

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 *Benthoosema 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 *Benthoosema 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).

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- μ m 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- μ m 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-

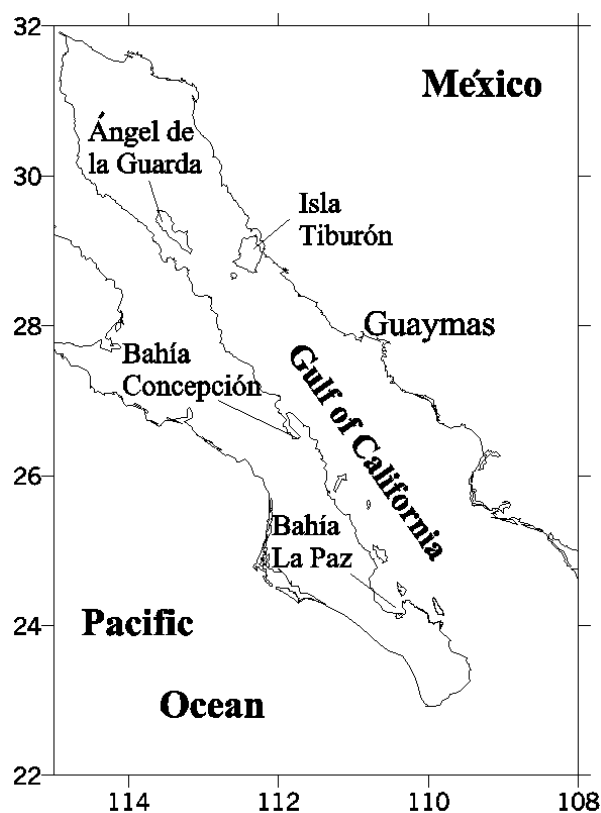


FIG. 1. – Study area.

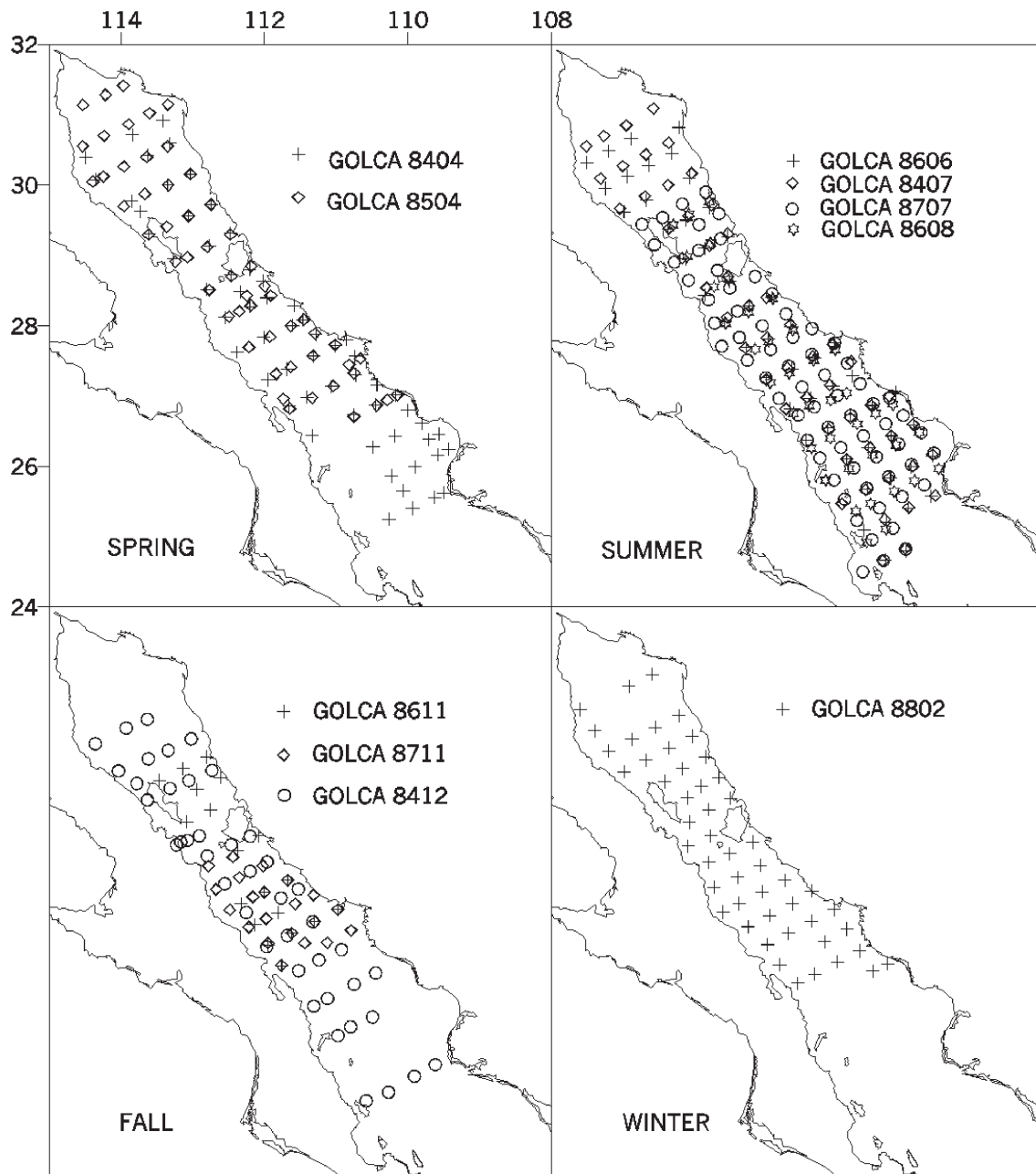


FIG. 2. – Sampling stations.

standardised to 10 m² 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 Decem-

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

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

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

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Taxon	%	(FA)-(Hab)	Taxon	%	(FA)-(Hab)
<i>Paralichthys woolmani</i> Jordan & Williams in Gilbert 1897	<0.1	(tr)-(sd)	<i>Achirus mazatlanus</i> (Steindachner 1869)	<0.1	(tr/st)-(sd)
<i>Xistreurys liolepis</i> Jordan & Gilbert 1880	<0.1	(tm)-(sd)	F. Cynoglossidae		
Paralichthyidae type 1	<0.1	-(sd)	<i>Symphurus atricaudus</i> (Jordan & Gilbert 1880)	<0.1	(tm)-(sd)
F. Bothidae			<i>Symphurus williamsi</i> (Jordan & Culver 1895)	0.5	(tr)-(sd)
<i>Bothus leopardinus</i> (Günther 1862)	<0.1	(tr)-(sd)	<i>Symphurus</i> spp.	0.2	(tr)-(sd)
<i>Engyophrys sanctilaurentii</i> Jordan & Bollman 1890	<0.1	(tr)-(sd)	O Tetraodontiformes		
<i>Monolene asaedai</i> Clark 1936	<0.1	(tr)-(sd)	F. Balistidae		
<i>Perissias taeniopterus</i> (Gilbert 1890)	<0.1	(tr)-(sd)	Balistidae type 1 (<i>Balistes polilepis</i> ?)	0.5	(tr/st)-(sd)
F. Pleuronectidae			F. Tetraodontidae		
<i>Hypsopsetta guttulata</i> (Girard 1856)	<0.1	(tm)-(sd)	<i>Sphoeroides annulatus</i> (Jenyns 1842)	<0.1	(tr/st)-(sd)
<i>Pleuronichthys verticalis</i> Jordan & Gilbert 1880	<0.1	(tm)-(sd)	<i>Sphoeroides lobatus</i> (Steindachner 1870)	<0.1	(tr/st)-(sd)
S.O Soleoidei			<i>Sphoeroides</i> type 1	<0.1	(tr/st)-(sd)
F. Achiridae			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	%	Rank	Taxa	%	Rank	Taxa	%
1	Myctophidae	45.3	33	Aulopidae	<0.1	65	Mirapinnidae	<0.1
2	Engraulidae	20.1	34	Bleenniidae	<0.1	66	Moridae	<0.1
3	Clupeidae	10.2	35	Bramidae	<0.1	67	Mugilidae	<0.1
4	Phosichthyidae	6.8	36	Bythitidae	<0.1	68	Mullidae	<0.1
5	Bathylagidae	1.7	37	Carapidae	<0.1	69	Muraenidae	<0.1
6	Scombridae	1.7	38	Chaetodontidae	<0.1	70	Nematistiidae	<0.1
7	Paralichthyidae	1.5	39	Chiasmodontidae	<0.1	71	Nemichthyidae	<0.1
8	Gobiidae	1.2	40	Coryphaenidae	<0.1	72	Neoscopelidae	<0.1
9	Albulidae	0.7	41	Cyematidae	<0.1	73	Nettastomatidae	<0.1
10	Carangidae	0.7	42	Derichthyidae	<0.1	74	Nomeidae	<0.1
11	Cynoglossidae	0.7	43	Ephippidae	<0.1	75	Notacanthidae	<0.1
12	Gerreidae	0.7	44	Exocoetidae	<0.1	76	Ogcocephalidae	<0.1
13	Merlucciidae	0.7	45	Fistulariidae	<0.1	77	Oneirodidae	<0.1
14	Eleotridae	0.6	46	Gempylidae	<0.1	78	Opistognathidae	<0.1
15	Balistidae	0.5	47	Gigantactinidae	<0.1	79	Paralepididae	<0.1
16	Haemulidae	0.4	48	Gonostomatidae	<0.1	80	Pleuronectidae	<0.1
17	Serranidae	0.4	49	Hemiramphidae	<0.1	81	Polynemidae	<0.1
18	Bregmacerotidae	0.3	50	Holocentridae	<0.1	82	Priacanthidae	<0.1
19	Ophichthidae	0.3	51	Howellidae	<0.1	83	Scaridae	<0.1
20	Scorpaenidae	0.3	52	Kyphosidae	<0.1	84	Sciaenidae	<0.1
21	Argentinidae	0.1	53	Labridae	<0.1	85	Scopelarchidae	<0.1
22	Bothidae	0.1	54	Labrisomidae	<0.1	86	Serrivomeridae	<0.1
23	Congridae	0.1	55	Linophrynidae	<0.1	87	Sparidae	<0.1
24	Elopidae	0.1	56	Lophiidae	<0.1	88	Sphyrnidae	<0.1
25	Ophidiidae	0.1	57	Lutjanidae	<0.1	89	Stomiidae	<0.1
26	Pomacentridae	0.1	58	Macrouridae	<0.1	90	Stromateidae	<0.1
27	Synodontidae	0.1	59	Malacanthidae	<0.1	91	Syngnathidae	<0.1
28	Triglidae	0.1	60	Melamphaidae	<0.1	92	Tetraodontidae	<0.1
29	Achiridae	<0.1	61	Melanocetidae	<0.1	93	Trachipteridae	<0.1
30	Antennariidae	<0.1	62	Melanostomiidae	<0.1	94	Trichiuridae	<0.1
31	Apogonidae	<0.1	63	Microdesmidae	<0.1	95	Tripterygiidae	<0.1
32	Atherinidae	<0.1	64	Microstomatidae	<0.1			

TABLE 3. – Total abundance standardized 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	%
<i>Benthoosema panamense</i>	5533	403	25999	58243	19105	24514	3071	14887	16518	759	5936	127861	34477	759	169033	34.2	
<i>Engraulis mordax</i>	610	3591	9	28	4269	2452	15258	28448	371	38868	4201	37	44077	38868	87184	17.6	
<i>Triphoetus mexicanus</i>	1700	295	7304	4241	3719	1754	224	876	13624	151	1995	18266	14724	151	35136	7.1	
<i>Vinciguerria luceta</i>	4785	1072	3561	9347	3719	1754	129	142	8917	125	5856	18382	9187	125	33550	6.8	
<i>Opishonema</i> sp.	1027	1424	507	8808	1984	13592	4039	887	4008	5895	2451	507	8934	5895	17787	3.6	
<i>Sardinops caeruleus</i>	2964	756	8011	429	960	1094	64	43	2936	96	3720	10493	3043	96	17352	3.5	
<i>Diogenichthys laternatus</i>				10938	75	660	135	11	371			11673	517		12190	2.5	
<i>Engraulidae</i> type 1			48	9							6827	57	22	1076	7981	1.6	
<i>Leuroglossus stilbius</i>	1684	5142					316	126	1356	1076	4619	6130	1798	448	6864	1.4	
<i>Scomber japonicus</i>	2172	2446	169	774	1664	5	32	339	152	459	3449	739	523	2	6156	1.2	
<i>Stacium ovale</i>	4		723									3597	4		3601	0.7	
<i>Etrumeus teres</i>	1183	2266		1457	491	1648		4			442				3470	0.7	
<i>Albula</i> sp.	368	75													3307	0.7	
<i>Merluccius productus</i>			598	2111	106	491						3307			3306	0.7	
<i>Euclinostomus gracilis</i>			286	2602		283		129			6		129		3043	0.6	
<i>Lythrypnus dalli</i>	6	28	355	1641	524	296	57	6	95	6	63	2817	158	6	3043	0.6	
Gobiidae	35		6	4	29	2653	4	84	46			2692	134		2826	0.6	
Eleotridae			200	980	322	1216		6	16			2719	22		2740	0.6	
<i>Symphurus williamsi</i>			3	1529	285	364						2181		8	2198	0.4	
<i>Ballistidae</i> type 1																	
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 *Benthoosema 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 ($\approx 40\%$). 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							nd
	cp	op	mp	bp	sd	dd		
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							totals
	cp	op	mp	bp	sd	dd	nd	
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					nd
	Tr-SbTr	Trans	Tm	Wd		
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					totals
	Tr-SbTr	Trans	Tm	Wd	nd	
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 percentage contribution for the 25 most abundant taxa in the Gulf of California during 1956-1957 (Moser *et al.*, 1974).

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

ing 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 38°C between winter and summer, while in the south seasonal variation is less dramatic, ranging from 22 to 31°C (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 ‰ \geq 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 mid-summer 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 sam-

ples. 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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