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PELAGIC INVERTEBRATE RESOURCES OF THE CALIFORNIA CURRENT

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I have been asked to discuss the pelagic invertebrate resources of the California Current, and this I will try to do, but I wish first of all to make one reservation: it is evident to me that none of these resources will have anything like the same economic importance as our potential pelagic fish resources, and if we cannot decide how to utilize these latter, then I'm not sure we should divert too much attention away from the problems of their utilization onto the problems of less important resources.

There appear to be three main possibilities in exploiting the pelagic invertebrates but I shall discuss only two of these: (i) that of expanding our small fishery for cephalopod molluscs, and (ii) that of starting a fishery for pelagic galatheid crabs, commonly called "red crabs." Discussion of the third possibility —that of utilizing planktonic copepods and euphausiids—I consider only an academic exercise at the moment, and even though mass occurrences of these sorts of animals are frequent in the California Current, I shall leave it to the future for their proper discussion.

Very much of what we know about the economically important cephalopods in the California Current derives from the work of Fields (1965), who studied the squid *(Loligo opalescens)* fishery, principally at Monterey. To see if there was any probability that this fishery could be expanded, it seemed to me appropriate to try to place it in a world-wide perspective; for this purpose I have surveyed summarily the literature, with the results that are set out in Tables 1 through 4.

These show, first of all, that while almost all nations which have any fishery at all catch at least a small amount of cephalopods, it is only Japan for which this forms a significant part of the total catch. It is also evident that cephalopods are more important in certain regions than in others: in the Mediterranean basin and adjoining parts of the Atlantic and in the Far East they are widely eaten; in the North Atlantic, the Scandinavians take significant amounts for use as bait in other fisheries. The migration of Far Eastern and Mediterranean peoples to other parts of the world has stimulated the establishment of cephalopod fisheries in places such as California.

Table 2 indicates some of the major features of the international trade in cephalopods; what is important is that a complicated trade network exists in the Far East, and that catches of Japanese vessels are purchased by some Mediterranean countries.

Table 3 shows that California even now dominates the U.S. catches; the Californian fishery, as Fields showed, originated in the Chinese fishing village in Monterey in about 1860, from which sun-dried squid entered the Far East trade. In about 1900 Italian fishermen introduced the lampara net into the fishery and took it over from the fishermen of Oriental origin. A peak was reached in 1932 with 5,500 tons of dried squid going into the Far East trade, which was closed to the U.S. in 1933. A second buildup occurred after World War II with the introduction of freezing and canning to the trade, but irregular, large-scale fluctuations of the fishery have been characteristic since then.

Table 4 surveys briefly the major squid resources of the world as they presently appear. The bulk of the Japanese landings is formed by *Todarodes pacificus;*

TABLE 1

THE APPROXIMATE WORLD LANDINGS OF CEPHALOPODS IN 1965, DERIVED FROM VARIOUS SOURCES, MAINLY FAO STATISTICS FOR THIS YEAR

Country	1965 catches (Thousand Tons)	
	Squids (*Ommastrephes*, *Loligo*, etc.)	Cuttlefish (*Sepia*, etc.)
Japan	472.5	26.9
Spain	19.1	17.2
Taiwan	8.8	5.4
Norway	8.5	--
United States (Pacific)	8.4	--
Canada (Atlantic)	8.3	--
Italy	6.6	12.6
France	3.9	--
Portugal	2.5	2.6
United States (Atlantic)	1.1	--
Hong Kong	1.0	0.4
Argentina	0.7	--
Peru	0.3	--
Ryukyu Islands	0.3	--
Venezuela	0.3	--
Iceland	0.2	--
Mexico	0.2	--
Yugoslavia	0.2	0.1
Australia	0.1	--
Belgium	0.1	--
Chile	0.1	--
England	0.1	--
Scotland	0.1	--
South Africa	0.1	--
Holland	<0.1	--
Korea	<0.1	--
Malaya	<0.1	1.2
Morocco	<0.1	1.0
St. Pierre	<0.1	--
Uruguay	<0.1	--
Wales	<0.1	--
Total	544.2	67.4
Grand total	----	611.6

TABLE 2
SOME IMPORTANT SECTIONS OF THE WORLD TRADE IN CEPHALOPODS, DERIVED FROM FAO STATISTICS AND FROM CLARKE, 1966

Product and country			Tons of cephalopods in thousands (excluding octopus)
		Dried, etc.	
Hong Kong	→	Malaya	0.7
		Thailand	0.4
		Others	2.3
Japan	→	Taiwan	0.1
		Hong Kong	0.1
		Singapore	0.1
S. Korea	→	Taiwan	1.1
		Hong Kong	0.2
		Japan	4.2
		Singapore	0.5
		Thailand	0.3
		Others	0.5
		Total	10.5
		Fresh, frozen	
Japan	→	Italy	6.9
		Portugal	2.1
		Others	1.3
		Total	10.3
		Total all products	20.8

TABLE 3
THE U.S. ACTIVITIES IN SQUID FISHERIES FOR 1965, BASED MAINLY ON STATISTICS COMPILED BY BUREAU OF COMMERCIAL FISHERIES

	Thousand Pounds
U.S. Landings (by areas)	
New England	840
Middle Atlantic	1,427
Chesapeake	255
South Atlantic	35
Gulf	54
Pacific	18,620
Hawaii	3
U.S. products	
Frozen, natural	5,963
Canned	12,419
U.S. Exports	
Frozen	--
Canned	4,510

the Atlantic counterpart, *T. sagittatus* is utilized largely for bait, and, though enormously abundant, has been said to be of poor flavor. *Illex illecebrosus* supports a large-scale bait fishery to the south of Newfoundland. The two species of *Ommastrephes* listed are extremely abundant in warmer parts of the Atlantic (e.g. at Madeira) and there form an important latent resource. Latent resources in the warmer parts of the eastern Pacific Ocean appear to be dominated by *Dosidicus gigas* which is at times very numerous in the offshore parts of the California Current and was, in fact utilized on one occasion in the 1930's by the California fishery (Clark and Phillips, 1936). This species appears to be the eastern Pacific counterpart, ecologically, of various species of *Ommastrephes* and *Symplectoteuthis*, and appears near the surface at night in oceanic regions, sometimes in vast numbers. The more neritic *Gonatus fabricius* may also form a latent resource in the California Current.

TABLE 3 B
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Ports	No. of vessels	Thousand Pounds		Thousand Dollars
		lampara net	dipnet	
Monterey	14	8.8	0.1	202
Santa Barbara	6	1.9	0.1	18
San Pedro	35	7.4	0.3	86
Total	55	18.7		306

TABLE 4
THE SQUIDS THAT APPEAR MOST LIKELY TO BE OF COMMERCIAL IMPORTANCE IN THE WORLD FISHERIES, BASED VERY LARGELY ON DATA FROM CLARKE, 1966

Species	Range	Fishery
Todarodes pacificus	N. W. Pacific	Bulk of Japanese landings from N. Pacific.
T. sagittatus	Atlantic	Lightly utilized, largely for bait but some for human food.
Ommastrephes caroli and *O. pteropus*	Sub-tropical Atlantic	Some fished at Atlantic islands; latent oceanic fishery.
Illex illecebrosus	Atlantic	Bait fishery on Grand Banks and elsewhere.
Nototodarus gouldi	S. W. Pacific	Increasing but low utilization in Australia (Mediterranean immigrants).
Symplectoteuthis spp.	W. Indo-Pacific	Latent oceanic resource.
Dosidicus gigas	E. Pacific	Latent oceanic resource.
Loligo opalescens	California	Lightly utilized in coastal fishery.
Gonatus fabricius	California	Latent neritic resource.

It is also quite evident that the population of *Loligo opalescens* could be fished to a far greater extent than it is at present; few of the many known regular spawning concentrations are utilized. If entry into new markets, or expansion of present markets, could be achieved, there is no doubt whatever that the latent resources of the California Current could be harvested at a much higher level of yield.

In general, cephalopod fisheries are prosecuted either by some form of multi-hook jig (hand or machine operated) or by various forms of round-haul nets; in both methods, night fishing, with concentration of squids by light, is normal. Such methods are well known and easily used by the California fishing community.

Let us turn now to the red or pelagic crabs, *Pleuroncodes planipes* of the California Current, where we are on less firm ground concerning the utility of the resources.

About five species of galatheids occur in massive concentrations, either as pelagic or benthic individuals, and one of these is our *Pleuroncodes planipes*. These forms are all typical of eutrophic regions of the ocean, where they often occur under conditions of very low dissolved oxygen. They are able to graze directly on blooms of phytoplankton, mainly large diatoms, and wherever they occur they figure largely in the diet of a wide range of large predators, from sea-birds to whales.

Off Chile, two of these species are harvested as an auxiliary catch by the shrimp boats when shrimp are not available; these species are *Pleuroncodes monodon* and *Cervimunida johni*, together known to the Chilean trade as "langostino." Starting in 1953 the langostino fishery has developed to its present level of landings in excess of 12 thousand tons per annum (Table 5).

TABLE 5

THE DEVELOPMENT OF THE CHILEAN LANGOSTINO FISHERY, BASED ON DATA SUPPLIED BY FAO, ROME (DONALD A. HANCOCK AND M. N. MISTAKIDIS, PERSONAL COMMUNICATION)

Year	Thousand Tons			
	Total catch	Consumed fresh	Canned	Frozen tails
1953	0.93	0.29	0.59	0.47
1954	2.64	0.85	1.20	0.58
1955	2.05	0.78	1.10	--
1956	5.71	1.61	3.57	--
1957	11.38	4.27	0.73	5.82
1958	12.83	5.37	0.22	6.33
1959	6.75	0.93	0.80	5.02
1960	8.12	1.22	0.83	6.02
1961	8.15	0.62	0.65	6.89
1962	7.99	0.36	0.94	6.69
1963	9.25	0.20	0.94	7.91
1964	10.67	0.68	0.94	9.03
1965	15.35	0.44	1.02	13.31
1966	13.37	0.39	0.78	12.18

What is striking about this fishery is that the crabs on which it is based are quite small, averaging a carapace length of 0.79–1.57 inches (20–40 mm) and a total net weight of 0.88 ounces (25 grams). The meat yield for tails is less than 10 percent. One wonders how such a fishery can be economic, but it evidently is, perhaps due to rather low labor costs.

Our California *Pleuroncodes planipes* differs from those species exploited off Chile in having both a benthic and pelagic phase instead of merely a benthic phase, and occurs in both phases in massive numbers. It has been shown (Longhurst, 1967) that the pelagic concentrations occur close to upwelling sites, and that their distribution is very sensitive to climatic variations and mass transport variations in the California Current.

The mean density of pelagic crabs in the southern part of the CalCOFI area in a normal year has been measured by Maurice Blackburn (personal communication) from a series of 5-foot net tows taken at standard CalCOFI stations. Extrapolated to a floating otter trawl with 326 ft^2 (30-m^2) mouth (a reasonable size for a small vessel) fished entirely randomly in this area, we get an estimate of about 0.25 ton per hour. Anybody who has observed *Pleuroncodes* swarms at sea knows how massive these are relative to the "background" densities of the animal, and it is obvious that selective fishing would raise this estimate by a factor of at least 10.

Pelagic *Pleuroncodes* are smaller than the langostinos exploited in Chile, so it is probable that a fishery would concentrate on the benthic phase, whose individuals are larger and are equivalent to those taken in the Chilean fishery. These benthic individuals occur in massive concentrations, mainly under upwelling areas and at depths corresponding to the depth of the oxygen minimum (Boyd, 1967).

The small amount of information which we have at hand suggests extremely high catch rates of the order of more than 25 tons per hour with a 10-m headrope (32.8 ft) demersal otter trawl. In fact, during a trawling survey for rockfish carried out a few years ago by the Bureau of Commercial Fisheries, it was found to be impracticable to trawl for fish at depths which benthic *Pleuroncodes* favored, because the net filled so rapidly and was torn by the weight of crabs (Herbert Perkins, personal communication). This supposition is also confirmed by the very recent reports from the Soviet factory trawlers, which took 5,000 tons of *Pleuroncodes* in an experimental fishery in 1967 off Baja California. It is presumed that these were reduced but we do not know for certain.

It appears quite evident, then, that there is a very large latent resource present, but it is much less clear what use can be made of it. If a satisfactory meal can be manufactured—perhaps of a specialty type, as for instance, an additive to trout food to give desirable flesh coloration and flavor—then it is probable that a fishery of local importance could be developed.

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