R: Crustacean Resources

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This section originated in the discussions of the *ad hoc* Working Party on the FAO Indicative World Plan (IWP), Survey of Crustacean Resources, which convened at the FAO World Scientific Conference on the Biology and Culture of Shrimps and Prawns in Mexico City between 12 and 24 June 1967. This Working Party consisted of the following participants, together with observers:

Appolonio, S.	Kutkuhn, J. H.
Boschi, E. E.	Lindner, M. J.
Broadhead, G.	Longhurst, A.R. (Convener)
Butler, T. H.	López, M. T.
Cadima, E. L.	Massuti, M.
Chapa-Saldaña, R.	Obarrio, J. L.
Chittleborough, R. G.	Rasmussen, B.
Ellis, R. W.	Simpson, A. C.
Gneri, F.	Simpson, J. G.
Hall, D. N. F.	Squires, H. J.
Hancock, D. A.	Slack-Smith, R. J.
Holthuis, L. G.	Tiews, K. F. W.
Ivanov, B.	Weber, D.
Johnson, D. S.	Williams, A. B.

The task of the Working Party was to review the first draft of the crustacean document which had been prepared by John Gulland (FAO Rome) and to accomplish this the Working Party decided to appoint a number of people as Regional Reporters with the responsibility of contacting individuals and organizations within their geographic area in order to obtain current data on the status of stocks of prawns and shrimps on a world-wide basis.

The Regional Reporters were as follows:

I	Northwest Atlantic—Squires, Appolonio
II	Northeast Atlantic—Simpson, A.C.
III	Mediterranean—Massuti
IV(a)	Northwest Pacific—Ivanov
IV(b)	Northeast Pacific—Butler
V	Western Central Atlantic—Lindner
VI	Eastern Central Atlantic—Longhurst
VII	Western Indian Ocean—Hall
VIII	Eastern Indian Ocean—Hall
IX	Western Central Pacific—Johnson
X	Eastern Central Pacific—Ellis
XI	Southwest Atlantic—Boschi
XII	Southeast Atlantic—Longhurst
XIII	Southwest Pacific—(vacant)
XIV	Southeast Pacific—Hancock

The Regional Reports were all received by the Convener by the end of 1968, and were then consolidated into a reasonably uniform style of presentation to form the basis of the present draft. Only in exceptional cases, and especially with regard to crustacean resources other than shrimps and prawns, was reference made to material other than the reports submitted by the Regional Reporters; the present draft is not intended to be a review of the literature on the subjects covered, and is only as complete as the material submitted by the Regional Reporters. It was originally intended that the survey of crustacean resources should include data on three levels, namely: *present fisheries*; *potential fisheries*, e.g. those areas in which the presence of resources in good quantities is known by exploratory fishing; and *hypothetical fisheries*, e.g. areas in which the depths, type of bottom or other data suggested the existence of quantities of crustacean resources but which have not been confirmed by actual surveys. However, it was evident from the data included in the Regional Reports that this was not a valid division of the material and it was decided to present information at only two levels: that concerning *present fisheries production*, and that concerning the *potential for increased production* in the future; it is necessary here to define the manner in which two terms are used in this paper: *production* may be a rate or an amount and is intended to refer to the catches from a stock of crustacea, and *potential* is intended to refer to the production that may be expected from a stock in the foreseeable future, using fishing techniques which are expected to be available within this period.

An interesting discussion of the whole problem of estimating potential production from present-day data, and in particular from data derived from resource surveys, was received from M. J. Lindner, the Reporter for Region V. His points should be borne in mind when reading the estimates of potential contained in this paper, and it is useful to quote them *in extenso* here.

"At this point it may be useful to discuss methods for estimating potential harvest from areas about which we have limited information. Starting first with an area that has not been fished we might make guesses based on the range of a species or on the size of trawlable fishing grounds. Projections of the fishable magnitude of the stocks of shrimps based on these two methods are subject to such wide error that they are of little or no use. More knowledge than we now have is required to obtain any meaningful projection by these methods. It has been well established that shrimps do not distribute themselves uniformly over vast areas but concentrate in certain localized areas where presumably the temperature, substrata, and food are suitable.

"A slightly different situation would prevail if we also had information from exploratory fishing in an area; however, we would still not be in a position to make reliable estimates of potential harvests. Stock estimates of shrimp calculated from exploratory fishing *per se* approximate only the standing crop or, in other words, only the weight present at any one time. An estimate of the standing crop, consequently, may be highly deceiving if we attempt to use it to estimate the fishable magnitude

of the stock, which means the total weight that can be produced from the stock during time intervals such as a year. We are primarily interested in the fishable magnitude of the stock rather than in the standing crop. We need to know how many tons we can harvest safely each year from the stocks. Obviously, we need more information than that provided by exploratory fishing if we desire good estimates of fishable stocks. This additional information may be ecological, involving knowledge of the life history of the feeding and nursery areas of species; it may be based on a comparison of the catch rates or landing data of the same or similar species with those in another area where intensive fishing is in progress; or, it may include the rates of growth, mortality, and recruitment.

"Precise measures of stock production must be based on growth, mortality and recruitment rates. These rates however are difficult to get and, indeed, may be impossible to obtain even though the species is heavily fished. The first two approaches, that is, using ecological data or catch data usually do not require the sophisticated methods involved in arriving at rates and frequently a combination of them can give fairly reliable estimates. It seems therefore that we need to start accumulating data on the first two subjects before we can project more accurately than now the fishable magnitude of shrimp stocks in areas that are not heavily fished."

For the reasons outlined above, and from the inconsistent nature of the data available, the estimates of potential production which are contained in this draft cannot be called other than educated guesses; this has been emphasized throughout, and wherever possible a conservative outlook has been taken with regard to estimates of potential production.

The bibliography which concludes this paper has been condensed from the regional bibliographies supplied by the Regional Reporters; it was felt by the Working Party in Mexico City that the value of this document would be greatly increased by the inclusion of comprehensive regional bibliographies, and an attempt has been made to do this for at least some regions.

An attempt has been made to standardize the use of scientific names throughout this draft, but it is certain that some taxonomic confusion is included, especially the reference to a single species by several names, and this was perhaps inevitable from the nature of the material on which the paper is based.

Crustacea are ubiquitous in their occurrence in the sea; they occur in the deepest abyssal benthic communities, in the plankton at all latitudes and all depths of the ocean, and in coastal waters, estuaries and lagoons. Apart from the unicellular animals, marine crustacea are probably, as a group, the most numerous animals on the planet, and they may constitute, as a group, the greatest animal biomass. The following approximate calculations, while not in any sense intended to indicate seriously the production of crustacea of all sorts which might be attained at some time in the future, serve to indicate the magnitude of the crustacean biomass in the oceans. If one considers only the planktonic crustacea, dominated by copepods, sergestids and euphausiids, and if one considers only the plankton of the upper 100 m of the ocean, it is probably near the truth that 100 g of plankton occurs on the average beneath each 10 m^2 of the sea surface. Extrapolating, this gives us 10 tons beneath each km^2 or 3.6×10^9 tons in the upper hundred metres of all the oceans, at any one time. Again, making some slightly dubious assumptions, one may take a value of 80% of this total plankton biomass as being composed of crustacea, and one may conservatively estimate that 50% of the total standing crop at any one time could in theory, be removed by man from the stock over a period of 1 year, providing that natural mortality by other organisms was somewhat under man's control. This gives a potential production of 1.4×10^9 tons annually, or about 30 times greater than the present production of all forms of animal material by the world's fisheries.

The purpose of this estimate is rather to indicate to what extent the presently exploitable crustacean resources are an extremely small part of the total crustacean biomass in the oceans. According to FAO fishery statistics the total world production of crustaceans in 1965 was approximately 1.2×10^6 tons, a figure approximately 1,000 times smaller than the estimate given above.

For the purpose of the present document we are ignoring all crustacean resources which are not likely to be exploited or exploitable within the next decade to any significant extent; because of the extremely tenuous nature of any arguments upon which potential estimates of the euphausiid populations of the ocean must be based, these are not included in the present consideration, even though serious study directed towards the exploitation of one species, *Euphausia superba*, has been begun in the Antarctic Ocean by the Soviet Union. It is felt at this juncture that the data on the potential from this type of resource are completely inadequate to estimate potential production, and euphausiids and similar stocks are not referred to in the body of this draft. (See also Section O, Antarctic).

The biological nature of the crustacean resources which are currently exploited in the ocean is very diverse both as to ecology, and perhaps more important (from a fisheries management point of view) with regard to such biological parameters as rates of growth, mortality and fecundity. Although many of the important crustacean resources occur in warm water, have extremely rapid growth rates, and are virtually annual species, some other important resources, especially those of high latitudes or of deep water, are extremely slow growing and have slow rates of recruitment to the fisheries. The management problems of these two different types of resource are, of course, very different, and too much extrapolation from one type of crustacean resource to all types of resources is to be avoided.

Crustacean resources are also extremely different in the amount of usable meat which is yielded by the processing of various forms; the yield may vary from as low as 8 to 10% in the case of the Chilean langostino to as high as 60 to 70% in some of the fisheries for large penaeid prawns. The figures used in the tabulated data in this text all refer to whole live weight, and to each species should be applied a factor, unknown in most cases, which would translate these into data referring to the usable meat yield.

The crustacean resources discussed in the following text may be categorized as follows: (1) lobsters, spiny

lobsters, and similar forms—*Homarus*, *Nephrops*, *Palinurus*, *Panulirus* and *Jasus*; (2) crabs of a number of different forms, king crabs (*Paralithodes*), Tanner crabs (*Chionoecetes*), edible or market crabs (*Cancer*), portunid swimming crabs (*Callinectes*), and galatheid crabs (*Pleuroncodes*), etc; and (3) prawns and shrimps, including the high latitude and deep-water pandalids (*Pandalus*), the low latitude penaeid prawns (*Penaeus*), the caridean shrimps (*Palaemon* and *Macrobrachium*), finally the deep-water penaeid prawns of low latitudes.

Lobsters and Spiny Lobsters

The true lobsters of the genus *Homarus* occur on rocky coasts on both sides of the North Atlantic; they are rather slow growing, the females reaching first maturity at 5–8 years (depending on latitude) and the individuals remaining in the fishery for 12 years or more, and occasionally surviving to 25 or 30 years old. The adult females have a 2-year moulting cycle, alternating with spawning years, so that spawning and moulting occur in alternate years. The females carry the fertilized eggs for from 10–11 months before releasing the larvae into the plankton, for the relatively short planktonic life of 4 or 5 larval stages. Evidently, this is a relatively slowly renewing source and in common with all fishery resources in which the individuals which are relatively long lived the fishery is not very productive in the sense that only a small proportion of the total standing crop or biomass may be removed annually on a sustainable basis. Probably for this reason, the lobster stocks are generally approaching an overfishing situation.

The Norway lobsters *Nephrops* spp. are much smaller organisms which occur on rather deep muddy bottoms in many parts of the world, having been recorded in the North Atlantic, the Indian Ocean and the Northeast Pacific. There are very few biological data on this genus, and as a whole the fishery exploits the stocks only rather lightly.

The spiny lobsters or rock lobsters of the genera *Palinurus*, *Panulirus* and *Jasus* occur in rather lower latitudes than *Homarus* and species of these genera are ubiquitous in occurrence on hard substrates throughout the warmer parts of the ocean, forming in the tropics a very characteristic component of the reef fauna, though *Palinurus* appears to be a component especially of rather soft deposits compared with *Panulirus* and *Jasus*. Despite this wide distribution, commercial concentrations occur relatively sparsely. Growth rates probably vary widely from species to species, and at least in the tropical oceans members of these genera are probably much faster growing than are the high latitude lobsters of the North Atlantic. Females carry their fertilized eggs and remain in berry for less than two months after the spawning season. The eggs hatch in the spring in latitudes in which the winter has ecological significance, and characteristically pass through a rather large number of planktonic stages. This planktonic phase may occupy periods of almost a year in some species, and this fact is probably of considerable importance when the aquiculture of these genera is being considered, and it may well prove more difficult to rear them commercially, than species of the genus *Homarus*.

Crabs, King Crabs, etc.

The edible crab, *Cancer pagurus*, of northern Europe has a biology which is probably typical of generalized crabs which are important in fisheries the world over. In this species, first maturity occurs at a carapace width of about 13 cm, or an age of 4–5 years, and subsequently the females spawn in alternate years. The species performs rather well marked seasonal migrations, occurring inshore during the summer and offshore in deeper water during the winter; during the inshore phase in June to July the eggs carried by the females hatch and the larvae enter the inshore plankton. In the atuumn the crabs moult and the large females move offshore where in deep water in December and January spawning occurs, the eggs being carried by the female from then on through an inshore migration in the early spring, in April and May, to be hatched again in shallow water the following year.

The king crab, *Paralithodes camtschatica*, of the North Pacific is a large anomuran crab (of spider crab form) occurring in water to 250 m deep, $-1°$ to 12°C. It is of rather slow growth, females maturing at a carapace length of 90 mm or at an age of 5–6 years. They spawn in the spring and carry eggs until the following spring when the larvae hatch into four planktonic stages in the months of March to June. The females spawn in shallow water and then return into deeper water, and the pelagic phase has a duration of about two months after which they descend into the benthic community. Female crabs molt annually after the eggs hatch, and just prior to mating. Males molt less frequently as they grow older, only once every three years for big crabs. King crabs live up to 15 years or more. Again, as in the case of the North Atlantic lobster, this is a resource which has rather a slow rate of renewal.

The brachyuran Tanner crab, Chionoecetes spp., which although it is only rather distantly related to the king crab has somewhat similar appearance, also has a somewhat similar ecology; the females mature at a carapace length of 8 cm at a rather advanced age carrying their eggs for 5–7 months and having a relatively short larval period.

The portunid swimming crabs, characterized by the blue crabs of tropical seas (*Callinectes*) are much more rapidly growing species than those discussed above and although their biology is rather poorly known it is probable that most of the low latitude species are essentially annual, and similar to the tropical prawns discussed below.

Prawns and Shrimps

The prawn resources of high latitudes in both the Pacific and Atlantic Ocean are dominated by pandalids of which the biology of *Pandalus jordani* in the Northeast Pacific Ocean is typical. This species is a protandric hermaphrodite in which sex reversal regularly occurs. The larvae are pelagic and occur in the coastal plankton, not entering estuaries or lagoons preferentially. At 2–3 years old the juveniles mature into male individuals and in the third or fourth year of life these individuals change into females. There is rather low fecundity from 1.0 to 4.0 $\times$ 10^3 eggs per female, which bears one brood of

eggs per year at which time a high female mortality occurs. The females carry their eggs over the winter for a 5-month period, and release them into their 3-month pelagic stages in the early spring. The adults die after 2–4 years of life, although in lower latitudes the fishery may include only 2–3 year olds.

Pandalus borealis occurs in the entire boreal and has a very similar biology to *Pandalus jordani*, but the first male maturity occurs only in the second and third year of life and the females are 4–5 years old. A small percentage of females mature directly at 1.5 years old. *Pandalus montagui* of the Northeast Atlantic has a rather similar biology and it is certain that most of these pandalids have a relatively high longevity when compared with the shrimp resources of the shallow water and low latitudes. The pandalid resources of high latitudes appear to exhibit submergence towards low latitudes, and throughout the tropics wherever prawn surveys have been carried out on the upper part of the continental slope pandalid resources, more or less abundant, have been found together with a number of deep-living penaeids. The biology of these deep-living pandalids and penaeids is apparently completely unknown.

A number of crangonid shrimps occur in all latitudes and the European shrimp, *Crangon crangon*, may be taken as a rather typical example, although the lower latitude species of *Palaemon* and related forms presumably have rather more rapid growth rates and are certainly, in general, annual species. Pelagic larvae of *Crangon crangon* occur in the plankton from December through August and the adult individuals, unlike the pandalids, are heterosexual although one worker has suggested the occurrence of hermaphroditism in this species. Maturity occurs in the first or second year of life and three broods per year per female appear to be normal. The eggs are carried by the females during the spring to summer months for short periods of 3–4 weeks after which they hatch. Males appear mostly not to survive beyond their second year of life and females beyond their third year.

The resources of penaeid shrimps which occur on continental shelves in low latitudes are heterosexual and the females do not carry the eggs, but these are released into the water as soon as fertilized. The most significant ecological difference between the various species is whether or not the pelagic larvae and post-larvae remain in the coastal, continental shelf plankton or whether they preferentially enter brackish water in estuaries and lagoons, there to pass their juvenile period. Typically, as with *Penaeus duorarum* of the tropical Atlantic, and *Penaeus monodon* and *Penaeus indicus* of the Indo-Pacific, the females have rather long spawning periods throughout the year during which one or more peaks of spawning occur; the number of individual spawnings per female during the course of the season is not known in most cases. Fertilized eggs and early larvae can be found of all these species in the neritic plankton, but the early larvae very rapidly concentrate around lagoons and estuaries and enter on the floodtide. The larvae are at first transparent, and pelagic in the lagoons, but very early settle on the vegetation in shallow water and progressively, as they grow, move into deeper water within the lagoon. Mostly, the larval and juvenile forms spend less than one year in their brackish water environment, at the end of which period they return to the continental shelf where spawning occurs. There are indications in a number of species with this kind of ecology that the life span is only 12–14 months and that the adults die rather soon after returning to the continental shelf and spawning. In this case the large biomass of adults and near adults which are exploited on the continental shelves in the great shrimp fisheries of the world must consist of an ephemeral stock with a very rapid turnover, new individuals being consistently recruited from the nearby estuaries and lagoons.

However, a number of species do not have this ecology; such species occur in regions, such as the Persian Gulf, in which there is little possibility (because of the nature of the geography of the region) for the larvae to enter brackish lagoons, or they may occur alongside species whose larvae regularly and preferentially enter brackish water. Examples of the first kind of species are those which occur, as suggested above, in the northwest part of the Indian Ocean, in the Red Sea, the Persian Gulf and the northern part of the Arabian Sea, where coastal lagoons and other brackish water environments are extremely limited or absent. Examples of the second sort, in which larvae do not enter estuaries even though these are available for entry are *Parapeneopsis atlantica*, and *Xiphopenaeus kroyeri* of the eastern and western tropical Atlantic respectively, and also *Penaeus latisulcatus* and *Penaeus esculentus* in northern Australia (Frank Alverson, personal communication). In the Gulf of Guinea *Parapeneopsis atlantica* is one of the most abundant inshore species of penaeid, occurring most abundantly on shallow muddy deposits off the mouths of estuaries and lagoons but, unlike is neighbour *Penaeus duorarum* which occurs on similar deposits, its larvae and juveniles are never found in the neighbouring lagoons and estuaries.

REGIONAL ASSESSMENTS

Region I—Northwest Atlantic

This region includes the west coast of Greenland and the Davis Strait, the eastern coast of Canada, and the coast of New England in the USA. Crustacean resources are rather poor in species, and the whole region, with the exception of the southern coast of New England, is influenced by the cold current which passes southwards along the coast of north-eastern North America.

A. *Lobster resources*

This is one of the two centres of production of the Atlantic lobster *Homarus*, which is here represented by *H. americanus*. Landings of this species have varied little in recent years, from an annual rate of about 32.0×10^3 tons:

Country	*1961*	*1962*	*1963*	*1964*	*1965*
USA	11.8	12.8	13.2	13.3	13.3
Canada	21.6	21.1	20.0	19.0	18.4

A slight decrease which can be detected since 1962 does not appear to be attributable to any decline in

fishing effort and, combined with evidence for a continuing change in population structure (at least off New England) towards a predominance of young individuals, suggests that the stocks are capable of no significantly increased production; indeed, the evidence indicates that only by proper management will the present level be sustained. The consumer demand for this species is extremely high, and with prices rising very significantly industrial tendencies will be towards increasing effort.

In recent years, this species is being taken increasingly towards the south and in recent years has been trawled in deep water as far south as North Carolina (Frank Alverson, personal communication), in Region V, probably in response to a climatic change in the marine environment. What effect this may have in the future is not predictable.

B. *Crab resources*

A trace of blue crab (*Callinectes* spp.) occurs in the landings in the most southerly parts of the region, but the major crab resources is that of *Cancer irroratus*, the rock crab. In 1966, the US landings of this species amounted to 2.2×10^3 tons. This crab occurs in considerable numbers along the eastern coast of Canada as far north as the Strait of Belle Isle (Squires 1966). There are also indications (Wilder 1966), that this species occurs also in deep water off eastern Canada, together with a spider crab (*Chinoecetes*) related to the Tanner crab of the Gulf of Alaska. It would seem altogether possible that a fishery to the extent of 10.0×10^3 tons might develop on all these species combined in this region.

C. *Prawn resources*

The prawns of this region are mostly cold-water pandalids, often occurring in deep water, together with some shallow water palaemonids.

Stocks of *Pandalus montagui*, *Spirontocaris spinus* and *S. lilljeborgii* are known to occur, but their potential is not known, and they are only exploited incidentally to the fishery for *Pandalus borealis*, which is the principal product of the prawn fisheries in the Northwest Atlantic.

While the fishery for *P. borealis* is concentrated mainly off Greenland, in very recent years a start has been made in Canada, where in the Bay of Funday 0.3×10^3 tons were taken in 1967. Resource surveys have proved shrimping grounds, at rates of from 100–800 lb per hour, to the southwest of Newfoundland and in the Gulf of St. Lawrence (Squires 1961). Although no estimates have been made, it is reasonable to assume a total potential in this rather large area of about 5.0×10^3 tons eventually.

The potential appears to be about the same off New England, where a minor fishery has existed for decades, but has been subject to remarkable stock fluctuation and therefore in availability to the fishery. The high catches in years of abundance do not properly reflect the relative stock abundance vis-à-vis poor years; when a very strong year-class is recruited to the fishery the market and processing facilities become glutted, and the catch is thus limited.

Year	*Massachusetts (tons)*	*Gulf of Maine (tons × 10⁴)*
1960	<1.0	—
1961	<1.0	—
1962	16.4	0.1
1963	10.5	0.2
1964	3.1	0.4
1965	8.1	0.9
1966	—	1.7
1967	—	3.0

It seems rather likely that this fishery will in the near future reach a production of 5.0×10^3 tons.

Off Greenland, the fishery for *Pandalus borealis* has built up very rapidly in recent years, most of this production coming from Disko Bay and other inshore West Greenland waters to the south. The landings from the Greenland fishery in recent years have been as follows:

1950—0.2	1964—3.7
1960—1.8	1965—5.0
1961—2.5	1966—5.4
1962—3.3	1967—5.6

Rasmussen suggests that a production of 7.0 to 8.0×10^3 will be realized in another decade; the potential of 6.0×10^3 tons guessed by Ivanov in 1964 had almost been attained by 1967; and Smidt suggests a potential of 12.0×10^3 tons, and perhaps more if offshore grounds in the Davis Strait are exploited by big vessels.

D. *Total Regional potential*

The following tabulation of the estimates suggested above indicates that the total potential of the region may increase by approximately a third in the foreseeable future, reaching a total of 69.0×10^3 tons.

	Present	*Potential*
Homarus americanus	31.7	32.0
Cancer irroratus (and others)	2.2	10.0
Pandalus borealis		
United States	3.0	5.0
Canada	0.3	5.0
Greenland	5.3	12.0
Pandalus montagui	—	5.0
Total	42.5	69.0 (tons × 10^3)

Region II—Northeast Atlantic

The crustacean production in this region is more diverse than in the Northwest Atlantic, to some extent because this region contains a greater degree of ecological diversity, due to the effect of the Gulf Stream on the European coast at high latitudes, but also perhaps due to the longer development of the fisheries in this region in historical terms, because of greater human pressures.

The 1965 catch was partitioned among 12 species, as tabulated on p. 211.

A. *Lobster resources*

(i) Common lobster (*Homarus gammarus*)

Lobsters occur from northern Norway to the Bay of Biscay, and are found on most coastal and near-coastal rocky grounds. Nearly all are national fisheries and over

Lobsters	
Homarus gammarus	2.3
Palinurus elephas	1.4
Nephrops norvegicus	25.5
Crabs	
Cancer pagurus	7.9
Carcinus maenas	0.7
Portunidae spp.	0.4
Maja squinado	4.7
Prawns	
Pandalus borealis	19.9
Pandalus montagui	0.1
Crangon crangon	45.8
Palaemon serratus	1.8
Parapenaeus longirostris	7.4
Total	117.9 (tons $\times$ 10^3)

90% of the yield is believed to be caught within 3 miles of the coast.

Present catch is small, about 2.0×10^3 tons, though the value is high. While most stocks are heavily fished there would appear to be scope for 50–70% increases in catches in Norway, United Kingdom and Eire by increased fishing in certain areas, including in deeper water, and better management in others (Thomas 1965). It is considered that there is little prospect of increased yields from Sweden, Germany, Holland or France.

Denmark used to produce over 150 tons per annum, in many years between 1930 and 1950, and it would seem possible that these levels could be achieved again by increased fishing.

The landings of this species, by country, in 1966 are tabulated below, together with an estimate of the resource potential.

Country	*1966 landings*	*Estimated maximum sustainable yield*
Norway	0.3	0.8
Sweden	0.1	0.2
Denmark	0.03	0.2
Germany	0.0	0.0
Holland	0.0	0.0
Belgium	0.0	0.0
Scotland	0.6	1.0
England and Wales	0.4	0.6
Eire	0.3	0.5
France	0.4	0.4
Spain	0.0	0.0
Portugal	0.0	0.0
Total	2.1	3.7 (tons $\times$ 10^3)

(ii) Spiny lobster (*Palinurus elephas*)

Palinurus elephas is a southern species extending north to Eire, southwest England and the Channel Islands. It lives in very rocky areas with strong tides and occurs from about 10–200 m. It is caught in baited traps, and just recently by full-time SCUBA divers off southwest England.

Country	*1965 catch*
Eire	0.2
England	0.1
France	0.7
Spain	0.4
Portugal	0.0
Total	1.4 (tons $\times$ 10^3)

There is very little information on the population dynamics of the species. Recent work in England and Ireland suggests that the populations there are recruited from further south (pelagic larvae? juvenile migration?) as animals below 2 lb weight are rarely seen, even by divers, and there are substantial long term variations in their abundances. Catches in Eire were of the order of 400 tons annually in the 1950s and 1960s and it is probable that 500 tons is nearer the average long term yield than the present 200 tons. The stock around southwest England is lightly exploited and could probably yield an average of at least 200 tons annually with increased effort. The potential of the French and Spanish grounds is not known but is likely to be somewhat above the present yields. The sustainable yield for the whole area is likely to exceed 2.0×10^3 tons.

(iii) Norway lobster (*Nephrops norvegicus*)

Nephrops norvegicus occurs in many areas from Iceland to the Mediterranean where the bottom sediments are a fine mud. Such grounds are typically in water over 120 m but in sheltered areas such as fjords, and where tidal currents are small (Irish Sea), *Nephrops* occur in depths as shallow as 20 m.

A number of new northern grounds have been exploited since 1939 with a steady increase in landings; 10.0×10^3 tons being landed in 1948 and 30.0×10^3 tons in 1964. It would seem probable that there are still some extensive populations which have not been exploited, especially at considerable distances from ports.

The habit of *Nephrops* to form burrows in the bottom and to remain in them at night (and also during full daylight in shallow waters) reduces the efficiency of capture and makes overfishing more difficult. There is little indication that many grounds are very heavily exploited, though recent declines in yield off Norway may be due to this. A decline in average size on some grounds off Scotland is probably due to fishing (Thomas 1965), but considerable increases in fishing effort off Iceland (Sigurdsson 1965) and continued heavy fishing in the Irish Sea (O'Riordon 1965, Gibson 1965) have not lead to decreases in average size of *Nephrops* in the catches in these areas.

The occurrence of *Nephrops* in the stomachs of cod over a wide area northeast of Scotland suggests that landings by Scottish boats from the North Sea could be about doubled to $5.0–10.0 \times 10^3$ tons per annum (Thomas, personal communication). It is also probable that landings from grounds around Ireland could be more than doubled (Gibson, personal communication).

While the stocks south of Norway may not be able to give a much greater yield it would seem probable that the sustainable yield from the Northeast Atlantic area as a whole could be about doubled to around 60.0×10^3 tons. However, it is possible that the most distant fishing grounds will not readily be fully exploited, as the larger boats may find it more profitable to catch fish than Norway lobsters.

The 1965 landings, by country, and the degree of exploitation are tabulated (p. 212).

B. *Crab resources*

(i) Edible crab (*Cancer pagurus*)

This crab is common where there is a rocky coastline,

Country	Area	Degree of exploitation	1965 production
Iceland	Near seas	Moderate	3.7
Faroes	Coastal areas	Light	0.1
Norway	Coastal areas	Light	0.2
Sweden	Kattegat	Heavy	0.3
	North Sea	Moderate	0.0
Denmark	Kattegat	Heavy	0.8
	Skagerak	Moderate	0.3
	North Sea	Moderate	0.0
Germany	Kattegat	Heavy	0.1
Holland	North Sea (by-catch)		0.0
Belgium	South North Sea		0.5
Scotland	North Sea (near seas)	Moderate	3.5
	West coast	Light to moderate	3.0
England and Wales	North Sea (near seas)	Moderate	0.4
Northern Ireland	Irish Sea	Moderate	0.9
Eire	Irish Sea	Moderate	1.0
	Celtic Sea	Light	0.0
France		Moderate	7.4
Spain	Near seas	Moderate	3.8
Portugal	Near seas	Light	0.2
Total			26.4 (tons $\times 10^3$)

though, due to seasonal offshore migrations, considerable quantities of crabs are also to be found up to 10 mi offshore and into depths of 80 m on soft ground. Crabs are nearly all caught by baited traps, though some are caught as an incidental catch by trawlers.

Crabs are low-priced and therefore long-distance transport to markets is usually not economic. Recent developments have been towards regional processing plants, leading to deep-freezing and canning, which has stabilized fisheries and allowed their expansion away from major consuming centres. This process is progressing in several countries. The most heavily exploited stocks are on the British coast, but recent investigations show that the fishery is now taking about the maximum sustainable yield (Edwards 1967).

Country	1965 landings	Estimated maximum sustainable yield
Norway	3.4	5.0
Sweden	0.2	0.4
Denmark	0.0	0.1
Germany	0.0	0.0
Holland	0.0	0.0
Scotland	1.8	3.3
England and Wales	2.6	3.5
Republic of Ireland	0.1	0.5
France		0.5
Portugal	0.1	0.1
Spain	0.1	0.1
Total	8.3	13.5 (tons $\times 10^3$)

It is possible that yields from Norway could be substantially increased as the average size of crabs caught there is large.

The maximum sustainable yield from the region is probably between 50 and 100% above the current yield of 8.0×10^3 tons, and a potential of 13.5×10^3 tons is assumed for our present purpose.

(ii) Shore crab (*Carcinus maenas*)

This crab is very abundant in coastal waters in the central and southern part of the area, being killed in shallow waters in the North Sea in severe winters. It is only exploited commercially in Spain and Portugal where a total of some 0.3×10^3 tons per annum are landed.

As it is a major predator on the young of a commercial species of mollusc, the development of a fishery for this species could benefit mollusc production. There is also a demand for "peeler" crabs of this species in Italy.

(iii) Spider crab (*Maja squinado*)

This species is common in the southern part of the area to the coast of Ireland and the Western English Channel and occurs also in the Mediterranean. At certain times of the year it aggregates (as does the Tanner crab in the North Pacific) into what are believed to be spawning piles, when large numbers can be caught by trawling. At other times they are usually caught by trapping. The meat yield is low during much of that year but the muscle tissue is sweet, and highly esteemed.

The present fishery is limited to France, Spain, Yugoslavia and Portugal and very small quantities in southern England, and separate landing statistics are only kept for Portugal. Present landings are 4.7×10^3 tons; this figure could probably be increased to about 6.0×10^3 tons.

(iv) Swimming crab (*Portunidae* spp.)

These crabs are common throughout most of the area but are only exploited by Spain. Potential yields are unknown.

C. *Shrimp and prawn resources*

(i) *Pandalus borealis*

This cold water (3–8°C) species occurs from north of Spitsbergen to the northern North Sea on clay and mud bottoms. It rarely occurs in quantity in water less than 60 m deep but extends to depths greater than 1,000 m. However, present day fisheries are limited to depths between 60 and 600 m.

Around Iceland the development of *Pandalus* fisheries has been only during the past decade and new grounds are still being found.

Present production is around 1.4×10^3 tons. This could be somewhat increased by reduced fishing in the

1965–1966 LANDINGS BY COUNTRIES

Country	*Iceland*	*Norway*	*Sweden*	*Denmark*	*Total*	*Potential*
Iceland	1.4				1.4	2.0
Faeroes					—	1.0
North Norway		4.4			4.4	6.0
Northwest		0.6			0.6	2.5
West		1.9[1]			1.9	2.0
South (Skagerak)		1.8[2]	1.5[3]	0.9[4]	5.1[5]	12.0
Kattegat				0.8	0.8	1.0
N. Sea Fladen				3.0	3.0	4.0
Farne Deep						1.0
Total	1.4	8.7	1.5	5.6	17.2	31.5 (tons $\times 10^3$)

[1] 3.5 $\times$ 10^3 tons per annum in 1960–64
[2] 3.2 $\times$ 10^3 tons per annum in 1960–64
[3] 5.0 $\times$ 10^3 tons per annum in 1962
[4] 2.0 $\times$ 10^3 tons per annum in 1962–64
[5] 10.2 $\times$ 10^3 tons per annum in 1962.

most heavily fished areas (Skuladottir 1967) and extended new fisheries, giving a yield which might be somewhere about 2.0 $\times$ 10^3 tons.

There is no fishery for *Pandalus* at Faroe. There is no information on the occurrence of *Pandalus* in this area but from temperatures, depths and bottom types, useful populations can be anticipated.

Fishery for *Pandalus* off Norway started in 1897 following research by Johan Hjort. The fishery has continued to expand and 1,500 Norwegian trawlers of 30–80 ft now work the whole length of the Norwegian coast and offshore grounds down to 600 m, wherever the ground is of soft clay and mud. There is no evidence of overfishing but a minimum mesh of 30 mm throughout the trawl is in force to minimize destruction of young prawns (Rasmussen 1967).

In that part of the Norwegian Deep which extends along the south coast of Norway, Denmark and Sweden, with mean annual yields in 1965 and 1966 of 1.8, 1.8, and 1.5 tons $\times$ 10^3 respectively.

Five-year means of landings from off the Norwegian coast since 1950 were as follows:

	1950–54	*1955–59*	*1960–64*	*1965–66*
	(tons $\times$ 10^3)			
North	1.0	2.0	3.2	4.4
Northwest	0.3	0.3	0.4	0.6
West	0.7	2.0	3.4	1.9
South				
(a) Norway	1.3	1.9	3.3	1.8
(b) Denmark	?	?	4.5	1.8
(c) Sweden	?	?	4.5	1.8

There appears to be some scope for further development, especially in northern Norway, and a mean total annual yield of about 20.0 $\times$ 10^3 tons is probably attainable without working into deeper water. The catches fluctuate partly as a result of variable year-class strength and partly from changes in water temperature, which can make the prawns leave the normal fishing grounds temporarily (Rasmussen 1967). Catches were down off West and South Norway in 1965 and 1966, but the maximum sustainable yield is probably slightly above the 1960–64 average 10.0 $\times$ 10^3 tons.

The Kattegat is only fished by Danish boats, which produce 0.2 to 0.8 $\times$ 10^3 tons a year. There seems little chance of raising this much above 1.0 $\times$ 10^3 tons as the grounds are all known and heavily fished.

Since 1960 Danish boats have been fishing the Fladen grounds of the North Sea and yields have been around 3.0 $\times$ 10^3 tons a year in 1965 and 1966. In 1967, German and Danish trawlers have started fishing the Farne grounds 15 mi from the coast of England but yields are not known.

(ii) Common or brown shrimp (*Crangon crangon*)

Total landings of shrimps for food and industrial uses from Germany and Holland have fluctuated between 4.0 and 70.0 $\times$ 10^3 tons in recent years. Increases in the size and efficiency of the Dutch fleet have been compensated by a reduction in the German fleet.

Crangon crangon is limited to estuarine and coastal waters between the Central North Sea and the Bay of Biscay, and also occurs in the Irish Sea. It forms important fisheries along the coast of Germany and Holland where extensive shallow sandy areas form its main habitat.

There is a substantial fishery in both countries for small shrimps for meal. Some increase in the weight of shrimps for human consumption can be expected by the use of larger meshes in the shrimp nets which would increase the efficiency of capture of the large shrimps as well as releasing small shrimps to be recaptured at a larger size.

At present Denmark does not permit fishing for shrimps within the 3 mi limit though the resources here could probably yield 1.0 $\times$ 10^3 tons per annum.

Dutch catches for human consumption could probably be increased by 50% by greater efficiency and the protection of small shrimps.

Catches by England in The Wash and in the Thames estuary could probably be increased to 1.0 $\times$ 10^3 tons by greater efficiency. The future of the Irish Sea fishery is uncertain due to the possible construction of a barrage across Morecambe Bay—the main shrimp fishing area—but annual catches from the whole of the Irish Sea could probably be maintained around 0.7 $\times$ 10^3 tons.

French catches have been increasing steadily in recent years

(tons × 10^3)	
1960—1.4	1965—2.0
1962—1.8	1966—2.3

and it is probable that the sustainable yield is around the 1.5×10^3 tons for the Channel and 2.5×10^3 tons for the Atlantic coast, if not more.

The following tabulation summarizes present and potential production of this species:

Coastal waters of	*1966 production*	*Potential yield from known grounds*
Denmark	—	1.0
Germany	27.3[1]	28.0
Holland	14.7[2]	15.0
Belgium	1.0	1.0
Scotland	0.1	0.1
England N. Sea	0.8	1.0
Irish Sea	0.5	0.7
France		
English Channel	0.9	1.0
Atlantic	1.4	1.5
Total	46.7	49.3

[1] Includes 21.6×10^3 tons small shrimps for industrial use
[2] Includes 6.5×10^3 tons small shrimps for industrial use.

(iii) Pink shrimp (*Pandalus montagui*)

This species extends from the English Channel to the Arctic and is found on harder bottom in estuaries and into deeper waters. It does not grow to a large size, rarely exceeding the size of the brown shrimp, the larger shrimps having a count of around 400 to the kilogramme.

At present it is only fished commercially by Britain where catches during the past decade have been only a few tens of tons compared with hundreds of tons prior to 1958. The reduced catches have been due to a general scarcity of the species on the three main fishing grounds—The Wash, Thames estuary and Morecambe Bay due to causes unknown.

No attempts have been made to find fishable concentrations in other countries, but it is probable that such concentrations exist, especially around Scotland, Norway, Faroes, and Iceland, where it is known to be present. But, being a small species, requiring picking by hand, it is uncertain whether fisheries would develop even if substantial concentrations were found.

(iv) *Dichelopandalus bonnieri*

This prawn is present in quantities which could probably support a fishery in various localities on the West of Scotland and probably elsewhere.

No fishery exists at present and it is impossible without more information to assess its potentialities.

(v) *Palaemon adspersus*

This prawn is only fished commercially in the Baltic by Denmark where catches have varied between 60 and 340 tons in the last 5 years.

While this prawn also occurs in many areas it is unlikely to be able to support substantial fisheries anywhere.

(vi) Crevette rosé (*Palaemon serratus*)

Palaemon serratus is one of the larger palaemonid prawn reaching counts of 100 per kg. It is a southern species, the most northerly fisheries being in the English Channel and Wales where cold winters cause substantial mortalities. It lives among sea weeds on rocky coasts and on the adjacent sea bed being caught both by baited traps among the algae and by trawls. Yields are not likely to be great anywhere, but it is at present the subject for artificial rearing (MAFF, Conway, and commercial enterprise in England) which if successful could give substantial production.

Production in 1966 was as follows:

English Channel	<10 tons (Potential 10–100)
French Atlantic coast	700 tons (Potential 1.0×10^3 tons)

D. *Total resource potential of Region II*

The following tabulation synthesises the various estimates and potentials discussed above. The rather surprising high potential increase in production rates which are suggested by these figures probably reflect rather the state of exploration of the region rather than that it is inherently rich in crustacean products. Such observations may be held to indicate that estimates made in rather poorly explored regions may very well be too low.

	Present	*Potential*
	(tons × 10^3)	
Lobsters		
Homarus vulgaris	2.1	3.3
Palinurus vulgaris	1.4	2.0
Nephrops norvegicus	26.4	60.0
	(29.9)	(65.3)
Crabs		
Cancer pagurus	8.2	13.5
Carcinus maenas	?	?
Maia squinado	4.7	6.0
Portunus spp.	0.4	1.0
	(13.3)	(20.5)
Prawns, etc.		
Pandalus borealis	17.2	31.0
Crangon crangon	46.6	49.3
Pandalus montagui	0.1	0.1(?)
Dichelopandalus bonnieri	?	?
Palaemon adspersus	<0.5	0.5
Palaemon serratus	<1.0	1.0
	(65.4)	(82.8)
Total	108.6	168.6

Region III—Mediterranean and Black Sea

These inland basins are rather unproductive of crustacea and the extremely oligotrophic nature of their ecology suggests that their potential production relative to other sea areas is likely to be low; nevertheless, the 25.0 to 30.0×10^3 tons of crustacea produced each year from this region is surprisingly high, yet this is probably only a reflection of the relatively highly exploited nature of the resources. As for fish, so for crustacea; the fishing pressure is probably extremely high relative to the low production rates of the marine resources as a whole in these seas.

The production statistics are extremely variable in their quality, and to obtain any overall estimate of present day and hypothetical production one must make many assumptions, perhaps more than in some other regions.

A. *Lobster resources*

(i) European lobster (*Homarus gammarus*)

There is a very small production of this species, scarcely exceeding 1.0×10^3 tons annually, in the Mediterranean Sea, mostly taken by Italian boats, although this apparent national preponderance may very well be due to anomalies in the reporting methods of production statistics from various countries.

(ii) Norway lobster (*Nephrops norvegicus*)

This species appears to occur rather widely in deep water in the Mediterranean Sea and production is considerably higher than for the European lobster. Again, however, the main producing country appears to be Italy with Algeria, Spain, and Yugoslavia each adding rather smaller quantities to the total. The total production from the Mediterranean has remained extremely constant for the last decade, varying only between 2.0 and 3.0×10^3 tons annually.

(iii) Spiny lobster, rock lobster (*Palinurus elephas*) = *P. vulgaris*

An extremely small quantity almost always less than 1.0×10^3 tons annually, of this species, together with traces of *P. regius* (green rock lobster) are taken in the Mediterranean Sea annually. The catches are produced mostly by vessels from Algeria, France, Italy, and Spain although it is extremely likely that small quantities are taken by a number of other countries, but do not show in their fisheries statistics.

B. *Crab resources*

Extremely small quantities of various species of crabs are taken in the Mediterranean basin, appearing in the statistics of France, Spain, and of Yugoslavia. The total has never been recorded as exceeding 1.0×10^3 tons annually and little expansion appears to be possible.

C. *Prawn and shrimp resources*

The bulk of the production of crustacea in the Mediterranean Sea is included in this resource category, the production of which has been rising slowly but rather steadily in recent year. From less than 20.0×10^3 tons a decade ago the production is now approaching 25.0×10^3 tons. This figure does not include shrimps and prawns which may be included in the statistical category "various marine crustacean" as reported by a number of countries, the total of which for the Mediterranean and the Black Sea basins is now approaching 10.0×10^3 tons. It is to be expected that 50–75% of this total should be applied to production from the prawn and shrimp resources. The production statistics from most countries do not permit partition of the total production among the constituent species, and it is difficult to apportion relative importance to the species which are known to occur in the Mediterranean and Black Sea catches, and which are tabulated here.

Of the species tabulated above, *Parapenaeus longirostris* is probably the species of which the greatest catch is taken currently in the Mediterranean, and this is certainly true for those countries such as Spain, France, and Italy for which the statistical data are relatively sophisticated. Probably next in importance are the deep-living prawns (known in the Spanish fishery as gamba de profundidad) and it is probably this resource from which the greatest increase of production may be expected, although it is already rather well surveyed and is already under fairly heavy exploitation, particularly in the western basin of the Mediterranean from Italy and Sicily to the Straits of Gibraltar; *Aristeus antennatus* is the only commercial shrimp taken at Malta, where it occurs at 200–400 m on soft clayey deposits. These Central Mediterranean grounds already appear to have reached their maximum production (J. A. Galea personal communication). While both gamba and gamba de profundidad are known to be dominant in the landings of Spain, France, Italy, Tunisia, and Algeria, the langostino, *Penaeus kerathurus* (which is a penaeid of exceptionally large size, and which occurs also along the tropical West African coast) is important in some of the smaller fisheries because of the relatively high value of the individual prawns on the market.

PRAWNS AND SHRIMPS OF ECONOMIC IMPORTANCE IN THE MEDITERRANEAN AND BLACK SEAS; SCIENTIFIC AND SPANISH NAMES

Gamba	
Parapenaeus longirostris	Gamba blanca
Solenocera membranacea	
Crangon crangon	
Gamba de Profundidad	
Aristeomorpha foliacea	Gamba roja
Aristeus antennatus	Gamba rosada (*Gambli rossi*—Mat.)
Plesionika edwardsii	Carabinero
Langostino	
Penaeus kerathurus	Langostino
Quisquilla	
Palaemon elegans (= *L. squilla*)	
Palaemon xiphias	
Palaemon adspersus	
(*Plesionika* spp. ?)	

The small shrimps of the genera Crangon and Palaemon are nowhere taken in large quantities; the largest production which is probably attributable to such forms appears to be that reported by Bulgaria where it has reached between 4.0 and 5.0×10^3 tons annually.

In the Central Mediterranean the only shrimp fishing in the Adriatic is beyond 600 m depth, while in the Ionian Sea coastal fishing predominates; in the remainder of the region (Tyrrhenian and Ligurian Seas, and around Sardinia and Sicily) shrimp trawling occurs from the coast out to 600 m. It seems, from the rather dispersed statistics available that Italian catches (1967—10.0×10^3 tons) dominate, and make up a large part of the total Mediterranean shrimp catches.

In the eastern Mediterranean, shrimp production occurs in only a few areas (Ivanov 1964) notably on both east and west coasts of Greece along the Turkish seaboard, on the coast of Israel, and off the Nile Delta.

The Greek production is based on *Penaeus kerathurus*, which forms 50% of the catch, together with *Parapenaeus longirostris* and *Palaemon elegans*. Catches are consumed fresh and locally and amount to almost 0.5×10^3 tons annually. The Turkish production amounts to about the same figure annually and probably depends upon the same species.

The Turkish shrimp production extends from the Sea of Marmora (where no trawling, only traps, is permitted)

to Adana in the east. The major exploited species are *Parapenaeus longirostris*, *Penaeus trisulcatus*, *P. semisulcatus*, and *Metapenaeus monoceros*, the last two of these being Indo-Pacific species which have migrated through the Suez Canal. Total production is less than 0.5×10^3 tons and no data are available regarding specific composition of the catches. Until recently, Iskanderum Bay at the eastern end of the coast was a major centre of production, but has now been fished out and the commercial fishery there has collapsed.

The Egyptian production is rather greater, and in 1957 the catches off the Mediterranean coast were about 2.8×10^3 tons. In recent years (if one accepts Hall's estimate that 50% of UAR production comes from the Indo-Pacific, see p. 28) the production has been about 5.0×10^3 tons. It is not known what species are represented in the catches. The effect of the Aswan High Dam will probably be to reduce production from this fishery.

D. *Total resource potential of Region III*

It is extremely difficult to estimate in an objective fashion the potential production in this region but it seems, from the stability of the landings, and from the general interest in the European markets in crustacea, that the relative level of exploitation is probably already rather high of fisheries as disparate as those in deep water around Malta and in shallow water in Iskanderun Bay, so that no great increase can be expected. As indicated earlier, any major increase will probably come from the deeper-living shrimps and prawns which, although their general distribution is now fairly well understood have only in recent years come under heavy exploitation.

Because of these facts it is not postulated that the landings could be expected to increase in the foreseeable future beyond 50.0×10^3 tons altogether and this estimate may in fact be generous, but is a conveniently rounded number, to be used here as the potential. In fact, it represents a little more than a 20% increase on present production, and an increase of this magnitude may be quite realistic.

Region IV—North Pacific

This region encompasses the whole of the North Pacific from the cold waters north of Hokkaido to the California Current at the level of the Mexican border. Here the important members of the crustacean fauna are quite different from the crustacea of the warmer parts of the Pacific—pandalid shrimp replace penaeids, various spider crabs replace spiny lobsters, and swimming crabs are virtually absent.

A. *Crab resources*

The king crab (*Paralithodes camtschatica*) has been for many years the most valuable single-species crustacean fishery in the region, being taken by fleets from USA, USSR, Japan and Korea. The total landings of this species have shown the following development:

(tons × 10^3)			
1938—79	1962—103	1966—	150
1948—18	1963—112	1967—	131
1958—66	1964—120	1968—	111
1961—88	1965—132	1969—	86

The centres of production of king crabs have been: the Okhotsk Sea (and Tartar Strait, W. Sakhalin and N. Hokkaido); the Bering Sea; the Gulf of Alaska, especially near Kodiak. Traditionally, the US fleets have fished the Gulf of Alaska and some parts of the Bering Sea, while the USSR and Japanese fleets have occupied themselves with the stocks in the Okhotsk and Bering Seas; the division of the catch among the various fleets in some recent years was as follows:

Country	*1963*	*1964*	*1965*	*1966*	*1967*
		(tons × 10^3)			
Japan	31.6	31.8	25.9	31.0	30.0
Korea	2.3	2.2	0.3	0.4	1.5
USA	35.7	39.3	59.7	72.5	57.9
USSR	42.5	46.2	44.2	46.0	42.3
Total	112	120	132	>150.0	>132.0

There have been indications that the stocks in the Okhotsk Sea to the west of Kamchatka have seriously declined in recent years and it is unlikely that the potential production is greater than the present figure of 40.0–45.0 × 10^3 tons together with less than 5.0×10^3 tons of blue king crab (*P. platypus*); this fact, is however, not demonstrated in the catch statistics because the Soviet and Japanese fleets turned their effort elsewhere. A decline, which may be the result of the year-class fluctuation or may be due to overfishing, is now becoming evident in the data from the Gulf of Alaska. In the early 1960s, before any decline in availability became

PRODUCTION OF CRUSTACEANS IN RECENT YEARS AND FUTURE POTENTIAL MEDITERRANEAN AND BLACK SEA (tons × 10^3)

	1958	*1961*	*1962*	*1963*	*1964*	*1965*	*Potential*
Prawns, etc.							
Crangon crangon	1.0	+	+	+	+	+	+
Others	19.0	21.0	21.0	21.0	22.0	23.0	
Lobsters							
Homarus gammarus	1.0	1.0	1.0	1.0	3.0	1.0	
Nephrops norvegicus	3.0	3.0	2.0	2.0	2.0	3.0	
Palinurus elephas	+	+	+	+	1.0	+	
Crabs							
Miscellaneous crabs	+	+	+	+	+	+	
Various crustaceans							
(Taxa not stated)	4.0	7.0	9.0	8.0	9.0	9.0	
Total	28.0	32.0	33.0	32.0	37.0	36.0	50.0

evident, the approximate distribution of the catch was as follows:

		(tons × 10^3)
Okhotsk Sea	—USSR	31.1
	Japan	11.1
Bering Sea	—USSR	9.0
	Japan	13.5–18.0
	USA	+
Gulf of Alaska	—USA	59.4

The evidence for a decline in king crab availability has turned attention towards the Tanner crabs of the genus *Chionoecetes*. Three species are important in the North Pacific, and there is some evidence that their abundance may be linked to that of the king crab (Alverson personal communication), so that their availability has increased as the stocks of king crabs have decreased: *C. tanneri* occurs commonly in deep water from California to Washington, while *C. opilio* and *C. bairdi* occur in shallower water in the Gulf of Alaska. Species of this genus form about half the Japanese crab landings, and are exported under the name of "snow crab".

Also occurring in the region is the Dungeness crab, *Cancer magister*, of the western seaboard of North America, together with similar species on the Asiatic coast. The landings on the American coast follow, but similar data for the Asiatic coast are not available:

Country	*1963*	*1964*	*1965*	*1966*	*1967*
USA	11.3	10.5	12.2	18.1	17.7
Canada	1.5	2.0	1.6	2.1	2.4

The crabs *Lithodes aequishina* and *Geryon quinquedens* are also available and may have some potential in the region, though they are deep water crabs occurring at 300–1,000 m and may require the development of special techniques for its exploitation. A Japanese trap fishery at 300–500 m mainly now produces about 3.0×10^3 tons per year of *L. aequidens*. Other species of crabs that could be commercially valuable are *Erimacrus isenbeckii*, *Telmessus cheiragonus*, and *Paralithodes brevipes*.

The recent decline in the availability of king crab suggests that the total potential of this resource may not be as high, on a sustained basis, as the highest annual catch rates recorded in the data. For this reason, a very conservative potential production of 100.0×10^3 tons annually is used here. The potential production of the Tanner crab is harder to guess. It has been suggested that it may be as high as that of the king crab, but if there is ecological competition between these species their potential productions should be considered together. For this reason, the yield of Tanner crabs is guessed at being half that of king crabs when both are being exploited and a combined figure of 150.0×10^3 tons for the two species is postulated.

The potential production from the Dungeness crab stocks is hard to estimate; the annual fluctuations in availability seem to be due to year-class fluctuations, and there seems to be no evidence of serious over-exploitation. An increase $\times 2$ over present average production of 22.0×10^3 tons is postulated for present purposes. It is assumed, also, that a same potential of *C. amphicetus* occurs on the Asiatic coast, though it is concealed in FAO production data, and a total potential of 50.0×10^3 tons for the whole region is used here.

B. *Prawn resources*

The prawn and shrimp resources of the region are dominated by about six species of pandalid prawn and a small number of crangonid shrimps, of much lesser importance.

On the Asiatic coast, the pandalid catch off South Korea amounted to about 3.2×10^3 tons in 1965, and was dominated by *Pandalus hypsinotus*; the North Korean catch, in which this species, together with some *Pandalus latirostris*, is again dominant, probably raises the total Korean catches to about 5.0×10^3 tons. In the Okhotsk Sea the pandalid resources are known to be rich, but production has not yet begun. Here, *Pandalus goniurus* dominates, expect along the west coast of Kamchatka, where *P. borealis* becomes important. The potential of this area is not known, but is guessed to be at least 10.0×10^3 tons annually.

The production statistics for the Bering Sea and the Gulf of Alaska are combined, and the composition of the catches are as follows: *Pandalus borealis* (80–90%), *Pandalopsis dispar* (5–15%), *Pandalus goniurus*, *P. hypsinotus* and *P. platyceros* (<5%). Annual catches for the whole of this area were:

Year	*USA*	*USSR* (tons × 10^3)	*Japan*	*Total*
1961	7.3		10.2	17.5
1962	7.7		18.0	25.7
1963	6.9		31.6	38.5
1964	3.5	0.6	20.9	25.0
1965	7.6	2.7	9.8	20.1
1966	10.9	10.7	2.9	24.5
1967	—	14.3	3.3	—

Especially in the Bering Sea, the bulk of the landings until the last few years had been made by the Japanese fleet, which has achieved a maximum production of around 30.0×10^3 tons. The resources are concentrated in a number of locations, among them the Pribiloff Islands in the Bering Sea. Here a Japanese fleet achieved the following production figures:

(tons × 10^3)	
1961—10.2	1964—20.9
1962—21.0	1965— 8.8
1963—31.6	1966— 2.9

This catastrophic collapse was probably due to gross overfishing, and the fleet has recently left these grounds, and turned its attention to the stocks of *P. goniurus* in the Anadyr Gulf.

There are extensive (but mostly unmeasured) areas in Alaskan coastal waters where shrimp fisheries may develop in the future. No reliable prediction of potential production is available. Now, fisheries are located on shrimp stocks with very high concentrations and/or close proximity to ports. As demand grows, operations will undoubtedly expand into more distant areas having

lower shrimp densities. Among the potential shrimp areas are southeast Alaska and the Aleutian region. About 17,500 km^2 of ground near the Shumigan Islands can also be considered a potential shrimp area since the Soviet fishery there is now restricted to the offshore zone by US closure to foreign fishing of the 12 mi zone. Dominant species in unexploited areas are expected to be *Pandalus borealis* and *Pandalopsis dispar*.

It is probably a reasonable supposition that when all latent resources in this area (Bering Sea–Alaska) are in production the catches will be at least double the present figure. This is used for present purposes, and the total potential production is assumed to be about 100.0 $\times$ 10^3 tons per year.

Off Canada, the present trap and trawl fisheries are supported by: *Pandalus jordani*, *P. borealis*, *P. platyceros*, *P. hypsinotus*, *P. danae* and *Pandalopsis dispar*. Recent years' catches follow:

(tons $\times$ 10^3)	
1961—0.5	1964—0.5
1962—0.7	1965—0.8
1963—0.8	1966—0.8

Only the area of shrimp trawling grounds is known with any certainty, the total area trawled now and in the past being about 180 km^2. The area of trap grounds for *P. platyceros* appears to be considerably less. The prevailing rate of exploitation is high on trawling grounds near Vancouver and around Vancouver Island, for *P. borealis* and *P. jordani*, and greater effort there will not increase catches appreciably. Stocks of *P. platyceros* available for trapping are believed to be utilized at a low level.

Exploratory fishing between 1953 and 1967 has revealed unexploited grounds for *Pandalus borealis*, *P. jordani*, *P. platyceros*, and *Pandalopsis dispar*. Catch rates, using 70 ft semi-baloon Gulf, and 36 ft shrimp otter trawls, were from 20–380 kg per hour in inlets and 50–600 kg per hour on the outer coast. An estimate of potential trawling area is 630 km^2, and virtually all suitable shrimp trawling grounds have been explored, they are not now under exploitation. On the other hand, probably more than half the British Columbia coast remains to be explored by traps. Consideration of the known potential and hypothetically fishable grounds leads one to anticipate that production will increase by 450 tons within 10 years, giving a total production potential of about 12.0 $\times$ 10^3 tons annually.

On the open Washington coast *Pandalus jordani* supports a trawl fishery. The present annual catch is variable, ranging from nil to 2.5 $\times$ 10^3 tons annually, and about 0.4 $\times$ 10^3 tons were landed in 1967. The size of the fishery is determined by the strength of the dominant year-class, and it is believed that production is near the maximum sustainable yield. In years of high availability, boats which normally trawl for bottom fish convert to shrimp trawling.

No potential or hypothetical fishery off Washington is known.

Species under exploitation in Puget Sound include *Pandalus jordani*, *P. borealis*, *P. platyceros*, and *P. danae*. Annual catches for the area, including Hood Canal, in 1965 and 1966 were 28 and 22 tons, respectively. A breakdown of the 1967 commercial catch showed that traps took 8.3 tons and beam trawls 3 tons. Also in 1967 the catch of the sport trap fishery for *P. platyceros*, *P. danae*, and possibly *P. jordani*, was estimated at 8.6 tons. Stocks are presently being fished to near their maximum potential.

The potential production of *P. jordani* and *P. borealis* in South Puget Sound and Hood Canal, from about 400 km^2, is estimated at about 2.5 tons. Undoubtedly there are small isolated populations of shrimp scattered throughout Puget Sound which are not now being fished. The total potential for Washington is less than 3.0 $\times$ 10^3 tons annually.

The only species currently subjected to trawling off Oregon is *Pandalus jordani*. Production averaged 1.1 $\times$ 10^3 tons for the 10-year period ending in 1966, and a record of 4.7 $\times$ 10^3 tons was reached in 1967. Recent surveys of Oregon shrimp grounds have shown stocks to be abundant in most areas. Population size is known to vary from year to year, yet it appears that the exploitation rate is at a level somewhat below the optimum. Thus, an increase in production may be expected and it is anticipated that the catch will double within 10 years.

No potential shrimp trawl fisheries are known, or anticipated, off Oregon. Of a hypothetical nature is a trap fishery for *Pandalus platyceros* on the rocky bottom of Heceta Bank, Stonewall Bank, and Astoria Canyon, consisting of at least 450 km^2. This type of bottom appears similar to that elsewhere where *P. platyceros* is fished.

A total production potential of 10.0 $\times$ 10^3 tons may, therefore, be assumed for Oregon.

Shrimps being fished at present on the California coast are *Pandalus jordani* and *P. platyceros*. Trawl catches of the former species in recent years were:

(tons $\times$ 10^3)	
1962—0.8	1965—0.6
1963—0.9	1966—0.5
1964—0.4	1967—0.6

P. platyceros catches from a trap fishery are negligible, not reaching tens of tons in recent years.

Other minor fisheries for three species of *Crangon* exist in San Francisco Bay, and a potential exists for development of a small trawl fishery for *Sicyonia ingentis* off Santa Barbara.

It is unlikely that the total California potential production will be greater than 2.0 $\times$ 10^3 tons annually, even with all minor potential species in production.

C. *Spiny lobster resources*

A very small fishery, landing about 250 tons annually, occurs for *Panulirus interruptus* off Southern California. This is fully exploited and is negligible in the present context.

D. *Total production potential of Region IV*

The Table on p. 217 indicates the conservative estimates of potential production of crustacea from Region IV that have been used in the above discussions. This may very well be considerably too low, but there do not appear to be good reasons from presently available data to set it higher.

	Present	Potential
	(tons 10^3)	
Crabs		
Paralithodes camtschatica	150.0	100.0
Chionoecetes spp.	38.0	100.0
Cancer magister	≈20.0	50.0
	(208.0)	(250.0)
Prawns		
Pandalus spp.		
Korea	5.0	5.0
Okhotsk Sea	?	10.0
Bering Sea and Gulf of Alaska	26.9	100.0
Canada	0.8	1.2
USA	8.4	15.0
	(41.1)	(131.2)
Total	249.1	381.2

Region V—Western Central Atlantic

This region comprises the Atlantic coast of the United States, the Gulf of Mexico, the Antilles and the Caribbean Sea, and south along the east coast of South America to the eastern boundary of Venezuela. This is an oceanographically complex region, covering the tropical and subtropical regions of the western Atlantic Ocean. The occurrence of great river effluents in the Gulf of Mexico, and along the coast of South America, combined with the occurrence of very extensive coastal lagoon systems renders it a very productive region for penaeid prawns, and these resources are perhaps more fully exploited here than anywhere else in the world mainly because of their proximity to the great crustacean markets of North America.

A. *Lobster resources*

Two species of spiny lobster occur in this region, both of them ranging rather widely from Bermuda, through the Gulf of Mexico and the Caribbean area, to the Atlantic coast of South America; these are *Panulirus argus* and *P. laevicauda*. The common lobster *Homarus americanus* has in recent years been trawled in deep water off Virginia and North Carolina, production reaching 75 tons annually.

The landings of these two species are partitioned between five countries as tabulated below:

REGIONAL LANDINGS OF SPINY LOBSTERS (tons 10^3)

Country	*1961*	*1962*	*1963*	*1964*	*1965*
Bahamas	—	—	—	—	1.2
Cuba	8.2	7.5	7.4	6.6	9.1
Mexico	—	—	0.2	0.2	0.1
USA	1.3	1.4	1.4	1.6	2.8
Venezuela	0.1	0.1	0.1	0.2	0.1
Total	9.6	9.0	9.1	8.0	13.3

Production from this region is now approaching 14.0×10^3 tons annually and although some areas, as around Cuba and Florida, the stocks are probably rather heavily exploited, it is reasonable to suppose that further development of the fishery is possible in the other relatively under-developed Antillean islands, and it is, therefore, guessed that a 50% increase over present production is likely to be possible. The potential of this region is, therefore, for present purposes, set at 21.0×10^3 tons annually. It is to be expected that the greatest increase in production will come from the islands of Jamaica, Dominica, and the Virgin Islands, with perhaps some new production from the eastern coast of Central America.

B. *Crab resources*

The greatest production of crabs in this region comes from the blue swimming crab and the Atlantic and Gulf coasts of the USA, *Callinectes sapidus*. The production from this fishery is considerably higher on the Atlantic than the Gulf coast of the USA but appears to have reached a point near its maximum sustainable production. The rather stable production in the last 5 years is probably due to a combination of resource limitation, and to the fact that the relatively low-priced products from this fishery still demand relatively high labour costs, and for this reason the northern fisheries of the Atlantic coast are declining relative to the remainder. The USA catches in recent years are as tabulated below:

US LANDINGS OF BLUE CRAB (*Callinectes sapidus*)
(tons : 10^3)

	1961—69.3	1964—71.3
	1962—70.4	1965—75.9
1963—65.9	1966—71.9 (Atlantic, 58.0 Gulf, 13.9)	

A small number of other species of crabs are also exploited in the USA and the rest of the region, these in recent years obtaining a production rate of only about 2.0×10^3 tons a year. The statistical category "various crustacea" reaches 5.0 to 6.0×10^3 tons annually in the region as a whole and probably contains a rather large percentage of crabs of various species, probably dominated by swimming crabs throughout the Caribbean and Central America. The potential of crabs from the region is extremely difficult to guess and for present purposes is set at the extremely conservative level of 80.0×10^3 tons annually, which is very little in excess of the present blue crab production off the USA. It may very well be that this figure should rather have been set, and will prove in the long run to be 150.0×10^3 tons annually in view of recent (1968) indications on increased production on the Texas coast.

C. *Prawn resources*

It is these which are the most valuable and largest crustacean resources of the region and this is one of the major centres of prawn production of the world. Approximately 10 taxa of shrimps and prawns are currently exploited and of these 7 are shallow-living members of the genus *Penaeus*, the adults of which live upon the continental shelf, spawn there, and as far as it known pass their juvenile period in coastal lagoons. Two species of penaeids not of this genus and smaller in size having a shallow continental shelf ecology but without entering lagoons in the juvenile stage are also exploited, as is a single species of deep-living penaeid which occurs throughout the entire region on the upper parts of the continental slope. The exploited species with their scientific and industrial names and indication of their

ranges within the region are given in the following tabulation:

Penaeus setiferus—white shrimp—New York to Campeche, Mexico
P. schmitti—camarón blanco—Honduras to Brazil
P. aztecus aztecus—brown shrimp—Massachusetts to Campeche
P. aztecus subtilis—camarón marrón—Honduras to Brazil
P. duorarum duorarum—pink shrimp—Chesapeake Bay to Mexico
P. d. notialis—caramel shrimp—Cuba to Brazil
P. brasiliensis—spotted pink shrimp—disjunct, Carolinas to Brazil
Xiphopeneus kroyeri—seabob—North Carolina to Brazil
Sicyonia brevirostris—rock shrimp—Virginia to Yucatan
Hymenopenaeus robustus—royal red shrimp—entire region

The white shrimp, *Penaeus setiferus*, has three centres of abundance where it is presently fished intensively. These are (1) off Georgia and north-eastern Florida on the Atlantic coast of the USA, (2) off the coast of Louisiana on the Gulf coast of the USA, and (3) near Isla del Carmen, Campeche, on the eastern coast of Mexico.

The camarón blanco, *P. schmitti*, is more dispersed than the above species, and fishable concentrations occur especially off Cuba, off the Honduras–Nicaragua area, and off Venezuela, but in none of these places do stocks appear to be comparable in density to those of *P. setiferus* off Louisiana.

P. aztecus aztecus, the brown shrimp, occurs in four principal fishable concentrations: on the Atlantic coast of the USA off the Carolinas; in the Gulf of Mexico between the Mississippi and north-eastern Mexico; from the north of Tampico to Veracruz, Mexico; and finally along the coast of Tabasco and south-western Campeche, Mexico. The area of greatest abundance is in the north-central and north-western Gulf of Mexico. The principal stocks of *P. a. subtilis* appear to be to the south of this region along the coasts of Guyana, Surinam, French Guiana, and Brazil, and this species is only of importance in Region V along the coast of Venezuela.

P. duorarum duorarum occurs in two great concentrations, one along the southwest coast of Florida and the other on the Campeche banks off the east coast of Mexico. *P. d. notialis* occurs in fishable concentrations only at Cuba, the Honduras–Nicaragua area, and in the Gulf of Venezuela.

P. brasiliensis is not a great commercial importance in this region, except in the region from Cabo Catoche to Isla Mujeres, Mexico, the coast of Honduras and Nicaragua, and to some extent to Colombia and Venezuela. The largest stocks are apparently to the south of the region.

Commercial concentrations of the seabob, *Xiphopeneus kroyeri*, occur as follows: in the northern Gulf of Mexico, particularly to the west of the mouth of the Mississippi River; off Nicaragua; of eastern Venezuela; and off Trinidad. The largest stocks of this species are also to the south of this region. Known concentrations of the rock shrimp, *Sicyonia brevirostris*, occur from about Charleston, South Carolina to New Smyrna, Florida; in the north-western Gulf of Mexico; and in the Gulf of Campeche.

The deep-water shrimp, *Hymenopenaeus robustus*, known to the trade as the royal red shrimp, is the only species of deep-water crustacean considered in this area, although a number of other species occur with a rather similar ecology. These are three localities where fishable concentrations of the royal red shrimp are known to exist. These are along the coast of the USA and are located (1) off the east coast of Florida between latitude 27–31°N, (2) along the Florida Straits between longitudes 82–84°W, and (3) southeast of the Mississippi River Delta between longitudes 87–91°W. These grounds are named, respectively, St. Augustine, Dry Tortugas, and Mississippi Delta.

In addition to these species which are discussed above, and on which the present production in the region is based, there are of course also many other species of prawns and shrimps in the area, these being mostly of small size (such as those of the genera *Parapenaeus*, *Penaeopsis*, and *Trachypeneus*) that may or may not be taken and utilized incidentally with present commercial operations, and which may or may not have future potential as a commercial resource. These have not been included either because they are not reported in present landings or because it is unlikely that specific fisheries will develop in the foreseeable future from them. Also not included in the present consideration are the deep-water penaeids (*Aristaeomorpha foliacea*, *Aristeus antennatus*, *Penaeopsis serrata*, and *Plesiopenaeus edwardsianus*), and the pandalid *Plesionika edwardsii* have been reported on numerous occasions as occurring throughout the area, but none of these except *Penaeopsis serrata* (which is of small size) has been located in concentrations sufficient to suggest supporting the commercial fishery. The following tabulation summarizes the present production of all species of prawn throughout the area by countries, and their estimated potential production. This cannot be broken down by species, as in almost every case the available national statistics are not stratified by species.

Country	*Present* (tons 10^3)	*Potential* (tons 10^3)
USA	78.7	102.0–127.0
Cuba	2.0	2.5
Mexico	30.9	33.0
Bahamas	1.0	2.0
British Honduras	0.2	0.4
Guatemala	+	0.2
Honduras	2.1	3.0
Nicaragua	2.1	4.0
Costa Rica	+	0.2
Panama	+	0.2
Colombia	0.4	2.0
Venezuela	7.8	11.0
Total	125.0	160.0–185.0

The estimates of present production or current production in the above table have been derived by Lindner, not from single recent years data but rather from long-term averages. For instance, the US current production is

derived from the 10-year average, 1958–67; the Mexican current production is based on the 9-year average, 1958–66 and includes landings of US vessels whose catches were made off the coast of Mexico. In some cases, such as that of Nicaragua, the estimates are rather made on the best available data even though this is for only a single year, in this case 1966, and from landings in that year by US vessels whose catches were reported as having been made off the coast of Nicaragua. The data from Venezuela and Mexico are probably not very reliable as a sizeable quantity of the landings in these areas are reported as "heads-on" in the data but in fact have probably been headed before landing; for these two countries, therefore, a factor of 1.68 to convert headless landings to live weight has been used. It was necessary to group all countries and entities throughout the Bahamas, the Greater and Lesser Antilles, with the exception of Cuba, for although practically all have small localized shrimp fisheries their magnitude is not large nor is it likely to become so, and available landing data are so scanty that both estimated production and potential production are really only guesses.

It should be noted that the estimates of potential landings given in the above tabulation include 15.0–40.0 tons from the US fishery which might be expected eventually to accrue by changing present management procedures. Eliminating this accrual from good management we arrive a little more than 140.0 $\times$ 10^3 tons as the potential we can expect by increased fishing in some localities and by fishing species which are not now utilized. In other words we can expect only about a 16% gain in landings by increasing our fishing effort. It would be quite unrealistic at the present moment to attempt to estimate what improved management procedures might accomplish in the remainder of the region and although these might significantly lift the final estimated potential production this is not done at the present as it would be entirely unrealistic.

D. *Total resource potential of Region V*

The estimates of present production and of potential production discussed above are tabulated below:

	Present (tons 10^3)	*Potential*
Lobsters		
Panulirus spp.	13.3	21.0
Crabs		
Callinectes spp.	74.9	80.0
Others	2.0	
Prawns		
Prawns and Crangonid prawns and shrimps	125.0	160.0
Total	215.2	261.0

The rather modest potential increase in production suggested for this region is undoubtedly a function of the relatively high level of exploitation already achieved, and which is discussed in the text above.

Region VI—Eastern Central Atlantic

Present catches are low, less than 5.0 $\times$ 10^3 tons; resources comprise crayfish of several species, less than 10 species of penaeid prawns, and a few other minor species. Deliberate exploration for crustaceans has been carried out only in the Bight of Biafra, and the unsatisfactory data for crustaceans from fish resource surveys make numerical projections of potential resources, and future yields very subjective.

A. *Lobster resource*

(i) *Palinurus mauritanicus*

Habitat: west coast of Africa from 18–25°N, 60–600 m, especially at 200 m on the Arguin Bank. *Actual landings:* 1963—2.5 $\times$ 10^3 tons from 40 French and Spanish vessels. *Potential:* presently over-fished (Postel 1967).

(ii) *Palinurus charlestoni*

Habitat: Cape Verde Islands, 150–300 m. *Actual landings:* 10–20 tons. *Potential:* perhaps 1,000 tons with other species (Postel 1967).

(iii) *Panulirus regius*

Habitat: from Cape Juby in Morocco to the south of Angola, including Cape Verde and Gulf of Guinea Islands; down to 40 m, but mostly <at 20 m, on rocky and other hard bottoms. *Actual landings:* 200–500 tons from Senegal–Mauritania directly to France; 75–125 tons at Dakar, Senegal; 10–50 tons in Ivory Coast; 10–20 tons in several other West African ports. *Potential:* negligible, perhaps 100 tons, in tropical Gulf of Guinea; 400 tons in Senegal and Mauritania; Angolan potential not known but possibly between 250–500 tons (Postel 1967, Williams 1968).

B. *Prawn resources*

(i) *Penaeus duorarum*

Habitat: in Eastern Atlantic the form commonly known under this name occurs from Cape Blanco to Angola; its identity with the Western Atlantic form does not appear to have been critically examined; coastal, down to 100 m, most common and abundant from 30–50 m in thermocline water and on soft mud associated with this depth. Juveniles in estuarine systems and lagoons. *Actual landings:* as tabulated below, in 1966, just under 3.5 $\times$ 10^3 tons for this region. *Potential:* only suggestion that MSY has presently been reached comes from Senegal rivers (e.g. R. Casamance). Elsewhere, exploitation is just starting, particularly from Nigerian ports, where production has now reached about 2.8 $\times$ 10^3 tons annually. Surveys, and patterns of exploitation, indicate that centres of production will be from Senegal to Guinea

PENAEUS DUORARUM, LANDINGS IN 1966 (tons $\times$ 10^3)

Senegal	—rivers	0.45
	—sea	0.52
Ivory Coast	—lagoons	0.30
	—sea	0.15
Dhomey	—lagoons	0.27
Nigeria	—sea	1.20
Cameroon	—sea	0.12
Gabon	—sea	—
Congo	—sea	—
Angola	—sea	0.15
Total		3.16

and from Dahomey to Gabon, including Fernando Po, with the greatest resources off the Niger Delta and in the Bight of Biafra. Catches off the US coast of the Gulf of Mexico of this and related species reaches 75.0×10^3 tons per year and it seems not improbable that a figure similar to this, between 50.0×10^3 tons and 100.0×10^3 tons is likely for the Gulf of Guinea, and could even be surpassed; the lower figure is adopted for present purposes.

(ii) *Parapenaeopsis atlantica*

Habitat: from Senegal to Angola, coastal and down to 60 m, but most abundant at 10–40 m; juveniles do not enter estuaries and lagoons. *Actual landings:* statistically, not generally separated from those of *P. duorarum*, and only in Ivory Coast and Congo are data available: in the former from 15–30 tons, in the latter from 1–5 tons annually appear to be landed. *Potential:* limited, but specialized fisheries may develop, as for the "seabob" and other shrimps smaller than *P. duorarum* in the Gulf of Mexico. Impossible to quantify an estimate at this moment.

(iii) *Parapenaeus longirostris*

Habitat: Mediterranean and west coast of Africa south to Angola; in tropical region occurs on deeper parts of the shelf expecially between 150–300 m. *Actual landings:* negligible, less than 50 tons annually by a few Spanish vessels north of Cape Verde. *Potential:* although survey data indicate the presence of this species throughout the Gulf of Guinea, it is not presently possible to quantify the potential yield (Crosnier 1967, Monod 1967, Williams 1968).

(iv) *Plesiopenaeus edwardsianus; Plesionika martia; Aristeus varideus; A. antennatus; Glyphus marsupialis*

Habitat: these are the main elements of a shrimp fauna on the upper part of the continental slope which occurs probably throughout the inter-tropical region from 200–900 m, each species probably having a preferred depth range. *Actual landings:* unknown, but some exploitation by Spanish trawlers off Sierra Leone and Senegal, landing in Las Palmas and Huelva. *Potential:* unquantifiable, but by analogy with Mediterranean fishery for some of these, and other related species with similar ecology, a yield of 10.0×10^3 tons annually in the tropical zone could be postulated (Crosnier 1967, Massuti MS., Monod 1967, Ivanov 1964, Williams 1968).

(v) *Palaemon hastatus; Hippolysmata hastatoides*

Habitat: estuaries and lagoons of tropical region, coming onto shelf areas during rainy season. Very shallow, along beaches. *Actual landings:* not known, but probably running into some hundreds of tons since beach seine catches at Lagos may take more than half-a-ton per haul during the season. *Potential:* unquantifiable, but probably less than 1,000 tons for the whole Gulf.

C. *Crab resources*

(i) *Portunus validus; Callinectes* spp.

Habitat: blue swimming crabs are common and abundant throughout the Gulf of Guinea, coastal and estuarine out to 50 m, usually shallower. *Portunus* dominant on continental shelf, *Callinectes* spp. in estuaries and lagoons. *Actual landings:* presently not quantified, and negligible except as minor element in indigenous fisheries. Trawler catches mostly discarded. *Potential:* by analogy with swimming crab fishery on eastern coast of USA, a yield of 10.0×10^3 tons for Gulf of Guinea appears possible, providing an economic basis was established. It seems extremely improbable that this potential will be realized in the foreseeable future, however.

D. *Total potential resources of Region VI*

The following tabulation is based on the production and potential estimates made above:

	Present (tons × 10^3)	*Potential*
Lobsters		
Palinurus mauritanicus	2.5	2.0
P. charlestoni	+	1.0
P. regius	+	1.0
	(2.5)	(4.0)
Crabs		
Portunus validus	+	10.0
		(10.0)
Prawns		
Penaeus duorarum	4.6	50.0
Parapenaeopsis atlantica	+	1.0
Parapenaeus longirostris	+	1.0
Deep penaeds	+	10.0
Palaemon hastatus } *Hippolysmata hastatoides* }	+	1.0
	(4.6)	(63.0)
Total	>6.0	77.0

That the suggested increase in production for this region is relatively large is a reflection of the fact that it is only in the last few years that exploitation of the most important crustacean resources, those of *Penaeus duorarum*, has been started. In the present state of knowledge of the stocks of this species the suggestion made here as to potential production must be extremely subjective.

Region VII—Western Indian Ocean

This region extends northwards from the boundary between South Africa and Mozambique along the coast of east Africa and around the Arabian Sea up to the western coast of Ceylon. It is one of the larger and more diverse regions and contains a very high number of species of crustacea, some of which support important fisheries.

A. *Rock Lobster resources*

There appear to be no major resources, or centres of production, of rock lobsters in this region which is to the north of the important stocks of *Jasus lalandii* in southern Africa. Only around the Kerguelen Island in the extreme southern part of this region is there a rock lobster resource of any abundance, and this is neither very extensive, nor are there good production figures for it, but it is known to be exploited by French langouste boats, and the species which is exploited there and in small amounts round New Amsterdam and St. Paul Islands is believed to be *Jasus paulensis*.

Turning to the African coast, the Natal rock lobster *Palinurus gilchristi* extends northwards along the southern coast of Mozambique, where small quantities are taken off South Africa. The exploitation of this species is just beginning and a plant capable of freezing 2.5×10^3 tons annually has been installed in Lourenço Marques. This figure is here used as the potential for *P. gilchristi* from Natal and Mozambique. In the Mozambique Channel, *Panulirus ornatus*, *P. longipes* and *P. versicolor* are taken by a number of methods and produce approximately 150 tons annually. From the nature of the environment, and the distribution of these species, it is impossible to employ industrial methods of fishing, and the production of these species in this area will be determined by the amount of individual effort which local fishermen are prepared to put into the fishery. Postel suggests a total production of 600–700 tons from this area annually.

On the southeast coast of Madagascar, *P. homarus* and *P. penicillatus* are taken with nets; the rate of production is extremely low, of the order of 20 tons annually. In the Mascarene Islands, *P. penicillatus*, *P. ornatus* and *P. longipes* are taken in small quantities along the coral reefs by local divers. In the Red Sea and the Gulf of Aden, *P. penicillatus* and *P. ornatus* are again present, and are taken in very small quantities by local divers.

Recently promising catches of deep-sea lobster, *Puerulus sewelli* have been taken in deep water (100–150 fm, *c.* 200–300 m) off Cochin.

In sum, it appears unlikely that the production of spiny lobsters throughout the region will significantly exceed 3.0×10^3 tons annually.

B. *Crab resources*

It is presently impossible to estimate the catches of crabs from this region. The rather large quantities of "other crustacea" reported in the landing statistics of India and Pakistan suggest that significant quantities of crabs, probably mostly portunid swimming crabs, are produced but the present breakdown in statistics makes it impossible to define this.

The only studies of edible crabs in the Indian Ocean, from a commercial point of view, appears to be that of Guinot (1967a). The degree to which crabs are utilized in the Indian Ocean appears to vary very widely, especially for smaller species, and the potential yield from more widespread fishing than is practised at the moment could be quite high, although Guinot attempts no estimates of production rates. He implies that at least some species, for example *Portunus pelagicus*, are rather heavily fished.

Off Mozambique, several species of crabs are landed in small quantities, partly as a by-product of the shrimp fishery. They include *Schylla serrata*, *Portunus pelagica*, and *P. sanguinolenta*. Possibly appreciable stocks of *S. serrata* (mangrove crab) occur in mangrove swamps along the entire East African coast.

C. *Shrimp and prawn resources*

In Mozambique, just to the north of the South African border, the important species appear to be *Penaeus indicus*, *P. monodon*, *P. semisulcatus*, and *Metapenaeus monoceros*. *P. indicus* constitutes about 70% of the catches. Species of secondary importance are *P. japonicus* and *P. latisulcatus*. The annual production in 1,000 metric tons of these species on the coast of Mozambique is given in the following tabulation; this production comes from an area of about 3,000 km² of offshore trawling grounds and 1,000 km² of inshore bays and estuaries, of which the inshore areas of Delagoa Bay, Inhambane, the mouth of the Save River and Meculi are the most important.

	1964	*1965*	*1966*
Offshore trawling	—	0.1	0.1
Inshore fisheries (beach seines and traps)	0.4	0.4	0.6
Total	0.4	0.5	0.7

It is thought that commercially exploitable stocks of *Hymenopenaeus triarthrus* are present in deeper water off Mozambique, below about 200 fm, together with species of *Aristeus* and *Hemipenaeus* which might contribute to this potential fishery. It seems likely that future production may expand in the shallow areas to the north and south of the Limpopo River, along the sofala Bank as far north as the Zambesi River mouth; in deeper water, at a depth of around 250 fm, prawns are abundant from Moma to Mozambique Island.

No detailed data are available for the fisheries off Madagascar which are based largely on stake traps and are much diffused, but statistics are maintained by one firm which took 30 tons from 20 traps during 1959; FAO statistics indicate 1.3×10^3 tons in 1966 and this number seems reasonable. *Penaeus indicus* probably constitutes about 70% of the catches, *P. monodon* 15% and *Metapenaeus monoceros* a further 15%; *Penaeus japonicus* and *Trachypenaeus curvirostris* may be common at times but are never caught in large quantities by present methods. Some shrimp trawlers may have recently begun operations but no details are available of their landings. A small fishery for *Nephrops andamanicus* has recently developed.

There are no good statistical data for present prawn and shrimp production from Tanzania though the FAO statistics mention a production rate of 0.5×10^3 tons annually. It is known that small Japanese-operated trawlers have been exploring the coast, and recently have been reported to be taking 10 tons per day from the region north of Dar-es-Salaam. It is likely from survey work in this area that the species which they are taking are primarily *Penaeus monodon*, *P. semisulcatus* and *P. indicus*. There are small subsistence level fisheries using fixed traps in the Rufiji Delta where small quantities of large *P. monodon* and all sizes of *P. indicus* together with small quantities of *Metapenaeus* spp. constitute the catches. On the coast of Kenya, small boat operations in the extreme south (Shimoni), and in the extreme north (Lamu) have been building up over the last 18 months but there is no record of their catch rate, nor of the species involved; it is considered likely, however, that the catch composition will not differ very much from that of Tanzania. There is no knowledge of prawn resources off

the coast of Somalia, and there appears to be no fishery in that area. An annual spawning run of penaeid shrimps in the mouth of the Juba River has been recorded, and small numbers of penaeids are known to occur in the estuaries of other small rivers but these stocks have neither been quantified nor exploited.

In the Red Sea, the Gulf of Aden and off the southern Arabian Peninsula there are fisheries for *Penaeus semisulcatus*, *P. japonicus*, *P. latisulcatus*, *Metapenaeus monoceros*, *M. stebbingi*, and *Trachypenaeus curvirostris*, but only *P. semisulcatus* is likely to be important commercially. The only statistical data from this area are those from Egypt which in 1963 quoted a total shrimp and prawn catch of 10.4×10^3 tons but without any record of how much, if any, of this catch was taken from the Red Sea, or the Gulf of Aden. A very small seasonal cast-net fishery for prawns exists in Aden at the inlets to the salt pans.

In the Persian and Arabian Gulfs an important prawn fishery has grown up in recent years, in which *Penaeus semisulcatus* dominates the catches and which also include small quantities of *P. latisulcatus* and *Metapenaeus affinis*, except for the Hormuz Strait-Bandar Abbas region where *Penaeus merguiensis* may be the dominant species in the catches. The estimated total commercial catches from this area in recent years are tabulated below.

(tons × 10^3)		
1959—0.6	1962—0.9	1965—11.4
1960—1.1	1963—3.1	1966—16.1
1961—1.7	1964—5.8	1967—14.6

The total area of the Gulf off Iran, Iraq, Kuwait, etc. is about 239.0×10^3 km^2: of this total about 142.8×10^3 km^2 is shallower than 20 fm (*c.* 36 m). The exploitable area of the Gulf is so limited by sand banks and coral reefs along the Arabian side, and by soft mud in waters deeper than about 25 fm (*c.* 45 m), that only 10–20% of the total area may be trawlable, say 35.0×10^3 km^2.

In the past 2 years, 1966 and 1967, the catch per unit of effort has declined and in 1967 the total production also fell though it increased again in 1968. Some concern has been expressed for the stocks, but a very recent assessment has concluded that there is no clear evidence as yet that the decrease in total catch was due to fishing pressure either directly or indirectly. It has been acknowledged, however, that in the more heavily-fished areas a further increase in fishing effort might reduce the total catch. In view of the present status of the stocks, it would be unrealistic to expect any further considerable expansion of the fishery, although some further developments in the more lightly fished areas is possible, and a maximum sustained production rate of 15.0×10^3 tons is used here for these Gulfs.

Off West Pakistan, *Penaeus merguiensis* is recorded as outnumbering all other prawn species in catches from coastal waters, with *Penaeus semisulcatus*, *P. penicillatus*, *Metapenaeus monoceros*, and *Parapenaeopsis stylifera* also being important. Caridean species do not appear to be important. The total production of shrimps and prawns from these resources in the last few years is as follows:

(tons × 10^3)	
1961— 6.6	1965—18.0
1962— 4.6	1966—18.2
1963— 9.2	1967—17.2
1964—16.1	1968—15.5

Commercial fishing by shrimp trawlers is conducted in the 7–23 m depth zone along the 300 ml of this coast of Pakistan, and by beach seines in the creeks. The total fishing area is about 11.0×10^3 km^2. The catch statistics show a stabilization of catch since 1964 despite an increase in the number of boats from 226 in 1964 to 363 in 1968. Most of the fishing is concentrated within about 50 mi of Karachi. These grounds are probably fully exploited, but exploratory fishing has shown that good catches can be obtained on most distant grounds, especially south of the Indus. These grounds do not seem to be heavily exploited and the shrimp there are noticeably bigger. A sustained yield of 25.0×10^3 tons should be possible with a more rational distribution of fishing.

The present fisheries along the west coast of India are rather heterogeneous in their specific composition, and productivity varies markedly along the coast. On the northwest coast (Maharashtra and Gujerat) which produces over 50% of the catch, the prawns are rather small species, being dominated by *Metapenaeus affinis*, *Parapenaeopsis hardwickii*, *P. stylifera* and *Solenocera indica*. The dominant caridean species are *Palaemon tenuipes* and *Hippolysmata ensirostris*, and these are caught in enormous numbers, together with the sergestid *Acetes indicus*, from April–May and from November–December. The fishing techniques for all these species are fixed bag and stake nets.

Along the south-western coast of India there is a bigger variety of fishing gear used and the catch is distributed in the approximate proportions 3:3:2:sea (trawls, boat-seines):backwaters (stake nets, dipnets, cast nets):paddy fields. The most important species are *Penaeus indicus*, *Metapenaeus dobsoni*, *M. affinis* and *M. monoceros* (marine and backwaters), *Parapenaeopsis stylifera* (only at sea), and *Macrobrachium rosenbergii* (only riverine). The purely fresh-water species are of small importance and *M. rosenbergii* is caught in very limited quantities in certain areas only. The production from the Indian west coast of penaeids and caridean prawns in recent years is tabulated below:

Year	*Penaeid*	*Caridean* (tons × 10^3)	*Total*
1960*	27.5	35.0	62.5
1961*	32.9	22.0	54.9
1962*	42.2	34.6	76.8
1963*	30.7	39.5	70.3
1964*	52.0	30.2	82.2
1965†	28.0	41.0	69.0
1966†	45.7	34.7	80.4

* Data from Indian Fisheries Department
† Data from FAO

The littoral prawns which are currently exploited occur down to about 30 m along the west coast of India but all the best areas are inside the 35 m line. Survey fishing in the 100–200 fm (180–360 m) range shows fairly large numbers of *Penaeopsis rectacuta* and *Aristeus*

semidentatus, but there is no estimate of the likely production from these deep water resources. From the manner in which the production has been rising in the last 5 years and from the fact that no production has yet been made from deep water resources it is considered for present purposes that a 20% increase over present production is quite likely, and a total production of 100.0×10^3 tons for the total west coast of India catch in the future years is, therefore, assumed.

Thirty-one species of penaeid prawn have been recorded from the waters of Ceylon. No analysis of the specific composition of prawn catches has been undertaken but the following species have been classified as being abundant on the west coast: *Penaeus indicus*, *P. merguiensis*, *P. semisulcatus*, *Metapenaeus dobsoni* (most abundant of all penaeids, but small in size), *Trachypenaeus salaco*, and *Parapenaeopsis coromandelica*. Only the first three of these species are likely to be of major commercial importance, and caridean prawns are of negligible importance. The catch in 1965 was 770 metric tons from Ceylon and it does not appear that the catches have yet passed the level of 1.0×10^3 tons annually which is suggested here as the potential production from the west coast of Ceylon.

The prawn catches in the Western Indian Ocean may be summarized as follows: *Penaeus indicus*, one of the species in which the juvenile passes a part of its life in a fresh or brackish water environment is the dominant prawn along most of the southern part of the East African coastline, and of Madagascar. Further northward (with increasingly arid terrestrial conditions) the dominant species are those which are less dependent on fresh-water habitats, such as *P. semisulcatus* and *P. merguiensis*, although post-larvae of both these species will migrate into fresh or brackish water areas if they can. These three species may all grow to a good size. The west coast of India has a much more varied penaeid fauna than do the regions to the west, and some elements are rather small in individual size; it is difficult to be certain which are the most important species in the absence of objective data, but further to the south, off Ceylon, all three of those mentioned above are important in the catches.

Wherever it is taken, namely throughout the region excepting the Red Sea, *Penaeus monodon* usually makes an important element of the catches, not because it is abundant but because of its very large adult size and excellent price in the market.

D. *Total resource potential of Region VII*

From calculations based upon the catch per km² per year over various prawning grounds in the Western Indian Ocean and on the assumed total area of hypothetical prawning grounds, Hall suggests that the total potential production of penaeids in the Western Indian Ocean might be approximately twice the present level and the production of caridean shrimps would be additional to this. This would give a total production of at least 200.0×10^3 tons annually and this is used as the regional potential for present purposes even though it is not supported in detail in the following tabulation of present and potential production in Region VII.

	*Present**	*Potential*†
	(tons × 10^3)	
Spiny lobsters		
Africa	<0.3	3.0
Madagascar	<0.1	<0.1
	(0.4)	(3.1)
Penaeid prawns		
Mozambique	0.7	1.0
Tanzania	0.1	0.5
Kenya	0.1	0.5
Red Sea, etc.	5.0	5.0
Persian Gulf, etc.	16.1	20.0
West Pakistan	18.2	25.0
India, west coast	45.7	50.0
Ceylon, west coast	0.8	1.0
Madagascar	1.3	1.3
	(86.6)	(104.3)
Caridean shrimps		
India, west coast	34.7	40.0(?)
	(34.7)	(40.0)
Total	121.7	147.4 (= 200.0, Hall)

* Data from most recent available year.
† Because of lack of data on present production a potential has not been guessed for portunid crabs, but this may be large.

Region VIII—Eastern Indian Ocean

This region extends from the east coast of Ceylon, around the Bay of Bengal and includes, at its extreme southeast corner, the western coast of Australia, the Indian Ocean coasts of Sumatra and Java, and the west coast of Malaya and Thailand.

A. *Spiny lobster resources*

The only part of this region for which there are data on the occurrence of spiny lobsters and on the production of fisheries for them is Western Australia. Several species occur here but only one, *Panulirus longipes cygnus* supports the important fishery. This species occurs from 21°–34°S along the west coast of Australia, the majority of the commercial catch being taken from 28°–32°S, the crayfish boats operating from a number of ports between Fremantle and Geraldton. Fishing grounds are approximately 24.0×10^3 km² of water shallower than 155 m, though not all of this areas has substrate suitable for this species. During the "red crayfish season", the boats may operate from offshore islands such as the Houtman Abrolhos Islands. The fishing season extends from late spring through to the next southern winter and catch data are, therefore, given for pairs of years. The production for recent seasons follows:

(tons × 10^3)	
1958–59—8.0	1963–64—8.1
1959–60—8.8	1964–65—7.4
1960–61—8.2	1965–66—8.0
1961–62—8.7	1966–67—8.6
1962–63—9.1	1967–68—9.9

A sustainable level of catch of $8 \pm 1 \times 10^3$ tons per year has been suggested (Bowen and Chittleborough 1966, Sheard 1962). Present exploitation rates are high (exceeding 60%).

The southern crayfish (*Jasus novaehollandiae*) is common on the coast to the south of 33°S, but surveys have failed to find sufficient to support a fishery in this region.

On the western coast of Australia north of 22°S, several species of panulirids occur (*P. versicolor*, *P. penicillatus*, *P. ornatus* and *P. polyphagus*). Local areas of abundance have been claimed for certain of these, but test fishing failed to obtain any catch although various types of traps and bait were used. The potential resource of these species is not known, but it is not considered to be high in this region.

B. *Crab resources*

Crabs are taken in small quantities in Western Australia and throughout the region. The same remarks as were made for Region VII apply also to this region in regard to this resource, which is presently unquantifiable.

C. *Shrimp and prawn resources*

The catch of prawns along the east coast of Ceylon in 1965 amounted to 1.5×10^3 tons; no analysis of the specific composition of the catches has been made, but the following species have been recorded as being abundant: *Penaeus indicus*, *P. merguiensis*, *P. semisulcatus*, *Metapenaeus affinis*, *M. ensis*, *M. dobsoni* (most abundant of all penaeids, but rather small in size), *M. elegans*, *Metapenaeopsis stridulans*, *M. toloensis*, *Trachypeneus salaco*, *Atypopeneus stendodactylus*. The first three of these species are undoubtedly of the greatest importance but the others, excluding *T. salaco*, may be abundant locally. Caridean species are of negligible importance in this area.

There are not data available on the status of the exploited stocks, but the 1965 catch apparently came entirely from the 0–20 fm range, so the deeper resources at the edge of the continental shelf which may be assumed to exist have neither been surveyed, nor are in production.

The prawn fisheries along the east coast of India amount to 10.0 to 12.0×10^3 tons annually; the most important species are *Penaeus indicus*, *P. monodon*, *P. semisulcatus*, *Metapenaeus dobsoni*, *M. affinis*, *M. brevicornis* and the caridean species *Palaemon styliferus*. There are four areas within which the resources are most abundant: (a) rivers and other entirely freshwater areas, dominated by species of *Palaemon* and *Macrobranchium*, of which *M. rosenbergii* is the largest, although *P. styliferus* dominates the riverine catches numerically; (b) the Chilka, Kolleru and Pulicat Lakes, which are major coastal lagoons, and which produce more than 1.0×10^3 tons annually from small locally-made shrimp traps. *P. indicus* constitutes some 65% of these catches, with *P. monodon* and *Metapenaeus monoceros* contributing about 15% each; (c) the deltaic areas of the River Ganges which also produce about 1.0×10^3 tons annually and where *Metapenaeus brevicornis*, *Parapenaeopsis*, *sculptilis*, *Palaemon styleriferus* and *Acetes indicus* are the most important species; (d) offshore areas accounting for most of the balance of the prawn catches, and producing almost 10.0×10^3 tons annually. The catches of the Andaman and Laccadive Islands are not included in these statistics, nor in those tabulated below, and are less than 5 metric tons annually. The total catches from the above four areas during recent years are tabulated.

Year	*Penaeid*	*Caridean* (tons × 10^3)	*Total*
1960*	4.3	1.3	5.5
1961*	6.2	1.7	7.9
1962*	6.0	0.4	6.4
1963*	10.3	1.0	11.3
1964*	11.4	1.3	12.7
1965†	7.9	0.4	8.3
1966†	9.8	0.7	10.5

* Data from Indian Fisheries Department
† Data from FAO

Again, as for the coast of Ceylon, the entire production from the Indian sector of the Bay of Bengal is from shallow water from 0-20 fm and does not include any production from such deeper resources at the edge of the continental shelf and below as may be assumed to exist.

Along the coast of East Pakistan, a fishery for palaemonid species flourishes during the rainy season when the salinity of the coastal waters is lowered by the rains, but during the remainder of the year the catches are dominated by penaeids, among which the most abundant appear to be *Penaeus semisulcatus*, referred to as the most important in the deltaic region and *P. indicus* and *Parapenaeopsis sculptilis*.

Commercial fishing is currently carried out entirely in estuarine areas, and has hardly expanded yet onto the continental shelf and certainly no catches are produced from the deeper resources which presumably exist in the Bay of Bengal.

There are no published data on the prawn and shrimp fishery of Burma, since the statements that the 1953 to 1954 season's catch from the floating prawn traps in the deltaic area took approximately 5.0×10^3 metric tons. There are certaintly very extensive unexploited resources in the shallow continental shelf area but these are apparently unknown at present, although Hall suggests that the Gulf of Martaban (which exceeds 35.0×10^3 km^2 in area) may be particularly valuable.

There are no good data on the prawn fisheries from the west coast of Thailand, for it is not possible to separate the catches from the east and west coasts in the fishery statistics from this country, which show that the total catch of marine and estuarine prawns in 1966 was 45.3×10^3 tons. It is considered however that the bulk of these catches came from the east side of the peninsula (see Region IX), and based on the relative length of the coastlines, the distribution of the human populations, and the location of major rivers, Hall suggests that possibly 10% of the catch may be associated with the Indian Ocean, e.g. marine and estuarine—4.5×10^3 tons; freshwater—0.3×10^3 tons.

By comparison with the specific composition of catches from Penang and the Alor Star area of northern Malaysia it is probably that the dominant marine species on the west coast of Thailand are *Parapenaeopsis harwickii*, *P. hungerfordi*, *P. sculptilis*, *P. coromandelica*, *Penaeus merguiensis*, *Metapenaeus brevicornis* and *M. affinis*. In the mangrove areas with a fresh or brackish environment the dominant species are likely to be *Penaeus indicus*, and *Metapenaeus ensis*.

There is no recent information on the Indonesian

prawn fishery which will enable us to separate the catch along the Indian Ocean coast of Sumatra and Java from that along their northern coast; but, bearing in mind the steepness of the Indian Ocean coastline profile of these islands compared with the Strait of Malacca/Java Sea profile, and the concentration of populations on the side away from the Indian Ocean, possibly 5% of the catch should be attributed to the Indian Ocean. Hall suggests that this is a total of a little less than 1.0×10^3 tons annually. The catches from Indonesia, like those from India, consist of four fairly distinct elements: (a) the marine catch taken by trawling, (b) the penaeid catch taken from prawn ponds, of which the most important species are *Penaeus indicus*, *P. semisulcatus* which is appreciated for its large size, *Metapenaeus ensis* and *M. brevicornis*, (c) the non-penaeid shrimp catch consisting mostly of fairly large freshwater species of which *Macrobrachium rosenbergii* is the most appreciated and very widely distributed. Other species quoted are *M. equidens*, *M. pilimanus*, *M. sintangense* and *M. lar*, (d) the non-penaeid catch consisting mainly of small atyids and Caridina species, but including also mysids and possibly *Acetes* spp., the importance of which lies in their vast numbers of small individuals.

Along the west coast of Malaysia the fishery for Udang prawns, or large penaeids, is not detailed statistically but in the south the important species are probably the same as those at Singapore, with the following being the most abundant: *Metapenaeus ensis*; *Penaeus indicus*; *Metapenaeus burkenroadi* and *affinis*. Local variations occur, so that inshore Malacca catches have *M. affinis* as a major element while *Penaeus merguiensis* is important in the northwest of Malaysia, where inshore fisheries tend to de dominated by *Parapenaeopsis* species, especially *P. hardwickii* and sometimes *P. coromandelica*. *Metapenaeopsis barbata* occurs in offshore catches along with other species of this genus and other genera.

The present annual catch from the Udang prawn fisheries is of the order of 25.0×10^3 tons altogether, this figure being dominated by the west coast and Malacca Strait total of 21.0×10^3 tons. There are no exact data on the status of these prawn stocks, but there may be some over-fishing in the inshore areas, while there are also considerable areas of mangrove and offshore grounds which are scarcely exploited. Thus, the fishery can withstand considerable increase in intensity, and a total of, say, 35.0×10^3 tons does not appear impossible for this fishery in the foreseeable future.

The fishery for Udang baring shrimps depends on several species of Acetes. In the south *Acetes vulgaris* comprises most of the catches, but in the north *A. sibogae* is important, while *A. erythraeus*, *A. spiniger*, and *A. japonicus* occur generally. Perhaps all species of this genus except the planktonic *A. serrulatus* are of some importance locally or seasonally. The catch may sometimes contain small quantities of mysids such as *Mesopodopsis* but these are seldom important. Production figures are approximately 5.7×10^3 tons for the west coast and Malacca Straits and there are no indications that the fishery is over-exploited, as these small prawns occur everywhere in immense numbers. It seems certain that the production figures could be raised to about 7.5×10^3 tons annually. The freshwater shrimp *Macrobrachium rosenbergii* is caught in estuaries, and is a valuable item of pond fish culture.

In addition to the above a fair quantity of small prawns is included in the landing statistics under the "mixed fish" and "manure fish" categories but there are no accurate data on the proportions. A fair percentage of beach catches certainly go unrecorded where they are used for local consumption by villagers, and there are also unrecorded subsistence fisheries in freshwater for *Atya spinipes*, species of *Macrobrachium* including *lanchesteri*, *geron*, *trompi*, *sintangense*, and *javanicum*. In our view all of these fisheries are currently neglibible.

Collections made by the former Singapore Regional Fisheries Research Station now held in the University of Singapore Zoology Department indicate that there may be commercial quantities of the pandalid prawn *Plesionika martia* along the upper part of the continental slope off northern Sumatra and north-western Malaysia, and this is entirely in agreement with assumptions that might have been made on the grounds of explorations in other parts of the tropical seas.

Finally, in the extreme south-eastern part of the region a trawl fishery is developing rapidly along the continental shelf of Western Australia, being presently concentrated mainly in Shark Bay and in Exmouth Gulf. Based on the exploitation of *Penaeus esculentus* (50% of production), *P. latisulcatus* (49%) and *P. merguiensis* (1%), this fishery has produced in recent years as follows:

1962—0.3	1966—1.2
1963—0.7	1967—2.2
1964—1.1	1968—1.4
1965—1.1	1969—2.1

Fishing operations reached Shark Bay in 1962 and Exmouth Gulf in 1964 and are presently extending to the northward; until this extension is completed, catches from this fishery will probably be regulated at somewhere near the present level by management procedures. A small fishery with handnets for *Metapenaeus bennettae* in the estuaries of Western Australia is not identifiable in currently available statistics and the landings are considered negligible for present purposes.

D. *Present production and future potential of Region VIII*

Apart from the coastline of north-western Australia the coasts of the Eastern Indian Ocean receive an abundant rainfall and the dominant species are those which spend a part of their juvenile lives in a fresh or brackish environment, and include: *Penaeus indicus*; *Metapenaeus monoceros*, *M. ensis*, *M. affinis* and *M. brevicornis*; *Penaeus semisulcatus* and *P. monodon* (which are appreciated for their size). Further offshore, species of *Parapenaeopsis* may dominate in the catches and note must be taken especially of the small *Macrobrachium rosenbergii* which extends from India to North Australia and is the most appreciated of the non-penaeid species. No studies have been undertaken on the status of any of the stocks in the Eastern Indian Ocean but there can be no doubt that throughout much of the region there appears to be little or no offshore exploitation which suggests that the resources in general are under-exploited. The Table indicates the present production of the various

types of resource from each country in the region together with a tabulation of the estimates that have been made in the text on the potential resources. It is to be noted that the figure of 53.0 as the potential production from the Eastern Indian Ocean excluding Malaysia and Western Australia is derived from the estimates of Hall, who based his figures on an area, and catch rate per area basis.

	Present (tons × 10^3)	*Potential*
Spiny lobsters		
Western Australia	8.6	8.0
Crabs		
Region	+	+
Prawns and shrimps		
Ceylon, east	1.5	
India, east	10.5	
Pakistan, east	7.8	
Burma	5.0	53.0
Thailand	4.8	
Indonesia	0.8	
Malaysia	26.7	42.6
Australia	2.1	5.0
Total	67.5	108.6

Region IX—Western Central Pacific

This includes most of Oceania, the coast of Asia from Japan to Singapore and the islands and archipelagos lying between Japan and New Guinea. Much of the region consists of enormous reaches of open ocean, sparsely studded with small islands, but paradoxically it also includes the greatest area of continental shelf occurring within tropical latitudes. The archipelagos of the Philippines and Indonesia, together with the smaller island clusters and the coast of southeat Asia, include an immense length of tropical coast line (there being 14.0×10^3 islands in the Philippines alone). This is a region of heavy rainfall and many rivers, creeks and lagoons open onto the continental shelf, and the coast itself is often low-lying and includes many sheltered, low salinity, muddy bays and gulfs. It is no surprise, therefore, to find that the statistics indicate a wealth of prawn resources, perhaps the greatest in the tropical seas, and largely unexploited.

A. *Spiny lobsters and similar resources*

The fishery for spiny lobsters is small by comparison with that of Australia and New Zealand, but some are taken in many places, notably Japan (1.6×10^3 tons per year), and Taiwan (0.1×10^3 tons per year). It is probable that in many places the landings of spiny lobsters are hidden in statistics of other crustaceans, rather than being identified specifically.

Spiny lobsters occur throughout the tropical regions and are probably an extremely under-exploited resource in this region; although population densities are unlikely to be high in tropical latitudes the stocks are sufficient to support small fisheries. A few vessels from New Zealand have, at times, fished the Kermadecs and Tonga, among other islands.

It seems probable that an estimate of 5.0×10^3 tons is not too high an estimate for the potential annual yield from the whole of this vast region. Similar species, such as the *Nephrops andamanica* which occurs along the continental edge off Hong Kong, would contribute to this total. Flapjack lobsters, *Thenus orientalis*, are caught in the Gulf of Thailand and on a small scale off Malaysia and Singapore, but there are no exact figures on production.

B. *Crab resources*

Many species of crabs are taken throughout the region; though not specified in most of the statistics, these appear to be largely portunid swimming crabs of several genera with *Scylla servata* and *Portunus pelagicus* predominating. This fishery is homologue of the blue crab fishery in the Western Atlantic.

Known catches of crabs in the region in 1965 were:

	(tons × 10^3)
Malaysia	1.5
Thailand	11.0
China (Taiwan)	1.8
Japan	25.0
Total	39.3

It may be safely assumed that the real catches of the region are actually at least 50.0×10^3 tons per year, since in many places (such as the Philippines) crabs are certainly caught, but are not identified in the available statistics.

The relatively short coastline of the eastern seaboard of the USA produces about 75.0×10^3 tons of *Callinectes* per year at close to maximum exploitation levels; it is not unreasonable to suppose that Region IX, with its very much greater shelf area and length of coastline could produce twice this quantity or 150.0×10^3 tons per year. This may be a gross under-estimate and the appropriate factor may rather be $\times 10$ than $\times 2$.

C. *Prawn resources*

Here the data are rather better, and it will be convenient to discuss the resources by five sub-regions.

(i) The Sunda Islands and New Guinea

Indonesia

Data are rather sparse, but suggest that the resources are large and under-exploited. No detailed statistical data exist on present fisheries, which Ivanov (1964) places at 2.5×10^3 tons, and which primarily exploit *Penaeus indicus* and *Metapenaeus ensis*, though it is reasonably certain that all species which are of economic value in Malaysia are also fished by Indonesia. It is known also that Belachan shrimp (*Acetes* sp.) are exploited, as are Terasi (juvenile penaeids, etc., and Mysidacea) for use as shrimp paste. Freshwater *Atya* and *Caridina* are also fished on a subsistence scale in many areas, especially in the Celebes.

In general, this area is very rich in prawn resources, and Malaysian fishermen consider it to be richer than their own waters; although the results of Indonesian resource surveys off Java and West Irian are yet to be published, it is reasonable to suppose that a potential of 100.0×10^3 tons is not too high for Indonesia. This, is, however, purely conjectural.

Brunei

Contiguous to grounds exploited by Malaysian fishermen, there is known to be a small fishery here which primarily exploits *Penaeus merguiensis*. No production data are available, but it is probably less than 1.0×10^3 tons.

Sabah

Some 21 species of penaeids are known to occur in the local fishery, and *Penaeus indicus* and *P. merguiensis* are the most important; the present production is about 3.0×10^3 tons per year, heads-on, from an estimated exploited area of 7.0 to 10.0×10^3 km^2.

Control measures exist and only the western fishery region seems likely to be capable of expansion, to an uncertain extent. It is suggested that a fishery for *Acetes* spp. could be developed in mangrove areas, as in Brunei and Malaya.

A total potential of 4.0×10^3 tons may be reasonably deducted from these observations.

Sarawak

Fishing is still on a small scale and though prawns (mostly *Penaeus indicus*, *P. monodon*, *P. merguiensis* and four species of *Metapeneaus*) are known to be present in commercial quantities, no production figures or estimates of potential are presently available. It is assumed here that a catch of at least 1.0×10^3 tons is possible annually.

Timor and Papua/New Guinea

No data are available for this area, though it is evident that resources must exist. From the size of the area, it seems that at least 10.0×10^3 tons could be taken.

Northern Territories, Australia

Exploitation of the northern, tropical prawn resources has only just begun, following resource surveys by CSIRO which indicate that the potential of this region exceeds that of the rest of Australia several-fold. A prawn-fishing base has been established on the Gulf of Carpentaria at Karumba, where 14 vessels landed 0.45×10^3 tons in 1967, and 40 vessels 1.36×10^3 tons up to August in 1968. Catches by mother-ship fleets of Japanese trawlers in the Gulf are not known, but are probably similar to the above.

The CSIRO resource surveys in the tropical northern regions indicate a potential of 11.4×10^3 tons for the Gulf of Carpentaria or 20.0×10^3 for the whole of the northern territory, and these estimates are certainly conservative.

(ii) Oceania

Tahiti

The only data available suggest a very small fishery for *Macrobrachium lar*, at subsistence level, and with a production probably $< 1.0 \times 10^3$ tons.

Tonga

Some prawns are taken on a subsistence basis.

Samoa

Prawn resources are known to occur, but identity and magnitude entirely unknown.

Fiji

A resource survey indicates the presence of stocks of *Penaeus monodon* in commercial concentration, but no fishery has developed and potential is not known. A subsistence freshwater fishery for *Macrobrachium lar*, *M. australe* and *M. latimanus* occurs, but there are no production data although fishing is said to be "quite heavy", and extension seems likely.

Guam and Marianas

There is a small subsistence fishery for *Macrobrachium lar*. Potential is very limited.

(iii) Asian coastline

Singapore

Prawn trawling offshore is incidental to fish trawling and only the larger prawns are saved from the catch; these include the following species: *Penaeus indicus*, *P. monodon*, *P. semisulcatus*, *Metapenaeus intermedius*, *Parapenaeopsis probata*, *P. hardwickii*, *Metapenaeopsis barbata*, and *M. merguiensis*. About 0.4×10^3 tons are obtained this way each year, and although there is no indication of the extent of potential fishing grounds, it is believed that offshore stocks would sustain a specialized fishery for prawns. It is rather likely that the potential for the offshore South China Sea coast of Malaya and Singapore would be at least 10.0×10^3 tons annually.

A varied catch is made of other, inshore, species of prawns with a variety of gear, mostly on a subsistence level, based on: *Metapenaeus affinis*, *M. lysianassa*, *Parapenaeopsis* spp., *Metapenaeopsis* spp., *Acetes* and *Palaemon*. Some of these catches are made incidentally in beach fishing. Production from such means approximates 0.4×10^3 tons at present.

Pond culture of penaeids produces 0.1×10^3 tons per year, 97% of the production comprises *Penaeus indicus*, *Metapenaeus burkenroadi*, *M. brevicornis*. Also important are *Penaeus monodon* and *P. semisulcatus* because of their high individual value.

Malaya (Johore and East Coast)

There is a fishery here which depends on the same species as at Singapore, and in which *Penaeus indicus*, *Metapenaeus ensis*, *M. burkenroadi* and *M. affinis* are dominant. Total production from this area is currently 3.4×10^3 tons, and there are indications that some of the inshore areas are already over-fished, though great areas of mangrove remain to be exploited; offshore areas are relatively virgin, but their potential is included in the offshore area discussed for Singapore. A potential, excluding offshore reaches of the South China Sea, of 5.0×10^3 tons seems probable for this area.

Thailand

Prawn catches by the Thai fishery in the Gulf and South China Sea adjacent have increased significantly in recent years:

(tons × 10^3)	
1958—10.3	1965—35.2
1959—23.3	1966—45.3

Commercial samples and non-official data suggest that prawns are the mainstay of the Gulf of Thailand fishery, which is based on *Penaeus merguiensis*, *P. indicus*, *P. monodon*, and *P. semisulcatus*, together with some *Metapenaeus* spp. and *Metapenaeopsis barbata*, *Parapenaeopsis* spp. and finally *Acetes* spp. inshore.

From the manner in which the catches have been rising in recent years and from surveys such as those by Tiews (1965) it seems likely that although some increase is possible this may well not result in a rise beyond 50.0×10^3 tons, which will be used here as the potential of the fishery.

A small fishery for the freshwater *Macrobrachium rosenbergii* and *M. lanchesteri*, and brackish to freshwater species of *Alpheus*, produces about 5.0×10^3 tons annually; nothing is known the state of this fishery or of its potential for expansion.

Khmer Republic

A total of 0.5×10^3 tons of miscellaneous crustacea are taken annually, but it is not known what part of this total is formed by prawns; *Penaeus monodon* is known to occur in this catch, however. Status and potential of this fishery is unknown.

Vietnam

Published statistics suggest that catches in southern Vietnam before the present crisis amounted to 29.0×10^3 tons annually and catches in the northern part of the country may have been on the same order of magnitude. There appears to be no information as to the composition of the catch but at least in the south it is probably similar to the Thai catch. For present purposes, a potential catch of 50.0×10^3 tons is assumed for the whole of Vietnam since there are no data on which to estimate the potential of the resource more objectively.

China (mainland)

"Though no exact figures are available, the Chinese People's Republic is undoubtedly one of the largest shrimp producers in the world" (Ivanov 1964).

Ivanov further suggests that 100.0×10^3 tons of prawns are taken annually, of which 70.0 to 80.0×10^3 are from the Yellow Sea and are dominated by *Penaeus orientalis* and *Acetes chinensis*. Although the East and South China Sea have a more varied fauna of prawns and shrimps, the Yellow Sea is much more productive commercially.

Most of the production is by small boats at present and probably 90% of all products are consumed by the coastal population, though some is exported to Japan.

For the present purposes, the figure of 100.0×10^3 tons perhaps should be retained as the potential of the resource, but an increase by a factor of 1.5 seems very likely with eventual resource management and offshore exploitation, and 150.0×10^3 is taken as the potential of the area.

Hong Kong and Macao

Nineteen species of penaeid prawn occur in the Hong Kong catches, and presumably those at Macao are rather similar in composition. The catches seem to be dominated by *Penaeus semisulcatus*, *P. monodon*, *P. merguiensis*, *Metapenaeus intermedius* and *M. affinis*.

Latest production figures available for Hong Kong and Macao are for 1965 when 10.4 and 4.0×10^3 tons respectively were taken from around 8.0×10^3 km^2 of fishing grounds. Although nothing certain is known, it is believed that the catches can be increased, and the potential is thought to be in the region of 20.0×10^3 tons.

(iv) The Asian Islands

Philippines

The marine catches are now about 20.0×10^3 tons annually, including *Penaeus indicus*, *P. merguiensis*, *P. monodon*, *P. semisulcatus* (= *P. canaliculatus*?), *P. esculentus*, *Metapenaeus ensis*, *M. burkenroadi* and *Trachypenaeus curvirostris*. Although research is presently being conducted in the Philippines on the rather undeveloped prawn trawl fishery, little information is presently available from it; a catch of at least double the present production would seem attainable, and 50.0×10^3 tons is taken as the potential of this sub-region.

As usual in this region, small quantities (production figures lacking) of *Macrobrachium lar* and related species are taken in freshwater.

Taiwan

A prawn trawl fishery exists in which *Penaeus monodon* appears to figure rather largely, and for which there are few data beyond the total production which is presently around 14.5×10^3 tons (the 1965 figure). Since Taiwan has a much shorter coastline and smaller shelf area than the Philippines there appears to be no justification for supposing that a very great increase in landings might be possible, and the potential increase used here is a very modest 10%, to give a total of 16.0×10^3 tons. It should be noted that the shallow, wide shelf areas of Taiwan face westwards towards the Chinese mainland, and any potential here will be shared between the two fisheries.

Japan

The Japanese are major producers of shrimps and prawns, their 1965 catch being in the region of 66.6×10^3 tons; a portion of this came from the Northern Pacific (Bering Sea and Gulf of Alaska) and a portion from the Guianas and Australia, outside Region IX. The prawn catch from the Western Central Pacific has declined in recent years; after 1963 it is not possible to separate it in available statistical data from total landings:

(tons $\times 10^3$)
1961—$53.7 \times 1.5 = 80.5$
1962—$52.9 \times 1.5 = 79.3$
1963—$51.0 \times 1.5 = 76.5$

(production statistics are as "heads-off" weights, and a factor is applied above, and throughout this section).

If the known Bering Sea catches are subtracted from the 1965 total it appears that the Western Pacific total by 1965 may have dropped to as low as 55.6×10^3 tons, heads-on, but may have been higher than this, there apparently being some confusion in the data.

The bulk of the landings from the Western Central Pacific region are taken in (1) the Inland Sea, and (2) the Yellow Sea.

In the Inland Sea and similar home-island fishing areas *Penaeus japonicus* forms 25–35% of the catches, but about twice that percentage of their value. *Metapenaeus joyneri* forms about 20%, the small species *Trachypenaeus curvirostris*, *Metapenaeopsis barbata* and *Parapenaeopsis tenella* about 45%, and the large, valuable species *Penaeus monodon* and *P. semisulcatus* about 5%.

The fisheries in the Yellow Sea, the East China Sea and the Korean Bight, which produced about 1.0×10^3 tons annually in the early 1960s, are dominated by the oceanic *Penaeus orientalis*, which occurs in rather deep water, where it is fished by larger shrimp trawlers, especially between November and March.

There are no suggestions in the data now available for review that a potential for increase exists in the Japanese warm-water prawn fishery except in the distant waters of other areas of the Western Central Pacific region. It is likely that any expansion which might be possible in the offshore resources, such as in the *Penaeus orientalis* fishery, might be offset by losses in the nearshore fisheries, especially those of the Inland Sea, due to industrial and agricultural pollution and competition from other uses of these sea areas. A total of 60.0×10^3 tons, heads-on, annually is therefore used here as the long-term production to be expected from this area.

(v) Pond production

Pond production of larger species of marine prawns is practiced in several places within the region, and fractionally increase the total prawn production of the region. Recent data on prawns from these sources follow:

		(tons × 10^3)
Philippines	*Penaeus monodon*	1.0?
Singapore	15 spp. Penaeidae	0.1
Japan*	Various *Penaeus* spp.	0.3
Indonesia	Madura, Java	6.2
	Coastal ponds	3.0
China (Taiwan)	*Penaeus monodon*	?
		<10.0

* Ivanov, 1964, gives 2.0×10^3

The data and available information on this form of production show several things rather clearly: that while in some places there are great possibilities for extending pond area and production, in others it is a diminishing resource because of urban and other encroachment (e.g. Singapore); that production is either of high value, preferred species (as in Japan) in which case production sites must be near centres of demand, or of many small species of penaeids, caridians and mysids which are used for biological reduction to paste or for drying; and that production is highest where local populations have a tradition of animal husbandry and pond culture of various fishes, without which its introduction into a new area is probably difficult.

With these limitations, evidently it is not possible to place a limit on the possible expansion of pond cultured prawn production: geographic and economic factors, presently impossible to assess, are limiting and it is now only possible to point to the relatively small proportion this production forms of the total for the region and to indicate that it seems unlikely ever to form more than 10–25% of present production.

Ivanov (1964) and Iversen (1968) give good reviews of prawn culture in this region.

D. *Total crustacean potential*

The above discussion of the regional production at the present time has been reviewed below; this indicates a total crustacean production of 323.1×10^3 tons whole weight annually. This does not correspond with the FAO annual statistics of fisheries because it is compiled from numerous sources, not all referring to the same year; it simply confirms that the total production of crustacea, over and above subsistence level catches which do not enter statistical data bases in most areas, is probably near 350.0×10^3 tons annually in this region in recent years.

Using the various projections, which are necessarily of different validity and usefulness, that are used in the preceding discussions, a total production or around half a million tons of crustacea annually seems possible for this region: this may only be an order of magnitude projection, but serves at least to emphasize the great potential of the area. To this figure must be added about 10.0×10^3 tons for freshwater production and perhaps 50.0×10^3 tons for pond production, giving a grand total of 604.1×10^3 tons.

	Present	*Potential*
	(tons × 10^3)	
Spiny lobsters		
Japan	1.6	
Taiwan	0.1	5.0
Oceania	+	
	(1.7)	(5.0)
Crabs		
Malaysia	1.5	
Thailand	11.0	150.0
Taiwan	1.8	
Japan	≈25.0	
	(39.3)	(50.0)
Prawns		
(Sea)		
Indonesia	2.5	100.0
Brunei	<1.0	1.0
Sabah	≈3.0	4.0
Sarawak	?	>1.0
Timor/New Guinea	?	>10.0
Australia, Northern Territories	3.0	>20.0
Tahiti	?	>1.0
Tonga, Samoa, Fiji, Guam	+	+
Singapore	0.8	10.0
Malaya	3.4	5.0
Thailand	35.2	50.0
Khmer	0.5	0.5
Vietnam	50.0	50.0
China (Mainland)	100.0	150.0
Hong Kong/Macao	14.3	20.0
Philippines	20.3	50.0
China (Taiwan)	14.5	16.0
Japan	55.6	55.6
Total	(304.1)	(544.1)
Prawns		
(Freshwater)	10.0	10.0(?)
(Ponds)	<10.0	50.0(?)
Grand Total	323.1	604.1

Region X—Eastern Central Pacific

For the purposes of this review, Region X has been taken to include the western seaboard of the American continent

from the northern boundary of California (42°N) to the boundary Ecuador/Peru.

A. *Spiny lobster resources*

Spiny lobsters of a number of species occur the whole length of the region, but catch statistics are available only for Ecuador (0.3×10^3 tons in 1965) and Mexico (1.2×10^3), and in the latter case the data refer to both east and west coast catches combined.

In Mexico, a fishery occurs along the Pacific coast of Baja California for *Panulirus interruptus* and *P. inflatus*, and along much of the coast of the Gulf of California and of Sonora and other west coast states for *P. inflatus*; much of this production finds it way to US markets, but statistics on it are meager. It seems certain that increased production is possible, but could not be expected to exceed 5.0×10^3 tons annually for the whole of Region X, and this figure, probably too large, will be used as an order-of-magnitude estimate for present purposes.

B. *Crab resources*

Crabs do not appear in any of the available fishery statistics for the region except in the case of Mexico, and here the catch figures, totalling 1.5×10^3 tons in 1965 again include both east and west coasts of the country. It is certain, that as in most tropical regions, the crab resources are under-utilized; many species of portunid swimming crabs occur, some of large size, and (once again) reference should be made to the Callinectes production of the eastern seaboard of the USA, in comparison with the very small landings in Region X. It is probable that an increase in production by a factor of at least 10 would be possible, but a more modest estimate based on a factor of only 5 is used here, to suggest that the crab potential of the region may be placed for present purposes at 7.5×10^3 tons annually.

C. *Prawn resources*

About 10 species of penaeids figure in the landing statistics in Region X, and these are listed below. The species composition in the landings is rather constant throughout the region, which is faunistically fairly uniform, having important faunal boundaries to the north and south. Information for Mexico and for Ecuador is not so detailed as for the remaining six countries, but there is no reason to suppose that much of the information relevant to these countries is not also relevant to Mexico and Ecuador. Ivanov (1964) indicates that even in the ecologically unique Gulf of California the important species are among those listed below as being important further to the south.

(a) White shrimp—Camaroncillo	*Penaeus vannamei* *P. occidentalis* *P. stylirostris*
(b) Brown or white—Café o blanco	*P. californiensis*
(c) Pink or red—Rojo	*P. brevirostris*
(d) Seabobs, tiger—Camaroncillo	*Trachypenaeus byrdi* *T. similis* *T. faoea*
(e) Seabobs—Titi	*Protrachypene precipua* *Xiphopenaeus riveti*

Although some mixing among stocks of prawns probably occurs between neighbouring countries, especially in Central America, all fishing fleets operate off their own national coasts and the fishing effort in relation to the available resources varies markedly; for these reasons, the data for landings and fishing effort for each country are here kept separate.

Relative abundance of species in the landings may not have any ecological significance: because *P. californiensis* and *P. brevirostris* live relatively deep, they are normally fished for only when shallower-living species are scarce, and the relative abundance of the various species of seabobs in the landings do not necessarily indicate their relative abundance on the grounds. In most fisheries, seabobs are frequently discarded at sea when prices are not favourable.

Fishing effort is primarily directed at white shrimp (*P. occidentalis*, *P. stylirostris*, *P. vannamei*, plus, in Panama and Costa Rica, *P. californiensis*). Adults of these species have similar ecologies and it is likely that their relative abundance in the landings does, in fact, represent their real abundance on the grounds. Some variation in relative abundance occurs: in Colombia, *Penaeus occidentalis* forms the bulk of the landings, as in Ecuador and Panama, but farther north, in El Salvador, it forms only about 30%. Here and northwards *P. vannamei* attains dominance in the landings.

The shrimp resources show marked local concentrations throughout the region off the mouths of rivers and estuaries, and in muddy bays and gulfs; small fisheries occur in the brackish areas of estuaries, lagoons and embayments but there are no statistical data on these, which seem to be directed at the juvenile stages of several important species of white shrimp, especially *P. vannamei* and *P. stylirostris*.

Landing data for white shrimp are more detailed than for the other groups and in most countries include effort and size frequency information.

In each country, the landings of white shrimp increased as the fleet built up while the catch per unit effort declined from an initial high. As this process developed, trips were made into progressively deeper water and fish and brown shrimp began to appear in the landings and the larger seabobs, previously discarded, began to be landed. In most countries the fishery for white shrimp appears to be stabilized, though there are considerable yearly fluctuations in availability; with the possible exception of Nicaragua, it seems that little increase in yield is possible except by curtailment of effort.

The landings of seabobs have fluctuated independently of the fishing effort and economic and technological factors have been casual. A further modest increase in seabob landings is clearly possible when it becomes economically practicable, especially for *Protrachypene* and *Xiphopenaeus*.

The landings of red and brown shrimp appear to be relatively stable but their exploitation is probably limited by the limited capabilities of the trawlers in the present fleets for trawling in deeper water, below about 50 fm, and perhaps by a coincidence of the time of their peak abundance with that of white shrimp, always the preferred object of the fishery.

TOTAL LANDINGS, ALL PRAWNS (TONS × 10^3)

	1961	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*
Ecuador	6.4	6.7	5.2	5.0	5.7	+	+
Colombia	1.8	1.8	0.9	1.0	0.9	1.0	+
Panama	5.5	6.1	5.6	7.1	5.9	5.6	+
Costa Rica	0.9	1.0	1.0	1.2	1.1	1.1	1.2
Nicaragua	+	+	+	+	0.3	0.9	0.9
El Salvador	3.9	3.8	3.5	8.5	3.1	4.6	3.5
Guatemala	0.6	1.0	0.8	1.3	0.8	1.4	1.1
Mexico	54.2	52.0	52.9	51.7	44.3	41.7	42.9
Total	(73.3)	(73.3)	(69.9)	(70.8)	(62.1)	(61.0)	+

It appears from the data presently available that the total prawn production in the region is about 65.0 × 10^3 tons; it is not unreasonable to suppose that increased effort on fish and brown shrimp, and decreased discarding of seabobs could certainly raise the annual production to at least 75.0 × 10^3 tons per year, which is taken as a conservative estimate for present purposes.

D. *Galatheid resources*

Five species of galatheid crabs are known to exist in mass occurrences, mostly in highly eutrophic regions of the ocean. Two of the species (*Munida gregaria* and *Pleuroncodes planipes*) occur in vast pelagic swarms as juveniles or young adults, and both species graze on diatom blooms when in the pelagic phase. These two species, and *Munida subrugosa* of the sub-Antarctic and *Cervimunida johni* and *Pleuroncodes monodon* of Chile also occur in massive benthic concentrations, usually of larger individuals.

Off both coasts of Baja California, *Pleuroncodes planipes* occurs in vast concentrations in both the pelagic and the benthic phase. It has also been found between Costa Rica and Mexico in 150–250 m. It appears likely that a fishery could be developed for it, and catch rates of 2.5 tons per hour with a 30 m^2 mid-water trawl are likely. The fishery for galatheids off Chile and Peru has been suggested to have a potential production of 50.0 × 10^3 tons per year, and it seems certain that at least half this quantity could be taken from the bottom-living stocks of *Pleuroncodes planipes* on a sustained basis. A potential of 25.0 × 10^3 tons per year is, therefore, used for our present purposes. (A suggestion that potential could be extremely large, taking into account the pelagic phase of *Pleuroncodes* is given in the section on oceanic resources.)

E. *Total regional potential yield*

This may be derived from the following tabulation which groups the estimates discussed above:

	Present (tons + 10^4)	*Potential*
Spiny lobsters	?	5.0
Crabs	<1.5	7.5
Prawns	65.0	75.0
Galatheids	—	25.0
Total	66.5	112.5

LANDINGS AND LANDINGS PER UNIT EFFORT FOR FOUR GROUPS OF PRAWN SPECIES

Species	*Landings—tons × 10^3 per year*							*Landings(kg) per boat per day*						
	61	*62*	*63*	*64*	*65*	*66*	*67*	*61*	*62*	*63*	*64*	*65*	*66*	*67*
Guatemala														
White shrimp			0.2	0.3	0.3	0.4	0.2			40	60	48	52	29
Brown shrimp			0.5	0.5	0.4	0.5	0.4			130	161	121	114	50
Pink shrimp			+	×	0.05	0.1	0.2			+	+	5	21	23
Seabobs			0.2	0.5	0.2	0.4	0.2			46	85	36	59	26
El Salvador														
White shrimp	1.8	1.6	1.6	1.7	1.0	1.6	1.0	115	98	92	90	56	80	54
Brown shrimp	0.5	0.1	0.1	0.1	0.04	0.1	0.1	114	104	97	96	60	85	58
Pink shrimp	0.8	0.5	0.5	0.4	0.5	0.5	0.4	49	34	26	20	23	25	21
Seabobs	0.9	1.5	1.3	1.2	1.6	2.4	2.0	61	93	71	64	84	122	101
Nicaragua														
White shrimp					0.1	0.5	0.3					82	137	74
Brown shrimp					0.1	×	0.05					115	166	85
Pink shrimp					0.1	0.3	0.3					55	93	67
Seabobs					×	0.1	0.2					×	53	48
Costa Rica														
White shrimp	0.4	0.3	0.3	0.5	0.3	0.3	0.3	×	31	31	63	29	31	×
Brown shrimp		×	×	×	×	×	×	49	×	×	×	×	×	×
Pink shrimp	0.1	0.2	0.2	0.1	0.1	0.1	0.2	9	23	17	9	16	14	×
Seabobs	0.5	0.5	0.6	0.6	0.6	0.6	0.5	71	62	63	68	78	57	×
Colombia														
White shrimp	1.0	1.0	0.8	1.0	0.9	1.0		86	74	85	113	102	106	
Brown shrimp	+	+	+	+	+	+			+	+	+	+	+	
Pink shrimp	+	+	+	+	+	+		+	+	+	+	+	+	
Seabobs	+	+	0.2	+	+			×	×	20	+	+	+	
Panama														
White shrimp	2.1	2.0	1.6	2.3	2.3	2.4	+	×	56	39	41	38	43	
Brown shrimp		+	+	+	+	+	+	59	+	+	+	+	+	
Pink shrimp	1.2	1.5	1.3	1.1	1.3	1.2	+	33	42	33	21	22	21	
Seabobs	2.2	2.4	2.7	3.6	2.3	2.1	+	62	66	67	67	38	38	

Region XI—Southwest Atlantic

This region has a very great latitudinal extent from the eastern border of Venezuela down to the southern tip of South America continent and the Falkland Islands; this encompasses a very considerable diversity of ecosystems from tropical continental shelves in the north, much influenced by the great rivers of Surinam and Brazil, through the sub-tropical continental shelves of southern Brazil and Argentina, to the Antiboreal regions of the south. As might be supposed, the major crustacean resources are those for shrimp in the regions of the major tropical river mouths, particularly in northern Brazil, Surinam and the Guianas, and also in the region of the rather extensive coastal lagoons and estuaries between northern Argentina and southern Brazil.

A. *Lobster resources*

There is a valuable fishery for spiny lobster, mainly *Panulirus argus* and *P. laevicanda*, along the coast of central Brazil from Belem to Santos; peak catches in recent years were made in 1962 when 4.3×10^3 tons were taken (Boschi), although the FAO statistics show a rather smaller number (2.9×10^3 tons) for this year. This stock has been the object of international fisheries in some years, having been exploited not only by local boats, but also by French langoustiers fishing for the French domestic market. It is probable that this stock is fairly heavily fished and no great increase in sustainable yield can be expected from it. For present purposes its potential is considered to be 4.0×10^3 tons, or near the present production. Negligible quantities of this species, and of other spiny lobsters, are taken off the coast of Surinam and the Guianas.

B. *Crab resources*

Rather more than 15.0×10^3 tons of crabs of various species, mostly swimming crabs of the family Portunidae, are taken on the Brazilian coast south of Santos. There are no data on the degree of exploitation of these resources or on their future potential which is here taken to be 20.0×10^3 tons, to reflect the steady increase in production in recent years.

C. *Shrimp and prawn resources*

The shrimp and prawn resources of this coast which are presently exploited comprise approximately 12 species which are tabulated below. The FAO landing statistics for shrimps and prawns for the east coast of South America indicate clearly that Brazil is the dominant producer followed rather distantly by Guiana.

Guiana

Until 1959, the only production of shrimps in Guiana were from the inshore Chinese shrimp nets which took only small quantities of the very small *Palaemon schmitti* and *Hippolysmata oplophoroides*. However, in 1959, offshore explorations by US shrimp boats discovered good stocks on the continental shelf of very large penaeids, and the recently increasing production year-by-year is due to initiation of production from these sources. The offshore stocks appear to be dominated by *Penaeus duorarum notialis* and by *Penaeus aztecus subtilis*. The former comprises about 80% of the landings from these stocks, and the latter only about 20%. Production is now probably in excess of 5.0×10^3 tons, and potential is expected to be at least 10.0×10^3 tons annually.

Surinam

In this country the situation is rather similar to that in Guyana, and until recent years only inshore stocks of seabobs (*Xiphopenaeus kroyeri*) were exploited, but more recently continental shelf stocks of penaeid shrimps, which appear to be dominated by *Penaeus brasiliensis*, have been discovered offshore at around 50 m depth and these have increasingly contributed to the landings as a small fleet of shrimp trawlers has built up. The catches from the continental shelf from Guyana, Surinam and the neighbouring territory of French Guiana have now reached together approximately 6.0 to 7.0×10^3 tons annually, and further increases can be looked for. It is quite certain that this production figure can be at least doubled, and a total potential of at least 15.0×10^3 tons is postulated here.

Brazil, north of Recife

This includes the rich area of the mouths of the Amazon and other rivers where the continental shelf is wide and all exploratory evidence points to there being extremely rich under-exploited stocks of penaeids. Present production from this region is 10.0 to 15.0×10^3 tons annually and is dominated by the small seabob *Xiphopenaeus kroyeri*, which forms about 60% of the production from this area, and there are indications that very large stocks

DISTRIBUTION OF KNOWN SHRIMP RESOURCES, REGION XI; ++ = IMPORTANT STOCKS, + = LESS IMPORTANT STOCKS; A–RIVERINE, B AND C—INSHORE, D—CONTINENTAL SHELF, LOW LATITUDES, E—CONTINENTAL SHELF, HIGH LATITUDES

		Guiana	*Surinam*	*N. Brazil*	*S. Brazil*	*Uruguay*	*Argentina*
A	*Macrobranchium amazonicum*	+	+	+			
	M. carcinus, et al.	+	+	+			
B	*Palaemon schmitti*	+	+	+			
	Hippolysmata oplophoroides	+		+			
C	*Xiphopenaeus kroyeri*	++	++	++	+		
D	*Penaeus schmitti*	+	+	+	+		
	P. aztecus subtilis	++	+	++	+		
	P. brasiliensis		+		+		
	P. duorarum notialis	++		++	+		
	P. paulensis				++	++	
E	*Hymenopenaeus muelleri*				+	+	++
	Artemesia longinaris				+	+	++

of larger, commercially interesting penaeids (including *Penaeus schmitti* and *P. aztecus*) occur along most of this coastline although they are of course especially concentrated near the mouths of the great rivers. Potential is expected to be relatively high and 25.0×10^3 tons seems a conservative estimate.

Brazil, south of Recife

There are two main centres of production of prawns in this area, both of which are probably determined largely by the occurrence of centres of human population rather than for other reasons. In the extreme south from the Doce River to Lagoa do Patos there are active shrimp fisheries off the mouth of the Rio Grande and while in the vicinity of São Paulo shrimp fisheries are again rather active. A number of species of penaeids are taken and these appear to be dominated rather heavily by *Penaeus brasiliensis*, which certainly dominates the Rio Grande fishery; from January to May the young of this species migrate out of the rivers and estuaries at the peak fishing season. Year-to-year fluctuations are very considerable and appear to be very largely under climatic influence, for in wet years the lagoons are too fresh for the production of large numbers of juveniles and a poor fishery results. The production over the last few years from the Rio Grande fishery is as follows:

(tons × 10^3)	
1956—17.3	1960—23.4
1957—20.6	1961—26.1
1958—18.5	1962—35.2
1959—19.5	1964—27.2

Potential production from this area is postulated here to be equal the highest annual production quoted above; with a modest allowance for the rest of the coast a total of 40.0×10^3 is postulated. Freshwater prawns (*Macrobrachium*) are, of course, important throughout the Amazon basin and production must be far greater than the 2.6×10^3 tons recorded statistically in 1967. It is not possible to guess logically a quantity for total potential production.

Uruguay

The present landings of shrimps and prawns, as of other crustacea from Uruguay, are negligible, though the occurrence of *Penaeus paulensis* in coastal lagoons in this country and of the northern part of the great estuary of the Rio de la Plata suggest that some potential for expanded production exists; if this occurs, it will in all probability also be based upon *Hymenopenaeus muelleri* and *Artemesia longinaris*. A potential of 1.0×10^3 tons is used here.

Argentina

There is very little information from the southern area of Argentina, and in the north shrimp catches, mostly of langostino (*Hymenopenaeus muelleri*) and camaron (*Artemesia longinaris*) have fluctuated in recent years very widely between 200 and 3,240 tons; these fluctuations are probably caused by fluctuations in spawning success and larval mortality rather than the effect of the fishery which presses rather lightly upon the resources. Surveys in the southern part of Argentina have indicated possibilities for expanded production; in the Patagonian area (particularly in the region of the Gulf of San José) some samples of large ripe females of *Hymenopenaeus muelleri* have been taken and offer the possibility of a fishery there for this species. There are also indications of the presence of deep water prawns and other crustacea of commercial interest off the coast of southern Argentina at depths around 100 m between 54 and 55°S, and a little further to the north the German research vessel *Walther Herwig* took commercially interesting quantities of a large species of sergestid shrimp, at depths of from 300–500 m with a mid-water trawl. This ship also took quantities of *Campylonotus*, *Nauticaris* and *Nephrops* in the waters between Buenos Aires Province and southern Brazil and Uruguay. Although these indications are slight and preliminary they do suggest that the occurrence of extensive deep water resources off the southern part of Argentina are at least a possibility. A potential of 5.0×10^3 tons is used here for all small natant crustacea. Between 44° and 55°S, *Lithodes antarticus* is fished off Patagonia and Tierra del Fuego, and catches total about 0.25×10^3 tons annually and a potential of 1.0×10^3 tons may be assumed.

D. *Potential production from Region XI*

The present and potential production from this region so far as it can be estimated from present data are indicated below:

	Present	*Potential*
	(tons × 10^3)	
Lobsters		
Brazil	3.5	4.0
Guianas	+	+
Crabs		
Brazil	15.0	20.0
Argentina	0.8	1.0
Prawns		
Guyana	>2.0	15.0
Surinam	>2.0	
French Guiana	>2.0	
Brazil	30.0–40.0	65.0
Uruguay	0.1	1.0
Argentina	1.0	5.0
Total	>56.4–66.4	111.0

This suggests that a doubling of present production may be possible and brings the total to about half the production from the Gulf of Mexico and Caribbean to the north; this suggests that the estimate may be too conservative, in consideration of the very great production to be expected off the mouth of the Amazon and the other rivers of northeast South America.

Region XII—Southeast Atlantic

The region extends from the northern border of Angola south through the region of the Benguela Current, and includes the coasts of the Republic of South Africa; to this extent it is an unnatural region as it extends around Cape Agulhas into the Indian Ocean, and includes part of the Indo-Pacific fauna along the coast of Natal.

A. *Spiny lobster resources*

A number of species of spiny lobster occur throughout this region and one of them (*Jasus lalandii*) forms the basis of an important fishery in southern Africa. The tropical west African *Panulirus regius* extends from the Gulf of Guinea southward along the northern part of the region and extends just to the southern part of Angola; however, it is nowhere abundant and although small quantities are presumably taken along the Angolan coast it does not appear in the catch statistics, and quantities must be presumed negligible. At Ascension Island and at St. Helena, offshore Atlantic islands which fall within this region, small stocks of *Panulirus echinatus* occur, and although these may have been fished in the past the quantities produced are negligible. Further to the south, at Tristan da Cunha and at Vema Seamount, stocks of *Jasus tristani* occur; the recent discovery of the stocks of this species on Vema Seamount, which is some 500 mi to the northwest of Cape Town has led to the development of a very active fishery there. Production figures for these offshore stocks were not, however, available to the Working Party.

Along the coasts of Southern Africa between Walvis Bay and Cape Agulhas, there are rather large stocks of *Jasus lalandii* which have been exploited for many years, and which are under strict management control. In the Indian Ocean, along the coast of Natal considerably smaller quantities of the Natal rock lobster *Palinurus gilchristi*, and *Panulirus homarus* and also some *P. versicolor*, and *P. ornatus* occur. Production figures for spiny lobsters from southern Africa in the last few years are tabulated below.

ROCK LOBSTER PRODUCTION IN SOUTHERN AFRICA IN RECENT YEARS (TONS × 10^3)

	Jasus lalandii		*Palinurus gilchristi*
	*Luderitz area**	*Cape Atlantic Coast*	*Natal Coast*†
1961	—	3.11	0.06
1962	—	3.02	0.07
1963	5.9	3.11	0.08
1964	7.6	3.11	0.18
1965	8.0	3.11	0.28

Total, 1965 = 11.4

* FAO statistics
† S.A. Department of Commerce and Industry Statistics

The management data for *Jasus lalandii* suggests that the stocks of this species around Southern Africa are presently fully exploited; evidence from steadily decreasing average size and steadily decreasing catch per unit effort support the supposition that production from known stocks of *Jasus* in southern Africa will not be significantly increased. In fact, in recent years pressure has been brought on the government's quota system for production of *Jasus* by the fishing companies in response to their diminishing returns. The discovery of new grounds, as at Vema Seamount, and the steadily increasing rate of production on the Indian Ocean coast of southern Africa will to some extent help the situation but it is thought that none of these resources will significantly relieve the pressure upon the main stocks of *Jasus lalandii*, which are concentrated to the west of Cape Agulhas.

B. *Prawn and shrimp resources*

Exploratory fishing off southern Africa for shrimps and prawns in recent years has been relatively profitless though finds of commercial quantities of large penaeid prawns (*Penaeus* sp. and *Hymenopenaeus triarthrus*) were made in depths of almost 250 fm at the edge of the southern African continental shelf together with good quantities of a species of *Solenocera*. Also present on these grounds, which are to the east of Cape Agulhas and off Natal, are *Nephrops andamanicus* and the Natal rock lobster.

There are small prawn fisheries in existence along the coast of Natal where, in 1966, about 90 metric tons were landed at Durban, and a few more tens of tons by a group of inshore fishermen at Santa Lucia; however it is assumed that most of the catches landed at Durban have been taken off the coast of Mozambique, which have been discussed with under Region VII. The species involved in the landings at Durban are the following: *Penaeus indicus*, *P. monodon*, *P. japonicus*, *Hymenopenaeus triarthrus*, and *Aristaeomorpha foliacea*; of these, about 70% probably is made up of a single species (*Penaeus indicus*) to judge from the specific composition of the prawn stocks off Mozambique. Lesser quantities, which are often not marketed, of *Metapenaeus monoceros*, *Plesionika martia*, and *Chlorotocus crassicornis* are also taken. *Penaeus indicus* is the most important species taken by inshore fishermen in Natal, with *P. japonicus* second in importance in southern Natal and *P. monodon* and *M. monoceros* about equal and second in importance in northern Natal.

Along the coast, north of Walvis Bay as far as the Kunene River there are very abundant stocks close inshore of the small prawn *Macropetasma*, which have been revealed by trawling surveys in this region; however, no commercial exploitation of them appears to have yet occurred.

Towards the end of 1966 a new fishery for prawns and shrimps was developed off the coast of Angola; this was initiated by the arrival of a single Spanish trawler skilled in trawling for deep water prawns in the western Mediterranean out of the port of Huelva. By the beginning of 1968, this vessel had been so successful that a small fleet of 40 trawlers (from 30–50 m overall) had built up in the Angola region, most of them from Spain and principally from the ports of Vigo, Huelva and Cadiz. These vessels are presently making campaigns of about 8 months in the region, and it appears that the annual production now exceeds 1,000 metric tons.

The species of shrimp fished are the gamba, *Parapenaeus longirostris*, the listado, *Aristeus varidens*, and the carabinero, *Plesiopenaeus edwardsianus*. These excellent, large prawns (gamba reach between 9 and 18 cm, listado reach 19 cm and carbinero almost 30 cm) are taken from 6°50'S to 12°S, and in a rather narrow, but deep, depth zone; throughout this region gamba are taken from 250–260 m and the other two from 540–600 m in depth. In this area the slope of the continental shelf is rather steep and the trawlers follow a very narrow

band of contours which gives them certain practical problems. It will be noticed by reference to the section upon Region III, and the Mediterranean and Black Sea, that species taken off Angola are identical with species which are also important in the western Mediterranean; this is an expression of the very similar fauna which occurs throughout the tropical Eastern Atlantic at depths below the break of slope on the continental shelf, and which contains very many species in common with the Mediterranean Sea and the coast of western Europe as far to the north as Ireland. In assessing the potential production from this region, it is certainly reasonable to assume an increase in production by a factor of $\times 2$ or $\times 3$ and it seems very probable that the total production of shrimps and prawns between South Africa and Angola inclusive could very easily reach a level of 5.0×10^3 tons, which estimate is used here. Also not included in the present consideration are four deep-water penaeids (*Aristaeomorpha foliacea*, *Aristeus varidens*, *Penaeopsis serrata*, and *Plesiopenaeus edwardsianus*) and the pandalid *Plesionika edwardsii* have been reported on numerous occasions as occurring throughout the area but none of these except *Penaeopsis megalops* (which is of small size) has been located in concentrations sufficient to suggest supporting a commercial fishery. These species, therefore, have not been included in the estimates. The following tabulation summarizes the present production of prawns throughout the area by countries, and their estimated potential production. This cannot be broken down by species as in almost every case the available statistics do not permit this.

	Present	*Potential*
	(tons $\times 10^3$)	
Congo to Kunene		
Parapenaeus longirostris, etc.	1.0	5.0
Kunene to Orange		
Macropetasma sp.	—	1.0(?)
Natal Coast		
Natal penaeids	<1.0	1.0(?)
Total	<2.0	7.0

C. *Total potential of Region XII*

The data discussed in the text above do not suggest that this region will become a major producer of crustacea in global terms; the tabulation below indicates the likely magnitude of potential production in the foreseeable future.

	Present	*Potential*
	(tons $\times 10^3$)	
Lobsters		
Jasus lalandii	10.4	10.5
Palinurus spp.	0.3	1.0(?)
Prawns		
Congo to Kunene	1.0	5.0
Kunene to Orange	—	1.0
Orange to Limpopo	<1.0	1.0
Total	12.7	18.5

Region XIII—Southwest Pacific

Region XIII comprises Australia (except W. Australia), New Zealand and its contiguous islands, including New Caledonia and New Hebrides. Exploitation of prawns and crawfish is actively pursued by local fleets, and also by Japanese and Soviet fleets, especially in the tropical northern parts of the region.

A. *Spiny lobsters*

Various species of spiny lobsters or crawfish are important exploited resources of New Zealand, and of the southern part of Australia.

New Zealand

Southern crawfish (*Jasus edwardsii*) has been under exploitation for many years by small vessels out of most New Zealand ports, especially those with access to the west coast grounds. Landings in recent years have been:

(tons $\times 10^3$)	
1962—4.6	1965—5.0
1963—4.6	1966—6.6
1964—4.6	

For many years the catches have been increasing steadily due mainly to exploitation of fresh grounds on a continuing basis. The sudden increase in 1966 was due entirely to extension of fishing onto the banks around the Chatham Islands, away to the east of the main islands.

Southeast Australia

The southern crawfish (*Jasus novaehollandiae*) is the principal species fished, but others occur, among them the painted crawfish (*Panulirus versicolor*), not presently taken because of its unwillingness to enter pots.

As the following catch statistics show, none of the eastern or southern states enjoy such heavy landings of crawfish as are taken in western Australia (see Region VIII), where *Panulirus cygnus* yields 7.0 to 8.0 $\times 10^3$ tons per year.

Catches in recent years of *Jasus lalandii* off Australia:

	1964–65	*1965–66*	*1966–67*
		(tons $\times 10^3$)	
New South Wales	0.2	0.2	0.2
Queensland	+	+	+
Victoria	0.6	0.7	0.7
Tasmania	1.5	1.8	2.0
South Australia	2.7	2.7	2.8
Total	5.0	5.4	5.7

The slowly rising catches in Australia and the rapidly rising catches in New Zealand, both in fisheries with rather rigid management policies, suggest that in neither place are the stocks fully exploited; in particular, it is likely that the opening of the Chatham Island grounds will further increase New Zealand's catches significantly.

Any catches by foreign vessels in those regions are not available, and any quantification of total potential yields from this region are to this degree uncertain.

B. *Crab resources*

Small quantities of several species of crabs are taken in Australia, not totalling as much as 1.0×10^3 tons, and

these catches are ignored here. Future potential of the stocks is entirely unknown. Spider crabs (*Jaquinotia edwardsii*) seem to offer fair prospects around Auckland I.

C. *Prawn resources*

Between 40 and 50 species of penaeid prawns occur in the region, and of these about 10 are presently useful in the fisheries; many smaller species of shrimps and prawns belonging to other decapod groups also occur, of course, and while some may have local or limited usefulness in the future there are no indications from present data that any will approach the value of the penaeids.

In Australia, exploitation is most complete near the southern and eastern centres of population, and is expanding most rapidly in the under-populated northern regions; off New Zealand, several recent surveys have shown no indication of major prawn resources. A number of species of penaeids occur, and *Nephrops challengerii* has been found in promising quantity in deep water (over 150 fm, 300 m).

Queensland

A trawl fishery operates along the continental shelf from Cairns south to the border of New South Wales, and landings are made in all ports of this area. Five species are exploited: *Penaeus plebejus* (65%), *Metapenaeus bennettae* (16%), and *P. esculentus*, *P. merguiensis* and *M. macleayi* (19%). *P. plebejus* is taken throughout the year, the others during more restricted summer seasons.

Production figures are slowly rising, mainly due to increasing exploitation of oceanic stocks of *Penaeus plebejus*, as tabulated below:

(tons × 10^3)	
1962—2.0	1965—2.6
1963—2.3	1966—2.7
1964—2.3	1967—2.7

The future of this fishery is presently unsure, since although a very limited increased production may be possible from the stocks of *P. plebejus*, the stocks of the other species already appear to be overfished.

A set-net fishery in the Moreton Bay rivers of Queensland takes small quantities of *Metapenaeus bennettae*, but this is not separable in the statistics and is included in the figures given above for the trawl fishery, as are the catches from a variety of small-boat trawls and hand-nets in the estuaries and brackish lagoons, where the catch is mainly of *Penaeus plebejus*, *Metapenaeus macleayi* and *M. bennettae*.

New South Wales

The trawl fishery discussed above extends southwards along much of the coast of New South Wales, at least as far as the port of Terrigal, the fleet being dispersed among many of the small ports.

The available statistics for this area do not permit partitioning the catch between the five species involved, which are identical to those in the catches off Queensland. The available data, tabulated below, show that peak production has probably already been achieved in this fishery and no significant increase can be expected from natural resources in the future:

(tons × 10^3)	
1963—2.1	1965—2.0
1963—3.0	1966—1.8
1964—2.8	1967—1.8

As in Queensland, catches from the estuarine and lagoon fishery and from a small pocket set-net fishery in lagoon channels, are included in the above data; the same species are exploited as in Queensland.

There appears to be no likelihood that the catches off New South Wales can be increased and present management policies are presumably designed to maintain the present yield; off Queensland, a modest increase is likely, mainly of oceanic *Penaeus plebejus*, but there appear to be no data on which to make a quantified estimate, though a figure between 10% and 20% over present catches seems not unreasonable.

D. *Total potential of Region XIII*

Only in the case of the tropical shrimp resources of Australia are there any known predictions by local fisheries agencies of the potential size of the catches of crustacea in the region. It seems reasonable to apply subjective, order-of-magnitude extrapolations to fisheries according to the trend of the catches in recent years so as to reach some estimate of the total potential in the whole region. This is done in the following tabulation:

	Present (tons × 10^3)	*Potential* (tons × 10^3)
Crawfish		
New Zealand	6.6	8.2
S.E. Australia	5.7	6.3
	(12.3)	(15.4)
Crabs		
Australia	<1.0	<1.0
	(1.0)	(1.0)
Prawns		
New Zealand	—	—
Queensland	2.7	3.1
New South Wales	1.8	1.8
	(4.5)	(4.9)
Total	17.8	>20.3

This estimate of potential catches ignores the possibilities where no fisheries now exist, or where no resource surveys have been performed. It is certain that some potential in tropical crawfish occurs on the offshore reefs of the Queensland coast, and off New Caledonia and New Hebrides, both of which currently report no fishing and no potential for crustaceans. It would probably be safe to add another 5.0×10^3 tons for such completely hypothetical resources, raising the grand total for the area to around 25.0×10^3 metric tons, in the long-term.

Region XIV—Southeast Pacific

The coasts of Peru and Chile fall within this region; though rich because of strong coastal upwelling, the narrow shelf and the generally rocky nature of the coast is rather unsuitable for the development of great crustacean resources, especially of prawns or shrimps.

A. *Crab resources*

Lithodes antarcticus has formed the basis of a small fishery in recent years which has shown a modest rate of increase in production, and which now approaches 500 tons per year (see tabulated data below); this is an ecological analogue of the king-crab of the North Pacific (*Paralithodes camtschatica*) which yielded catches approaching 150.0×10^3 tons. Although (i) the shelf area on which *Lithodes antarcticus* is known to occur is very much less than that for the northern form, and (ii) the southern form averages less than 2 kg against 4 kg for the northern form, it still seems possible that an expansion in this fishery will develop in southern Chile's region of fjords and offshore islands: an increase by a factor of 2–3 seems not unlikely and will be used here, and it is suggested that the potential catch is at least 1.5×10^3 tons per year.

Other species (*Cancer* spp., *Taliepus* spp., and *Homalaspis* spp.) of crabs form the basis of a fishery which is presently considerably larger than that for *Lithodes*, and which yields a little less than 1.5×10^3 tons annually in Chile and about 0.2×10^3 tons in Peru. There is no evidence to suggest that this fishery is capable of expansion, but in view of the great length of Chile's indented coastline and the present extent to which the fishery is concentrated near centres of population, a factor of 10 is applied for potential production. It is, therefore, suggested that at least 15.0×10^3 tons may eventually be taken by that fishery each year.

Galatheids of two species (*Pleuroncodes monodon* and *Cervimunida johni*) support a Chilean fishery which is to some extent complementary to that for prawns. The same vessels fish each stock and the landings of galatheids and of prawns vary inversely. In recent years the catches of galatheids have been ranging from 10.0 to 13.0×10^3 tons per year, and it is evident from surveys of the abundance of galatheids on parts of the shelf off Chile and Peru influenced by deposition of material from phytoplankton blooms that an increase of at least a factor of $\times 5$ seems possible. This places the potential catches from these stocks at around 50.0×10^3 tons annually. Meat yield is rather low from galatheids, however, and this represents a total of only about 5.0×10^3 tons of tails.

B. *Spiny lobster resources*

Small stocks of spiny lobsters occur, the most important species being *Jasus frontalis*, which occurs especially at the offshore islands (e.g. Juan Fernandez) but does not seem to occur on the mainland. The data tabulated below shows the small size of this production and suggests that the potential yield may not be much in excess of 0.1×10^3 tons per year.

C. *Prawn resources*

A fishery based on *Heterocarpus reedi* and *Rhincocinetes typus* yields about 11.0×10^3 tons in Chile and about 0.5×10^3 tons in Peru annually. Resource surveys of the grounds on which the species occurs in commercial quantities indicate that these have an extent of 1,600 km^2, and do not extend below 37°S. The grounds are heavily exploited near ports, but rather lightly farther away from markets, and an increase by a factor of 2 for a total of around 20.0×10^3 tons potentially, seems very probable.

A second species, *Hymenopenaeus diomedeae*, has been surveyed, but is not yet exploited commercially. Occurring rather deeply, at >150 fm, it has not been easy to estimate its potential yield, or the extent of its occurrence satisfactorily. Exploitation will be possible only when production problems imposed by the nature of its habitat are solved, and for present purpose a conservative estimate of 1.0×10^3 tons is placed on its potential yield.

ANNUAL RATE OF PRODUCTION OF CRUSTACEA BY CHILE, 1961–66
(tons $\times 10^3$)

	Lithodes	*Crabs*	*Galatheids*	*Spiny lobsters*	*Prawns*	*Barnacles*
1961	0.2	1.0	8.1	0.1	2.3	0.5
1962	0.3	0.9	7.9	0.1	4.3	0.9
1963	0.1	0.9	9.2	0.1	3.6	1.5
1964	0.3	1.0	10.6	0.1	5.9	1.0
1965	0.3	1.3	13.3	0.1	5.0	1.5
1966	0.4	1.3	11.3	0.1	10.9	0.9

D. *Barnacle resources*

Chile is unique in its exploitation of the giant barnacle, *Balanus* (*Megabalanus*) *psittacus* which reached 2.0×10^3 tons in 1954, but is lightly fished and market-limited, so that in some recent years only 1.0×10^3 tons were taken. It may reasonably be expected to yield 5.0×10^3 tons potentially.

E. *Total regional potential yield*

This may be expressed as:

	Present (tons $\times 10^3$)	*Potential* (tons $\times 10^3$)
Crabs	14.2	66.5
Spiny lobsters	0.1	0.1
Prawns	11.5	20.0
Barnacles	1.0	5.0
Total	36.8	91.6

But it must be emphasized that this potential increase, by an overall factor of almost $\times 3$, is based on extremely subjective judgments, and must not be taken in any other light.

GLOBAL ASSESSMENT

The tabulation below summarizes the 14 regional assessments presented in the body of the text.

It shows that on the descriptive evidence and on the quantitative data available for this review, the world catch of crustaceans, presently about 1.26×10^6 tons, may be expected to rise in the future to almost double this figure, or 2.31×10^6 tons annually. This estimate supposes that no "break-throughs" in harvesting technology which cannot now be foreseen will occur, and that in consequence the resources to be exploited will be similar to those we exploit today.

SUMMARIZED TABULATION OF PRESENT AND POTENTIAL WORLD PRODUCTION OF CRUSTACEA (TONS $\times 10^3$)

	Region	Present			Potential		
		Lobsters	*Crabs*	*Prawns*	*Lobsters*	*Crabs*	*Prawns*
I	Northwest Atlantic	31.7	2.2	8.6	32.0	10.0	27.0
II	Northeast Atlantic	29.9	13.3	65.4	65.3	20.5	82.8
III	Mediterranean	4.0	+	23.0	4.0	+	50.0
IV	North Pacific	+	208.0	41.1	+	250.0	131.2
V	Western Central Atlantic	13.3	76.9	125.0	21.0	80.0	160.0
VI	Eastern Central Atlantic	2.5	+	4.6	4.0	10.0	63.0
VII	Western Indian Ocean	0.4	+	21.3	3.1	+	144.0
VIII	Eastern Indian Ocean	8.6	+	58.9	10.0	+	98.1
IX	Western Central Pacific	1.7	39.3	304.1	5.0	150.0	544.1
X	Eastern Central Pacific	+	<1.5	65.0	5.0	32.5	75.0
XI	Southwest Atlantic	3.5	15.8	37.1	4.0	21.0	86.0
XII	Southeast Atlantic	10.7	+	2.0	11.5	+	7.0
XIII	Southwest Pacific	12.3	1.0	4.5	14.5	1.0	4.9
XIV	Southeast Pacific	0.1	14.2	11.5	0.1	66.5	20.0
	Total	118.7	372.2 (1.26×10^6)	772.1	179.5	641.5 (2.31×10^6)	1,492.1

This final tabulation invites some discussion of the implications it contains of the degree of exploitation of the various resources, and also of the relative validity of the estimates which it comprises.

It is evident from the lack of quantitative data that crab resources, with a few notable exceptions, are either largely ignored, or are treated as of such small importance, that they are lost in statistical "catch-alls" and recorded only as "miscellaneous crustacea" or some similar category. It is probably in this general group of resources that both our estimates of present production, and our prognostication of how trends in harvesting will run in the future, are poorest. In the final estimates there is a very large component of subjectivity; the numbers used in this table, however, from the nature of the doubts expressed here, will be minimal and are likely to be exceeded by reality, rather than the opposite.

It is probably also an indication of this data problem, and hence of the great difficulty of making predictions, that makes the apparent percentage increase in production which the table suggests to be rather low.

On the other hand, the quantitative data for all forms of lobster-like crustaceans reflect the high esteem with which these animals are held in world markets. In most cases, the figures used here are rather reliable and the modest size of the increase in production which appears to be possible is probably just a measure of the high intensity of exploitation, and of management, to which stocks of "lobsters" are already subjected.

The quality of the data which are available for prawns and shrimps is extremely variable: in such places as the Gulf of Mexico and the Eastern tropical Pacific Ocean it is very good, while for some resources (such as the deep penaeids and pandalids) the data are very incomplete, and for several regions (such as the Eastern Indian Ocean) they are very subjective.

Perhaps the two areas of greatest uncertainty in estimations of prawn resources concern the deep red prawns on the upper parts of the continental slope, and the stocks of small, brackish water carideans, especially in the tropics.

Although prawns of rather a small number of species and genera, typically having rather great areas of distribution, have apparently been found whenever looked for below the continental edge in low and middle latitudes, these are exploited in only three areas; the Gulf of Mexico, the Mediterranean and off Angola. While the Angolan experience in recent years shows that substantial production can be achieved from these resources, there are presently no data on the biological parameters required to judge what sort of sustainable yield may be taken from presently almost virgin stocks. Nor are the survey data elsewhere, for instance in the Eastern Indian Ocean, sufficiently quantitative to compare prospects elsewhere with production in the Mediterreanean or off Angola.

The appearance in the production statistics for the western coast of Indian of 35.0×10^3 tons of small caridean shrimps is very surprising in terms of other similar regions. The coast in question is not typical of tropical regions, but is significantly distinguished by the excellence of the statistical reporting system at the village level, and it must be supposed that similar catches could be (or are) made in parts of the Gulf of Guinea, in the Indonesian and Philippine archipelagos and along northern Australia. Such suppositions appear to be rather poorly supported by the available quantitative data.

Appendix

TABLE R1. CATCHES OF CRUSTACEANS BY SPECIES AND BY COUNTRIES ('000 METRIC TONS, LIVE WEIGHT)

Species	*Country*	1958	1963	1964	1965	1966	1967	1968	1969
Sea-spiders, crabs, etc.		197.0	272.0	288.0	318.0	365.0	368.0	388.0	397.0
Blue crab		50.0	66.0	71.0	78.0	77.0	68.0	58.0	68.0
Dungeness crab		21.0	13.0	13.0	15.0	20.0	22.0	25.0	24.0
Edible crab		10.0	10.0	10.0	8.0	8.0	8.0	8.0	10.0
King crab		64.0	110.0	117.0	130.0	150.0	131.0	112.0	86.0
	USA (Pacific)	5.1	35.7	39.3	59.7	72.3	57.9	37.2	25.3
	Japan	28.2	31.6	31.8	25.9	31.0	30.3	30.4	22.5
	USSR	30.9	42.5	46.2	44.4	46.0	42.3	40.4	37.1
Other marine crabs		52.0	73.0	77.0	87.0	110.0	139.0	185.0	209.0
	Japan	30.9	39.6	42.0	37.7	40.7	55.9	87.5	70.9
Lobsters, rock lobsters, spiny lobsters, etc.		79.0	90.0	92.0	92.0	92.0	88.0	96.0	...
European lobster		4.0	3.0	5.0	3.0	2.0	2.0	2.0	2.0
Northern lobster		32.0	34.0	33.0	32.0	30.0	28.0	32.0	34·0
Spiny lobster, rock lobster		43.0	53.0	53.0	56.0	59.0	57.0(a)	(61.0)	...
	Namibia	4.0	5.9	7.6	8.0	8.9	5.9	8.5	...
	South Africa	12.7	8.3	8.4	8.4	8.0	8.3	6.7	...
	Cuba	4.2	7.4	6.6	9.1	9.0	8.3	8.9	11.1
	Brazil	1.1	3.6	3.3	3.4	2.8	2.5	3.2	6.3
	Australia	10.0	14.3	12.6	11.9	13.6	14.4	15.1	13.0
	New Zealand	4.4	4.5	4.6	5.0	6.6	8.1	10.9	8.9
Squat-lobsters, nephrops, etc.		32.0	38.0	41.0	43.0	45.0	51.0	50.0	59.0
Squat-lobsters		13.0	9.0	11.0	15.0	13.0	20.0	18.0	24.0
Norway lobster		19.0	29.0	30.0	28.0	32.0	31.0	32.0	35.0
Shrimps, prawns, etc.		502.0	671.0	670.0	663.0	697.0	757.0	771.0	...
Common shrimp		49.0	73.0	57.0	51.0	60.0	45.0	50.0	47.0
	Germany (Fed. Rep. of)	29.4	42.4	28.7	28.3	38.4	24.3	33.1	27.6
	Netherlands	13.1	24.7	21.9	17.4	15.5	14.3	11.2	11.7
Deep-water prawn		13.0	26.0	23.0	25.0	21.0	22.0	23.0	24.0
Prawns and shrimps		440.0	572.0	590.0	587.0	616.0	690.0	698.0	...
	Mexico	50.2	72.0	69.0	59.1	65.8	70.1	58.6	54.7
	USA (Atlantic)	88.9	99.4	89.5	101.4	92.8	114.9	110.2	115.4
	USA (Pacific)	8.1	9.6	6.6	9.1	15.6	24.7	25.6	28.4
	Brazil	17.4	28.3	28.1	39.4	34.7	35.5	39.5	36.7
	China (Taiwan)	4.0	9.0	9.8	14.2	16.3	19.5	25.6	34.4
	India	86.7	81.6	94.9	77.2	90.8	91.7	99.8	107.6
	Japan	55.6	86.7	77.8	66.5	68.8	61.0	70.7	61.2
	Korea (Rep. of)	16.4	14.2	18.1	17.2	12.1	21.0	11.4	6.8
	Malaysia (West)	9.0	19.0	19.3	20.8	24.4	32.3	32.9	39.4
	Pakistan (b)	14.9	18.4	20.7	22.0	22.2	25.0	23.4	26.0
	Philippines (c)	13.7	20.3	21.5	22.9	26.3	24.0	21.5	23.5
	Thailand	10.3	23.3	29.5	35.2	45.3	61.7	75.0	77.1
Miscellaneous marine crustaceans		36.0	53.0	67.0	69.0	77.0	102.0	106.0	...
Total, all crustaceans		860.0	1,140.0	1,170.0	1,190.0	1,280.0	1,360.0	1,400.0	...

Notes: (a) In the computation of this total, more than 10% was estimated by FAO
(b) 1958, "Prawns and shrimps" includes "Freshwater crustaceans"
(c) Up to 1966, "Prawns and shrimps" includes "Other marine crabs"
... No data
Brackets denote estimation

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