard 1854	<0.1	(tm)-(sd)
Scorpaena spp.	<0.1	(tr/st)-(dd)
Scorpaenodes xyris(Jordan & Gilbert 1882)	<0.1	(wd)-(sd)
Sebastolobus altivelis Gilbert 1896	<0.1	(st/tm)-(dd)
Scorpaenidae	<0.1	
F. Triglidae		
Bellator loxias (Jordan 1897)	<0.1	(tr)-(sd)
Prionotus ruscarius Gilbert & Starks 1904	<0.1	(tr)-(sd)
Prionotus stephanophrys Lockington 1881	<0.1	(wd)-(sd)
Triglidae	<0.1	-(sd)
O. Perciformes		
S.O. Percoidei		
F. Serranidae		
Hemanthias signifer (Garman 1899)	<0.1	(tr)-(sd)
Hemanthias spp.	<0.1	(tr)-(sd)
Mycteroperca spp.	<0.1	(tr/st)-(sd)
Epinephelus spp.	<0.1	(tr/st)-(sd)
Diplectrum spp.	0.1	(tr/st)-(sd)
Paralabrax maculatofasciatus (Steindechner 1868)	<0.1	(tm/st)-(sd)
Serranus spp.	0.2	(tr/st)-(sd)
Pronotogrammus multifasciatus Gill 1863	<0.1	(tr)-(sd)
Paranthias colonus (Valenciennes 1846)	<0.1	(tr)-(sd)
Pseudogramma thaumasium (Gilbert 1890)	<0.1	(tr)-(sd)
Serranidae	<0.1	-(sd)
F. Priacanthidae		
Pristigenys serrula (Gilbert 1891)	<0.1	(wd)-(sd)
Priacanthidae type 1	<0.1	-(sd)
F. Apogonidae		
Apogon retrosella (Gill 1863)	<0.1	(tr)-(sd)
Apogon spp.	<0.1	-(sd)
Apogonidae type 1	<0.1	-(sd)
F. Carangidae		
Alectis ciliaris (Bloch 1787)	<0.1	(tr)-(cp)
Caranx caballus Günther 1868	0.3	(tr/st)-(cp)
*Caranx sexfasciatus*Quoy & Gaimard 1825	<0.1	(tr)-(cp)
Caranx spp.	<0.1	-(cp)
Chloroscombrus orqueta Jordan & Gilbert 1883	<0.1	(tr/st)-(cp)
Decapterus spp.	<0.1	(tr)-(cp)
Elagatis bipinnulata (Quoy & Gaimard 1825)	<0.1	(tr)-(cp)
Gnathonodon speciosus (Forskål 1775)	<0.1	(tr)-(cp)
Oligoplites saurus Gill 1863	<0.1	(tr)-(cp)
Oligoplites type 1	0.2	(tr/st)-(cp)
Selar crumenophthalmus (Bloch 1793)	0.1	(tr/st)-(cp)
Selene brevoortii (Gill 1863)	<0.1	(tr/st)-(cp)
Selene peruviana (Guichenot 1866)	<0.1	(tr)-(cp)
Selene spp.	<0.1	(tr/st)-(cp)
Seriola lalandi Valenciennes 1833	<0.1	(wd)-(cp)
Seriola spp.	<0.1	-(cp)
Trachinotus rhodopus Gill 1863	<0.1	(tr)-(cp)
Trachurus symmetricus (Ayres 1855)	<0.1	(tm/sa)-(op)
Carangidae type 1	<0.1	-(cp)
F. Nematistiidae		
Nematistius pectoralis Gill 1862	<0.1	(tr/st)-(cp)
F. Coryphaenidae		
Coryphaena hippurus Linneaus 1758	<0.1	(tr)-(op)
F. Bramidae		
Bramidae type 1	<0.1	-(mp)
F. Lutjanidae		
Lutjanus argentiventris (Peters 1869)	<0.1	(tr)-(sd)
Lutjanus guttatus (Steindachner 1869)	<0.1	(tr)-(sd)
Lutjanus novemfasciatus Gill 1862	<0.1	(tr)-(sd)
Lutjanus peru (Nichols & Murphy 1922)	<0.1	(tr)-(sd)
Lutjanus spp.	<0.1	(tr)-(sd)
Lutjanidae type 1	<0.1	(tr)-(sd)
F. Malacanthidae		
Caulolatilus princeps (Jenyns 1842)	<0.1	(wd)-(sd)
F. Gerreidae		
Diapterus peruvianus (Sauvage 1879)	0.1	(tr)-(sd)
Eucinostomus currani Yáñez-Arancibia 1978	<0.1	(tr/st)-(sd)

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Taxon	%	(FA)-(Hab)
Eucinostomus dowii (Gill 1863)	0.1	(tr/st)-(sd)
Eucinostomus gracilis (Gill 1862)	0.6	(tr)-(sd)
Gerreidae type 1	<0.1	
F. Haemulidae		
Anisotremus davidsoni (Steindachner 1875)	0.2	(tm)-(sd)
Anisotremus spp.	<0.1	(tr)-(sd)
Orthopristis spp.	<0.1	(tr)-(sd)
Xenistius californiensis (Steindachner 1875)	0.2	(tr/st)-(sd)
Haemulidae type 1	<0.1	
F. Sparidae		
Calamus brachysomus (Lockington 1880)	<0.1	(tr/st)-(sd)
F. Sciaenidae		
Menticirrhus undulatus (Girard 1858)	<0.1	(tr)-(sd)
Roncador stearnsii (Steindachner 1875)	<0.1	(tm/st)-(sd)
Seriphus politus Ayres 1860	<0.1	(tm)-(sd)
Umbrina roncador Jordan & Gilbert 1882	<0.1	(st)-(sd)
Sciaenidae	<0.1	
F. Mullidae		
Mullidae type 1	<0.1	-(sd)
F. Kyphosidae		
Kyphosidae type 1	<0.1	-(sd)
F. Ephippidae		
Chaetodipterus zonatus (Girard 1858)	<0.1	(tr/st)-(sd)
*Parapsettus panamensis*Steindachner 1875	<0.1	(tr)-(sd)
F. Chaetodontidae		
Chaetodontidae type 1	<0.1	-(sd)
F. Pomacentridae		
Abudefduf troschelii (Gill 1862)	<0.1	(tr)-(sd)
Chromis type1	<0.1	(tr)-(sd)
Chromis type 2	<0.1	(tr)-(sd)
Hypsypops rubicundus (Girard 1854)	<0.1	tm-(sd)
Stegastes rectifraenum (Gill 1862)	0.1	(st)-(sd)
Pomacentridae type 1	<0.1	-(sd)
F. Opistognathidae		
Opistognathus spp.	<0.1	-(sd)
F. Howellidae		
Howella spp.	<0.1	-(mp)
S.O. Mugiloidei		
F. Mugilidae		
Mugil cephalus Linnaeus 1758	<0.1	(tr/st)-(cp)
Mugilidae type 1	<0.1	(tr/st)-(cp)
S.O. Polynemoidei		
F. Polynemidae		
Polydactylus approximans (Lay & Bennett 1839)	<0.1	(tr/st)-(sd)
Polydactylus opercularis (Gill 1863)	<0.1	(tr/st)-(sd)
S.O. Labroidei		
F. Labridae		
Halichoeres dispilus (Günther 1864)	<0.1	(tr)-(sd)
Halichoeres semicinctus (Ayres 1859)	<0.1	(tm)-(sd)
Halichoeres spp.	<0.1	-(sd)
Oxyjulis californica (Günther 1861)	<0.1	(tm)-(sd)
Semicossyphus pulcher (Ayres 1854)	<0.1	(tm)-(sd)
Thalassoma spp.	<0.1	(tr)-(sd)
Xyrichthys mundiceps Gill 1962	<0.1	(tr)-(sd)
Xyrichthys pavo (Valenciennes 1840)	<0.1	(tr)-(sd)
Labridae	<0.1	-(sd)
F. Scaridae		
Scarus spp.	<0.1	(tr)-(sd)
S.O. Trachinoidei		
F. Chiasmodontidae		
Chiasmodon niger Johnson 1864	<0.1	(tr/st)-(mp)
Chiasmodontidae type 1	<0.1	(tr/st)-(mp)
S.O. Blennioidei		
F. Tripteygiidae		
Tripteygiidae	<0.1	(tr/st)-(sd)
F. Labrisomidae		
Labrisomus xanti (Gill 1860)	<0.1	(tr)-(mp)
F. Blenniidae		
Hypsoblennius gentilis (Girard 1854)	<0.1	(tm)-(sd)
Hypsoblennius jenkinsi (Jordan & Evermann 1896)	<0.1	(tm)-(sd)
Hypsoblennius spp.	<0.1	(tm)-(sd)
Ophioblennius steindachneri Jordan & Evermann 1898	<0.1	(tr)-(sd)
Blenniidae type 1	<0.1	-(sd)
S.O. Gobioidei		
F. Eleotridae		
Eleotridae type 1 (*Erotelis armiger?*)	<0.1	
Eleotridae	0.6	
F. Gobiidae		
Coryphopterus type 1	<0.1	-(sd)
Gillichthys mirabilis Cooper 1864	<0.1	(tm)-(sd)
Gobulus crescentalis (Gilbert 1892)	<0.1	(st)-(sd)
Ilypnus gilberti (Eigenmann & Eigenmann 1889)	<0.1	(tm)-(sd)
Lythrypnus dalli (Gilbert 1890)	0.6	(tm)-(sd)
Lythrypnus spp.	<0.1	-(sd)
Quietula y-cauda (Jenkins & Evermann 1889)	<0.1	(tm)-(sd)
Gobiidae type 1	<0.1	-(sd)
Gobiidae	0.6	-(sd)
F. Microdesmidae		
Clarkichthys bilineatus (Clark 1936)	<0.1	-(sd)
Microdesmidae type 1	<0.1	-(sd)
S.O Sphyraenoidei		
F. Sphyraenidae		
Sphyraena argentea Girard 1854	<0.1	(tm)-(cp)
Sphyraena ensis Jordan & Gilbert 1882	<0.1	(tr)-(cp)
Sphyraena lucasana Gill 1863	<0.1	(st)-(sd)
S.O Scombroidei		
F. Gempylidae		
Gempylus serpens Cuvier 1829	<0.1	(tr/st)-(mp)
Gempylidae type 1	<0.1	-(mp)
F. Scombridae		
Auxis spp.	0.2	(tr/st)-(op)
Euthynnus lineatus Kishinouye 1920	0.1	(tr)-(op)
Sarda chiliensis (Cuvier 1832)	<0.1	(tm/sa)-(cp)
Sarda type 1	<0.1	-(cp)
Scomber japonicus Houttuyn 1782	1.4	(tm/st)-(cp)
Thunnus spp.	<0.1	(tr/st)-(op)
F. Trichiuridae		
Lepidopus fitchi Rosenblatt & Wilson 1987	<0.1	(st)-(mp)
Trichiurus nitens Garman 1899	<0.1	(wd)-(mp)
Trichiuridae type 1	<0.1	-(mp)
S.O Stromateoidei		
F. Nomeidae		
Cubiceps pauciradiatus Günther 1872	<0.1	(tr)-(op)
Cubiceps spp.	<0.1	-(op)
Psenes sio	<0.1	(tr)-(op)
Psenes type 1	<0.1	-(op)
Nomeidae type 1	<0.1	
F. Stromateidae		
Peprilus type 1	<0.1	(tr)-(sd)
Stromateidae	<0.1	-(sd)
O Pleuronectiformes		
S.O Pleuronectoidei		
F. Paralichthyidae		
Citharichthys fragilis Gilbert 1890	0.2	(tm/st)-(sd)
Citharichthys gordae Beebe & Tee-Van 1938	<0.1	(tr)-(sd)
Citharichthys platophrys Gilbert 1891	<0.1	(tr)-(sd)
Citharichthys spp.	<0.1	-(sd)
Cyclopsetta panamensis (Steindachner 1876)	<0.1	(tr)-(sd)
Etropus crossotus Jordan & Gilbert 1882	<0.1	(tr)-(sd)
Syacium ovale (Günther 1864)	1.2	(tr)-(sd)
Hippoglossina stomata Eigenmann & Eigenmann 1890	<0.1	(tm)-(sd)
Paralichthys californicus (Ayres 1859)	<0.1	(tm)-(sd)

TABLE 1 (Cont.). – Systematic list of the fish larvae collected in the Gulf of California during 1984-1988 with the percent abundance (%). Faunistic affinity (FA): tropical (tr); subtropical (st); temperate (tm); subarctic (sa); wide distribution in the eastern Pacific (wd). Habitat (Hab): shallow demersal (sd); deep demersal (dd); coastal pelagic (cp); ocean epipelagic (op); mesopelagic (mp); and bathypelagic (bp).

Taxon	%	(FA)-(Hab)
Paralichthys woolmani Jordan & Williams in Gilbert 1897	<0.1	(tr)-(sd)
Xistreurys liolepis Jordan & Gilbert 1880	<0.1	(tm)-(sd)
Paralichthyidae type 1	<0.1	-(sd)
F. Bothidae		
Bothus leopardinus (Günther 1862)	<0.1	(tr)-(sd)
Engyophrys sanctilaurentii Jordan & Bollman 1890	<0.1	(tr)-(sd)
Monolene asaedai Clark 1936	<0.1	(tr)-(sd)
Perissias taeniopterus (Gilbert 1890)	<0.1	(tr)-(sd)
F. Pleuronectidae		
Hypsopsetta guttulata (Girard 1856)	<0.1	(tm)-(sd)
Pleuronichthys verticalis Jordan & Gilbert 1880	<0.1	(tm)-(sd)
S.O Soleoidei		
F. Achiridae		
Achirus mazatlanus (Steindachner 1869)	<0.1	(tr/st)-(sd)
F. Cynoglossidae		
Symphurus atricaudus (Jordan & Gilbert 1880)	<0.1	(tm)-(sd)
Symphurus williamsi (Jordan & Culver 1895)	0.5	(tr)-(sd)
Symphurus spp.	0.2	(tr)-(sd)
O Tetraodontiformes		
F. Balistidae		
Balistidae type 1 (*Balistes polilepis?)*	0.5	(tr/st)-(sd)
F. Tetraodontidae		
Sphoeroides annulatus (Jenyns 1842)	<0.1	(tr/st)-(sd)
Sphoeroides lobatus (Steindachner 1870)	<0.1	(tr/st)-(sd)
Sphoeroides type 1	<0.1	(tr/st)-(sd)
Tetraodontidae type 1	<0.1	-(sd)

according to their specific pigmentation patterns and morphometric characteristics, though some larvae could not be identified to species or to type owing to a lack of information or distinguishing characters, which means that these taxa (genus or family) could include one or more species.

Among the 95 families identified only eight exceeded 1% of the total capture; together these eight represented 88.5 % of the total abundance (Table 2). Twenty species, including mesopelagic, epipelagic and demersal species, represented 90% of the total abundance (Table 3). The principal characteristic of the larval fish community in the Gulf of California was the dominance of mesopelagic forms, primarily of the families Myctophidae, Phosichthyidae and Bathylagidae, which represent-

TABLE 2. – Taxonomic list of families of fish larvae in the Gulf of California during 1984-1987, ranked by their relative abundance (%).

Rank	Taxa	%
1	Myctophidae	45.3
2	Engraulidae	20.1
3	Clupeidae	10.2
4	Phosichthyidae	6.8
5	Bathylagidae	1.7
6	Scombridae	1.7
7	Paralichthyidae	1.5
8	Gobiidae	1.2
9	Albulidae	0.7
10	Carangidae	0.7
11	Cynoglossidae	0.7
12	Gerreidae	0.7
13	Merlucciidae	0.7
14	Eleotridae	0.6
15	Balistidae	0.5
16	Haemulidae	0.4
17	Serranidae	0.4
18	Bregmacerotidae	0.3
19	Ophichthidae	0.3
20	Scorpaenidae	0.3
21	Argentinidae	0.1
22	Bothidae	0.1
23	Congridae	0.1
24	Elopidae	0.1
25	Ophidiidae	0.1
26	Pomacentridae	0.1
27	Synodontidae	0.1
28	Triglidae	0.1
29	Achiridae	<0.1
30	Antennariidae	<0.1
31	Apogonidae	<0.1
32	Atherinidae	<0.1
33	Aulopidae	<0.1
34	Blenniidae	<0.1
35	Bramidae	<0.1
36	Bythitidae	<0.1
37	Carapidae	<0.1
38	Chaetodontidae	<0.1
39	Chiasmodontidae	<0.1
40	Coryphaenidae	<0.1
41	Cyematidae	<0.1
42	Derichthyidae	<0.1
43	Ephippidae	<0.1
44	Exocoetidae	<0.1
45	Fistulariidae	<0.1
46	Gempylidae	<0.1
47	Gigantactinidae	<0.1
48	Gonostomatidae	<0.1
49	Hemiramphidae	<0.1
50	Holocentridae	<0.1
51	Howellidae	<0.1
52	Kyphosidae	<0.1
53	Labridae	<0.1
54	Labrisomidae	<0.1
55	Linophrynidae	<0.1
56	Lophiidae	<0.1
57	Lutjanidae	<0.1
58	Macrouridae	<0.1
59	Malacanthidae	<0.1
60	Melamphaidae	<0.1
61	Melanocetidae	<0.1
62	Melanostomiidae	<0.1
63	Microdesmidae	<0.1
64	Microstomatidae	<0.1
65	Mirapinnidae	<0.1
66	Moridae	<0.1
67	Mugilidae	<0.1
68	Mullidae	<0.1
69	Muraenidae	<0.1
70	Nematistiidae	<0.1
71	Nemichthyidae	<0.1
72	Neoscopelidae	<0.1
73	Nettastomatidae	<0.1
74	Nomeidae	<0.1
75	Notacanthidae	<0.1
76	Ogcocephalidae	<0.1
77	Oneirodidae	<0.1
78	Opistognathidae	<0.1
79	Paralepididae	<0.1
80	Pleuronectidae	<0.1
81	Polynemidae	<0.1
82	Priacanthidae	<0.1
83	Scaridae	<0.1
84	Sciaenidae	<0.1
85	Scopelarchidae	<0.1
86	Serrivomeridae	<0.1
87	Sparidae	<0.1
88	Sphyraenidae	<0.1
89	Stomiidae	<0.1
90	Stromateidae	<0.1
91	Syngnathidae	<0.1
92	Tetraodontidae	<0.1
93	Trachipteridae	<0.1
94	Trichiuridae	<0.1
95	Tripterygiidae	<0.1

TABLE 3. – Total abundance standarized for each oceanographic survey of the most abundant species found in the Gulf of California.

Species/Cruise GOLCA	8404	8504	8606	8407	8608	8709	8611	8711	8412	8802	SPRING	SUMMER	FALL	WINTER	TOTAL	%
Benthosema panamense	5533	403	25999	58243	19105	24514	3071	14887	16518	759	5936	127861	34477	759	169033	34.2
Engraulis mordax	610	3591	9	28			15258	28448	371	38868	4201	37	44077	38868	87184	17.6
Triphoturus mexicanus	1700	295	7304	4241	4269	2452	224	876	13624	151	1995	18266	14724	151	35136	7.1
Vinciguerria lucetia	4785	1072	3561	9347	3719	1754	129	142	8917	125	5856	18382	9187	125	33550	6.8
Opisthonema sp.			2761	8808	1984	13592		27				27145	27		27172	5.5
Sardinops caeruleus	1027	1424	507				4039	887	4008	5895	2451	507	8934	5895	17787	3.6
Diogenichthys laternatus	2964	756	8011	429	960	1094	64	43	2936	96	3720	10493	3043	96	17352	3.5
Engraulidae type 1				10938	75	660	135	11	371			11673	517		12190	2.5
Leuroglossus stilbius	1684	5142	48	9					22	1076	6827	57	22	1076	7981	1.6
Scomber japonicus	2172	2446					316	126	1356	448	4619		1798	448	6864	1.4
Syacium ovale	4		169	3523	774	1664		4	15	2	4	6130	19	2	6156	1.2
Etrumeus teres	1183	2266	723	11		5	32	339	152	459	3449	739	523	459	5171	1.0
Albula sp.				1457	491	1648		4			0	3597	4		3601	0.7
Merluccius productus	368	75								3028	442			3028	3470	0.7
Eucinostomus gracilis			598	2111	106	491						3307			3307	0.7
Lythrypnus dalli	6		286	2602		283		129			6	3171	129		3306	0.7
Gobiidae	35	28	355	1641	524	296	57	6	95	6	63	2817	158	6	3043	0.6
Eleotridae			6	4	29	2653	4	84	46			2692	134		2826	0.6
Symphurus williamsi			200	980	322	1216		6	16			2719	22		2740	0.6
Balistidae type 1		9	3	1529	285	364				8	9	2181		8	2198	0.4
Remain species	1206	1256	6682	14185	5982	8353	505	1270	3548	1889	2462	35202	5324	1889	44876	
TOTALS	23276	18764	57225	120086	38626	61039	23834	47287	51995	52809	42040	276977	123116	52809	494943	

ed almost 54% of the abundance, but the coastal pelagic families Clupeidae, Engraulidae and Scombridae contributed 32% to the total catch (Table 2).

Winter had the fewest species (33) (Table 4), with a high abundance of *Engraulis mordax* and *Sardinops caeruleus* (Table 3). Accordingly, coastal pelagic species were the most abundant component of the ichthyoplankton (63%) (Table 4), as were species with temperate affinity (96%) (Table 5). In contrast, summer had the highest number of species (271), mostly with tropical-subtropical affinity (73%). The number of shallow demersal species was highest during the summer (130), but the most abundant taxa were mesopelagic (mainly *Benthosema panamense*), representing the 65% of the total catch (Table 4). Fall and spring had more tropical/subtropical species (58 and 59%) than temperate species (27 and 28%), however, the abundance of tropical/subtropical species and that of temperate species was nearly similar (≈ 40%). Mesopelagic taxa again were the most abundant group during fall and spring, but their dominance over the next most abundant group (coastal pelagics) was not as pronounced as during winter and summer (Table 4). For example, the mesopelagic *Leuroglossus stilbius* was the most abundant species during spring with 16% of the total catch, and the coastal pelagic *E. mordax* was first during fall with 11%. In contrast, *E. mordax* was the most abundant species during winter with 74% of the total (Table 3).

DISCUSSION

The taxonomic list of fish larvae in the Gulf of California given here is the most extensive yet presented. The 283 taxa identified represent approximately 38% of the 753 species recorded as adults in the Gulf (Castro-Aguirre *et al.,* 1995); however, the list is undoubtedly conservative because at least 32 of the taxa could include more than one species, and the selectivity of the sampling technique did not allow catches of some species from shallow waters (e.g. Haemulidae and Achiridae).

The Gulf of California represents one of the most diverse ecosystems in the Eastern Pacific (Castro-Aguirre *et al.,* 1995) and this diversity is reflected in the collections of fish larvae obtained in this work. In contrast with the 283 taxa identified from the Gulf of California, much more extensive samplings made in the California Current contained only 249 larval fish taxa in 31,214 samples (Moser and Smith,

TABLE 4. – Seasonal larval abundance and number of species by habitat: (cp) coastal pelagic; (op) ocean epipelagic; (mp) mesopelagic; (bp) bathypelagic; (sd) shallow demersal and (dd) deep demersal; (nd) not determined. Numbers in parenthesis are the percentage by season.

Season	Abundance cp	op	mp	bp	sd	dd	nd
spring	14951 (36.0)	215 (0.5)	24997 (60.0)	18 (>0.1)	1061 (2.0)	624 (1.4)	174
summer	49980 (18.0)	2487 (1.0)	177874 (65.0)	97 (>0.1)	41991 (16.0)	265 (>0.1)	4283
fall	56801 (46.2)	72 (0.1)	62695 (51.0)	59 (>0.1)	3044 (2.5)	222 (0.2)	223
winter	33270 (63.0)	53 (0.1)	16371 (31.0)	158 (0.3)	316 (0.6)	2640 (5.0)	0
totals	167439 (34.0)	2862 (0.5)	267811 (55.0)	311 (>0.1)	46501 (9.5)	5336 (1.0)	

Season	No. of species cp	op	mp	bp	sd	dd	nd	totals
spring	15 (22)	3 (4)	14 (21)	2 (3)	28 (41)	6 (9)	6	74
summer	45 (19)	9 (4)	38 (16)	7 (3)	130 (54)	10 (4)	32	271
fall	16 (16)	3 (3)	18 (17)	2 (2)	57 (55)	7 (7)	16	113
winter	8 (24)	2 (6)	6 (18)	1 (3)	13 (40)	3 (9)	0	33
totals	48 (18)	9 (3)	43 (16)	9 (4)	143 (54)	14 (5)	17	283

TABLE 5. – Seasonal larval abundance and number of species by faunal affinity: (Tr-SbTr) tropical/subtropical; (Trans) transitional; (Tm) temperate; (Wd) wide distribution and (nd) not determined. Numbers in parenthesis are the percentage by season.

Season	Abundance Tr-SbTr	Trans	Tm	Wd	nd
spring	16664 (40)	7099 (17)	14411 (35)	3816 (8)	50
summer	224995 (89)	20080 (8)	6137 (2)	1828 (1)	23937
fall	50093 (41)	17353 (14)	53563 (44)	686 (1)	1421
winter	1223 (2)	609 (1)	50328 (96)	469 (1)	180
totals	293000 (62)	45166 (10)	124499 (27)	6465 (1)	

Season	No. of species Tr-SbTr	Trans	Tm	Wd	nd	totals
spring	38 (59)	5 (8)	18 (28)	3 (5)	10	74
summer	134 (73)	13 (7)	27 (15)	9 (5)	88	271
fall	49 (58)	8 (10)	23 (27)	4 (5)	29	113
winter	16 (52)	3 (10)	10 (32)	2 (6)	2	33
totals	143 (70)	15 (7)	37 (18)	10 (5)	78	283

1993). Less exhaustive studies showed the presence of 214 taxa in the northern region of the west coast of Baja California (Jiménez-Rosenberg *et al.*, 2000), and 102 taxa from 132 samples south of the Gulf, in the Jalisco and Colima area (Franco-Gordo *et al.,* 1999). At a higher taxonomic level, Aguilar-Ibarra and Vicencio-Aguilar (1994) report 37 families in the vicinity of the Costa Rica Dome, Ahlstrom (1972) reported 56 families in a larger survey of the Eastern Tropical Pacific, and Moser *et al.* (1974) reported 50 families during 1956-1957 in the Gulf of California compared with 95 found in this work.

Diversity differences at the family level between this study and Moser's could reflect a lack of sampling during summer because we found a large increase in the number of species during this season, but differences in the species composition and abundance were also evident, even within seasons. The most abundant species during 1956-1957 in the Gulf of California were *Vinciguerria lucetia* and *Bregmaceros bathymaster* (Table 6; Moser *et al.,* 1974), and *B. panamense*, *L. stilbius* and Engraulidae were found with the lowest abundances. In contrast, during 1984-1987, *B. panamense* and *E. mordax* were the most abundant species and *B. bathymaster* was ranked 27th, with less than 0.3% of the total catch. Mesopelagic taxa contributed 39% of the total catch in 1956-57 compared with 55% in 1984-87, while for coastal pelagic taxa the values were 22 and 34% respectively.

Engraulis mordax larvae were absent in the Gulf of California during at least 1972 (Moser *et al.*, 1974), but in 1984, two years before the unexpected high commercial fishery catch of northern anchovy in this region, this species was one of the most abundant. The high catch of this species in 1986, accompanied by a dramatic decline in the sardine catch and the analyses of scales in laminar sediments of the

TABLE 6. – Rank and percetage contribution for the 25 most abundant taxa in the Gulf of California during 1956-1957 (Moser *et al.,* 1974).

Rank	Species	%	Rank	Species	%
1	*Vinciguerria lucetia*	21.9	14	Serranidae	1.5
2	*Bregmaceros bathymaster*	19.0	15	Disintegrated	1.5
3	*Opisthonema* spp.	9.2	16	Engraulidae	1.4
4	*Triphoturus mexicanus*	7.5	17	*Etrumeus teres*	1.1
5	*Scomber japonicus*	6.5	18	Scorpaenidae	1.0
6	*Diogenichthys laternatus*	5.1	19	Gerridae	0.8
7	*Sardinops sagax caeruleus*	3.2	20	*Auxis rochei*	0.7
8	*Benthosema panamense*	2.9	21	Carangidae	0.7
9	Unidentified	2.7	22	Gobiidae	0.7
10	*Leuroglossus stilbius*	2.0	23	Pomadasyidae	0.5
11	Trichiuridae	2.0	24	*Synodus* spp.	0.5
12	Bothidae	1.7	25	*Symphurus* spp.	0.4
13	Sciaenidae	1.5		All others	4

Gulf, proved that contrary to the general agreement that the northern anchovy did not occur in the Gulf of California (Ahlstrom, 1967), *E. mordax* as well as mackerel, myctophids and sardine have cycles of several decades of high and low abundance (Holmgren-Urba and Baumgartner, 1993) that are associated with climate change and have strong effects on the ecosystem structure. Similar changes were observed in the abundance of fish larvae in the California Current region during a cool regime from 1950-1975 and a warm regime from 1975-2000 (Moser *et al*., 2001). In the Gulf of California the warm regime apparently began in 1982-1983, as recorded in several physical variables of the sea and the atmosphere (Bernal *et al.*, 2001), but effects on the ichthyoplankton community have not been reported. The presence of *E. mordax* as one of the most abundant fish larvae during spring 1984 and 1985 may reflect this regime change, and the same may be true for the changes in abundance of *B. panamense*, *B. bathymaster* and *L. stilbius*.

Engraulis mordax and *B. panamense,* as well as the increase in the relative proportions of mesopelagic and epipelagic taxa, seem to characterise the warm regime in the Gulf of California. Unfortunately, because most taxa were not identified to species during the cool regime, we cannot address possible changes in faunal affinities except to note that on the basis of the most abundant species, both the cool and warm regime have a strong tropical/subtropical faunal component with seasonal changes in abundance and species composition.

In general, during 1984-1987 the larval fish community of the Gulf of California had a strong tropical component in both species composition and abundance (70 species and 62% of the total larvae), mirroring the faunal affinities of the adults inhabiting the area (Walker, 1960; Thompson *et al.,* 1979; Briggs, 1974; Castro-Aguirre *et al.,* 1995). Seasonal variability, however, shows contrasting changes between a well-developed tropical community during summer, clearly dominated by mesopelagic taxa, and a more temperate community during winter, dominated by coastal pelagic forms, but with lower species richness with transitional periods in spring and fall that nearly have a co-dominance between tropical-subtropical and temperate taxa (but with the mesopelagic as the more abundant group during spring). Another general characteristic of the larval fish community is the species richness of the shallow demersal taxa that represent almost 50% of the total species all year round, which is especially high during summer.

Seasonal changes in species composition and abundance in both faunal and habitat affinities reflect the sharp seasonal climate changes that exist between winter and summer in the Gulf of California. Sea surface temperatures reported between 1983-1996 in the northern Gulf range from 9 to 38ºC between winter and summer, while in the south seasonal variation is less dramatic, ranging from 22 to 31ºC (Soto-Mardones *et al.,* 1999). Seasonal changes in the hydrography of the Gulf provide suitable environments for fishes that allow them to share the Gulf as a reproduction area. Tropical Pacific water, a warm water mass of low salinity (34.65 £ ‰ ≥ 34.85), reaches the southern limit of the Gulf during winter, but during spring it flows north along the east coast (Alvarez-Borrego, 1983), so that by midsummer the whole area has tropical conditions (Rosas-Cota, 1977). This allows the reproduction of tropical-subtropical shallow demersal species, and promotes the dominance of mesopelagic species with epipelagic larval stages from the eastern tropical Pacific that were observed in our summer samples. During autumn, tropical Pacific water starts to recede southward, decreasing the sea surface temperature, and the relict temperate/subarctic fauna starts its reproductive period so that in winter the larvae of temperate species become dominant. Coastal upwelling enhances the nutrient concentration and permits increased primary productivity of the area, which in turn supports the increased number of coastal pelagic species that was observed.

General intra- and inter-annual changes observed in the ichthyoplankton species composition since the first studies in the Gulf of California reflect a close relationship with the environmental changes that occurred. The appearance of larvae of species like *E. mordax*, before adults were recorded in the Gulf of California, as well as the changes in abundance of several species, show that ichthyoplankton studies are useful to make predictions about changes in the fisheries of this semi-enclosed ecosystem and that the analysis of the entire community can give us more information about the changes in the ecosystem. How these changes occur in space and time in the larval fish community is a second task of our future work.

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