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THE MAGNITUDE, DISTRIBUTION AND AVAILABILITY OF PRAWN (PENAEIDAE) RESOURCES IN COASTAL AND ESTUARINE WATERS OF KENYA, 1970*

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ABSTRACT

The present world wide demand for crustacea products necessitates the proper management and exploitation of resources belonging to developing nations.

An account is given of present environmental conditions and indigenous (prawn Penaeidae) fisheries within the developing nation of Kenya. The marine resource is reviewed on the basis of present information and the potentially important species in Kenyan waters are named and discussed.

INTRODUCTION

IN 1969, Kenya's marine fish production was 6,396 metric tons valued at U.S. $989,143 with the total crustacean catch (167 metric tons) valued at U.S. $90,000. Price per metric ton, however, for crustacean products (prawn, spiny lobster and crab) was more than three times that of fish products—U.S. $539 *vs.* U.S. $155. Although these figures do not represent large fishery resources, as yet, they do point out the economic need for placing top-priority on the crustacea resource.

Because there has been, in past years, no real effort to delineate Kenya's crustacea resource it is imperative that this potentially valuable fishery stock be defined. The magnitude, distribution and availability of these exploitable stocks must be described and clearly understood for maximum utilization in future commercial operations.

The purpose of this paper is to present an evaluation of the exploitable prawn stock found in the estuarine and offshore areas of the Kenya coast and to give exploratory information gathered between December, 1969 and October 1970. The biological parameters of the dominant species of prawns are also discussed.

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THE KENYA CRUSTACEA ENVIRONMENT

The Kenya coast is characterised by the presence of a fringing coral reef which extends along the 300 nautical mile shoreline. Patch reefs are also found randomly distributed along the coast in waters of moderate depth (8-20 fathoms).

From the Tanzania border in the south to the Somalia border in the north, this shallow veneer of coral shelf area is only obscured or broken by the important river and estuarine systems that discharge their fresh water runoff into the Western Indian ocean. These river and estuarine complex's are located at Vanga, Mombasa, Mtwapa Kilifi, Mida Creek, Sabaki River outlet, Tana River outlets and within the extensive Lamu area (Fig. 1).

Offshore Demersal Trawling—The continental shelf area along Kenya's coast is narrow—average width is 3 nautical miles to the 100 fathom contour—with large sections of rough bottom topography (coral formations). There are two major excep-

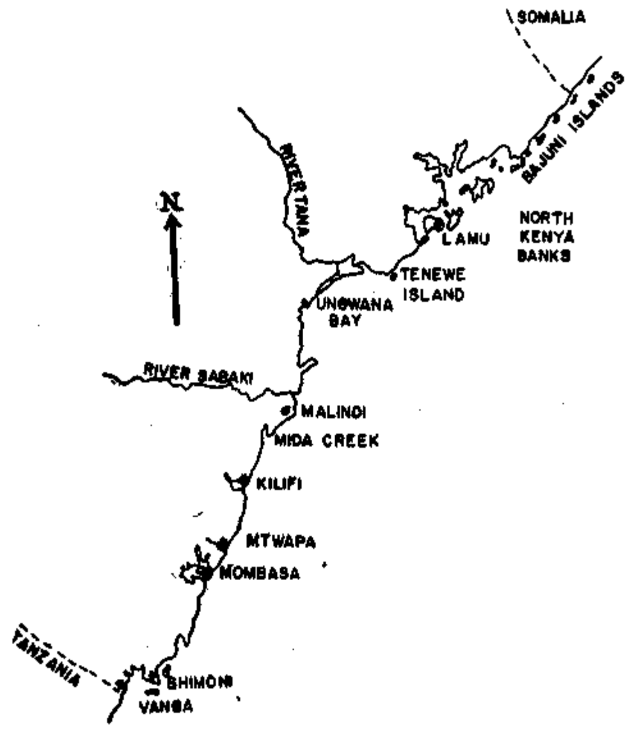

Fig. 1. The Kenya coastline, showing major offshore and estuarine areas.

tions, however, where a sizable amount of smooth shelf area is available for offshore demersal type trawling. These areas are located within the Ungwana Bay complex (La. 2°45.0′ S, Lo. 40°25.0′ E) and in the vast North Kenya Banks region which lies offshore of the Lamu archipelago (Fig. 1). The latter area has approximately 1,140 square nautical miles of water less than 100 fathoms. These banks are comprised of rock, coral formations and some clear areas which may be suitable for future prawn trawling. On the other hand, the Ungwana Bay complex has excellent trawl grounds from shore to 25 fathoms.

The only area surveyed was the Ungwana Bay complex which includes the Sabaki/Mambrui grounds (Fig. 2). These areas are most likely the only location in which the indigenous Kenya Fisherman might exploit prawn resources on a profitable commercial basis. From shore to 10 fathoms Ungwana Bay proper includes 349 square nautical miles of smooth mud-sand-shell bottom. Emptying into this system, is the Tana River (with headwaters approximately 400 miles up-country) and several tidal creeks (Fig. 2). Because of the heavy but seasonal discharge of fresh water and silt, most of the bottom area encompassed within the bay proper is free of coral growths. Beyond 10 fathoms, coral formations plus the steepness of the continental shelf (15 to 20 fathoms/0.3 nautical mile) prohibit conventional prawn trawling techniques. In summary, the southern half of the system appears to have some areas of untrawlable bottom (coral and sponge formations) because of minimum fresh water runoff from tidal creeks. The northern portion, including all areas north of the Kalifi River, have good to excellent grounds from shore to 10 fathoms.

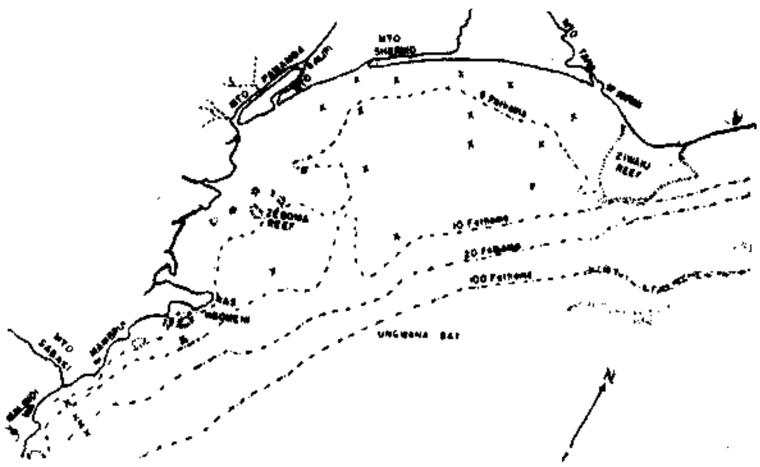

Fig. 2. The Ungwana Bay Complex, showing systematic survey station locations (x). 6.4 mm=1 NM.

Trawling grounds (10-25 fathoms) outside the bay to the ESE lie in close proximity to the mouth of the Sabaki River (Fig. 2). Although this trawl area only includes 55 square nautical miles, prawn concentration is very dense and the port of Malindi is within 45-minutes steaming time of the grounds.

Estuarine Demersal Trawling.—Penaeid prawns have a distinctive life history where the adults spawn at sea and the resulting post-larvae, influenced by ocean currents, reach estuarine areas. Here they remain and grow rapidly before returning to the open sea as sub-adults (90-140 mm). Kenya's estuarine areas are characterised by large tidal influences (maximum height difference between flood and ebb tides averages 6 feet) and the presence of mangrove swamp habitat. Most East African estuarine regions, therefore, have definite limiting factors which control and influence maximum production, utilization of penaeid environment (mangrove

In Kenya's offshore and estuarine waters, there had been no continuous and systematic exploration surveys nor modern exploitation techniques utilized on potentially important commercial prawn stocks.

Evidence of prawn abundance was reported by Sparks (1965), Government of Kenya (1965-1968) and in the unpublished 'Report of Kenya Fisheries' of 1969. There was, however, no mention of the magnitude or density of the resource other than excellent catch/effort data from the Lamu estuarine system, and within Ungwana Bay proper. Although there were indications of exploitable standing crops, there was no further systematic evaluation of the prawn resource except for sporadic data collection by the Kenya Fishery Department until 1970. The reasons for non-development by commercial enterprise were many but the inability of the indigenous coastal populations and/or governmental agencies to capitalize on initial exploratory findings of the resource has been chiefly responsible.

Systematic Exploratory Surveys

From January, 1970 through October, 1970 an attempt was made to evaluate offshore prawn populations within the Ungwana Bay Complex using systematic monthly trawl surveys. Most survey cruises were made using the Kenya Fishery Departments 22.4m stern-trawler, R.V. *SHAKWE*. Each cruise was of 4-6 days duration. In addition, the departments smaller (7.6m) M.V. *FAIRTRY* was utilized in the Sabaki/Mamburi area during June, July, and October, 1970. Using these vessels as sampling platforms, systematic trawling was accomplished within the Ungwana Bay Complex in specified depths and areas (Fig. 2). Sampling locations were established so as to gather maximum information per unit of effort over the entire Ungwana Bay Complex. Because of trawl equipment shortages, and the nature of exploratory survey's themselves, it was impossible to utilize the same basic fishing gear. Bottom trawls from 8.2 to 26.2 meters were interchanged throughout the survey. Trawl hauls were of 20-60 minute duration and in this paper refer to actual 'fishing time' on the ocean floor.

In the same vein, data was also gathered from Kenya's estuarine systems. With a small 5.3 meter motor boat and a 3.3 meter flat trawl, data were taken from the Mombasa and Kilifi Estuaries from April through August, 1970.

A post-larval monitoring station was established at the entrance to the Mombasa estuarine Complex from June to October, 1970 in efforts to show Penaeid utilization of the area as a nursery ground and also to advise indigeious fisherman of future time periods of peak abundance (juvenile prawn stocks), if any, within the Mombasa Estuary.

Species present.—There are five species of Penaeid prawns which are of commercial importance within the trawlable areas of the Ungwana Bay Complex. These are (in order of general abundance):

Penaeus indicus H. Milne-Edwards, 1837	75-90 %	station	catch/month
Metapenaeus monoceros (Fabricius, 1798)	15-20	,,	,,
Penaeus semisulcatus De Haan, 1850	5-10	,,	,,
Penaeus monodon Fabricius, 1798	5-10	,,	,,
Penaeus japonicus Bate, 1888	2-5	,,	,,

A sixth species, *Metapenaeus stebbingi* (Nobili, 1904), is also caught but constitutes less than 0.25% (heads-on-weight) of any total catch in any surveyed month. All six species caught during the survey were taken at all sampled depths (0-25 fathoms).

The same species caught in offshore waters were taken from estuarine areas. (Fair to good stocks of the River Shrimp, *Macrobrachium sp.*, were also found in the upper reaches of the Mombasa estuarine system). Although Penaeid specimens were mostly juvenile forms (25-90 mm in total Length) in all sampled areas, species composition was changeable. In the Mombasa estuary—Port Reitz—, the dominant species was *P. semisulcatus* while in the Kilifi Estuary the most abundant species was *P. indicus*.

Fishing Seasons.—Although the survey was limited to a seven-month period, it was apparent (from heads-on catch/effort weights) that offshore prawn stocks are concentrated seasonally within specific depth zones (Table 1). During the NE Monsoon, prawn populations were located in the 0-5 fathom zone (average catch per unit/effort=23.8 Kg/hour) while the 16-25 fathom areas had an average C/E of 4.2 Kg/hour in the same monsoon period. Conversely, the prawn C/E during the SE Monsoon was 4.6 Kg/hour in 0-5 fathom areas. Catch effort at 16-25 fathoms, however, was 67.4 Kg/hour. This apparent prawn movement between depths within the Ungwana Bay Complex may be caused by the low salinities of the SE Monsoon's oceanic environment in May plus the large fresh water river discharge in March and April, 1970, which lowered salinities still further in the 0-5 fathom areas.

TABLE 1. *Catch Effort Data*[1] *(Species Combined) from the Ungwana Bay Complex of Kenya*

Depth Zones (Fms.)		0/5		6/10		11/15		16/20		21/25	
		C/E	*No Trawls*	*C/E*	*No Trawls*	*C/E*	*No Trawls*	*C/E*	*No Trawls*	*C/E*	*No Trawls*
Months											
January	1970	30.0	9	*	1	..	0	..	0	7.0	2
February	,,	18.0	12	3.0	10	11.0	2	..	0	2.0	1
March	,,	27.0	4	8.5	5	..	0	1.0	1	..	0
June	,,	4.5	5	7.6	13	13.0	1	135.0	5	117.5	3
July	,,	5.0	1	1.6	17	..	0	20.0	2	79.0	5
October	,,	..	0	26.0	1	20.5	89	58.0	9	21.7	6

[1]/=Catch effort projected/1-hr. trawl haul using a single 19.7-meter flat trawl
*=less than one Kg.
C/E=Kg./Hr. (heads-on-weights)

It should also be noted that day and night trawl hauls were taken at each station during January, February and March survey cruises. Catch data from these trawling operations indicate no significant difference in diel C/E from 0-5 fathom stations. A slight increase in nocturnal C/E was noticeable, however, from 6 to 10 fathoms and more studies of this nature are needed within the Ungwana Bay system.

Within the sampled estuarine systems of Mombasa and Kilifi, there appeared to be no peak population strengths from April through August. Catch effort within these regions was always less than one kg/15 minute trawl haul. The hypothesis is that there was no influx of large numbers of Penaeid post-larvae during the surveyed period which would have led to population strengths within the systems.

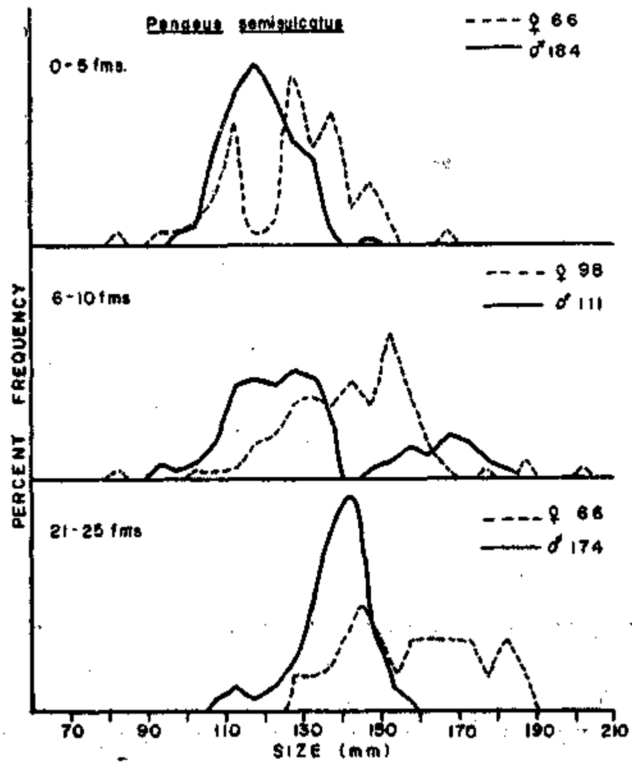

Fig. 5. Length frequency of *P. semisulcatus* taken from three depths within the Ungwana Bay Complex, 1970.

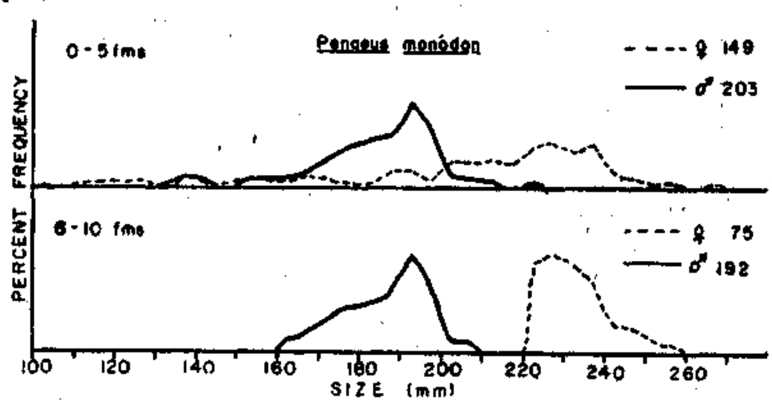

Fig. 6. Length frequency of *P. monodon* taken from two depths within the Ungwana Bay Complex, 1970.

Estimate of Stock Size.—An estimate of offshore Penaeid prawn population strengths, based on density per square nautical mile, is shown in Table 2. These estimates of stock size, based on 1970 survey cruises, indicate large concentrated prawn populations within the trawlable areas of Ungwana Bay proper and the smaller Sabaki/Mambrui grounds. Unequal sample size (within areas and in time), different gear utilization, etc., cause some doubt as to the validity of these estimates. If one considers, however, that the total 1969 Kenya prawn catch amounted to only 62,161 kg (heads-on-wt) it is quite evident that the resource is under-developed. The offshore prawn stocks that are present within the Ungwana Bay Complex would benefit the coastal economic structure if it were exploited in the future. Development of course, must proceed with caution and should be based on future research findings of Kenya's Fishery Management Biologists.

TABLE 2. *Estimate of biomass (wt) of prawns in Ungwana Bay and Sabaki/Mambrui areas*

	depth zones (fm)	total area (sq.n.m)	no. of trawls[1]	prawns caught (kilo)	catch per hour	density (kilos/sq. n.m.)	estimated total weight
January 1970[4]							
Ungwana Bay	0-5	93	7	94	20.3	1,691.6	157,319
	6-10	150	10	*	*	1.3	171
Sabaki/Mambrui	6-10	6	1	0	..	..	..
	11-20	26	2	4.5	8.5	708.3	18,416
February 1970[2]							175,906
Ungwana Bay	0-5	93	12	84	13.8	920.0	85,560
	6-10	150	9	7.5	1.8	120.0	18,000
Sabaki/Mambrui	6-10	6	1	5	9.5	633.3	3,831
	11-20	26	3	11.5	11.5	766.7	19,934
March 1970[3]							127,325
Ungwana Bay	0-5	93	5	40	16.1	1,073.3	99,817
	6-10	150	2	*	*	20.0	3,000
Sabaki/Mambrui	6-10	6	2	15.5	15.5	1,033.3	6,210
	11-20	26	1	*	*	20.0	3,000
June 1970[4]							112,027
Ungwana Bay	0-5	93	5	15	7.5	277.8	25,835
	6-10	150	2	10.5	10.5	388.9	58,335
Sabaki/Mambrui	6-10	6	0	..	..	..	..
	11-20	26	2	108.5	108.5	4,018.5	104,481
July 1970[3]							188,651
Ungwana Bay	0-5	93	1	1.5	3.0	250.0	23,250
	6-10	150	3	6	4.2	350.0	52,500
Sabaki/Mambrui	6-10	6	..	..	..	..	..
	11-20	26	1	51.5	128.1	10,675.0	277,550
October 1970[3]							353,300
Ungwana Bay	0-5	93	0	..	..	..	..
	6-10	150	0	..	..	..	..
Sabaki/Mambrui	6-10	6	1	17.3	26.0	7,333.3	44,000
	11-20	26	34	964.6	48.9	3,260.0	84,760
							128,760

[1]—30 to 60 minute trawl hauls
[2]—35-foot flat trawl
[3]—45-foot flat trawl
[4]—80-foot semi ballion trawl
*—less than one kilogram (for estimation, counted as .3-kilo's)

No estimates of population size were developed for estuarine stocks, as sample number and sampling times were too sporadic for any type of meaningful analysis.

Size Distribution.—Measurements of a harvestable resource should be made in order to ascertain the influence of (1) recruitment and (2) optimum areas of maximum yield (i.e.—locations where yield to commercial exploitation is greatest). Prawn populations in Kenya's offshore waters were measured to delineate size distribution over time in efforts to define areas of maximum biomass. All measurements were total length—T. L.—(tip of rostrum to tip of telson) and were combined by depth zones for each species. In Figure 3 through 7, the length-frequencies for all species caught within all sampled depths are shown. (Frequencies with less than 50 female or male measurements per species at a given depth were excluded). A small but distinct size with depth relationship can be observed. The females of each species, within all depth, attain larger size than males and there is evidence of recruitment (T. L. less than 100mm). The only exception being *P. monodon*; this Penaeid must migrate to offshore waters at a larger size.

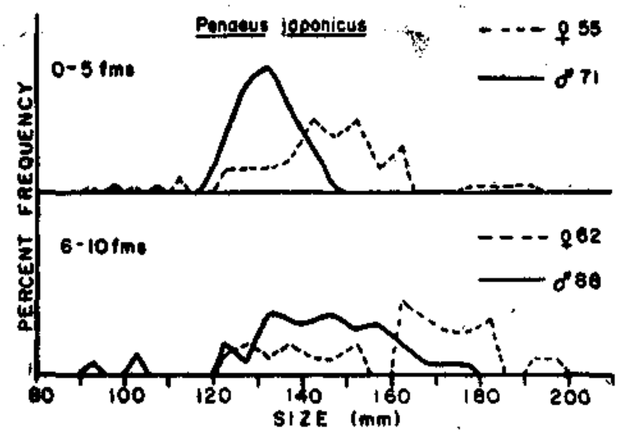

Fig. 7. Length frequency of *P. japonicus* taken from two depths within the Ungwana Bay Complex, 1970.

Size ranges common to each species are found at all depths inhabited by that species. This anomaly is probably caused by (1) absence of distance from shore to depth relationships (Fig. 2) and (2) the apparent mass movement of prawns during the monsoon seasons.

The sex ratio common to most Penaeids approaches a 1:1 female-male relationship in deeper depth zones (10-30 fathoms). Within the shallow zones (0-10 fathoms), however, the ratio is variable due to recruitment.

Within the Ungwana Bay complex, measurement data indicate that only *P. indicus* (0-10 fms) and *M. monoceros* (21-25 fms) approach the normal. Within all other depths and for all other species, sex ratio fluctuates from 31.3 to 75.8 for males. For *P. monodon*, *P. japonicus* and *P. semisulcatus*, there was an inbalance of males to females (mean average=37 : 63) at all depths.

In summary, size increases slightly with depth although most size ranges common to a particular species can be found at any given depth within the Ungwana Bay system. Females are larger than males in any given depth but the sex ratio imbalance favours males. Lastly, recruitment is apparent from length-frequencies of most species taken during the survey period.

Recruitment.—The offshore movement of the dominant species *P. indicus* within the Ungwana Bay complex is shown in Fig. 8. Most Indian Prawns begin to leave their estuarine nursery areas in late-February through mid-March. (It should be

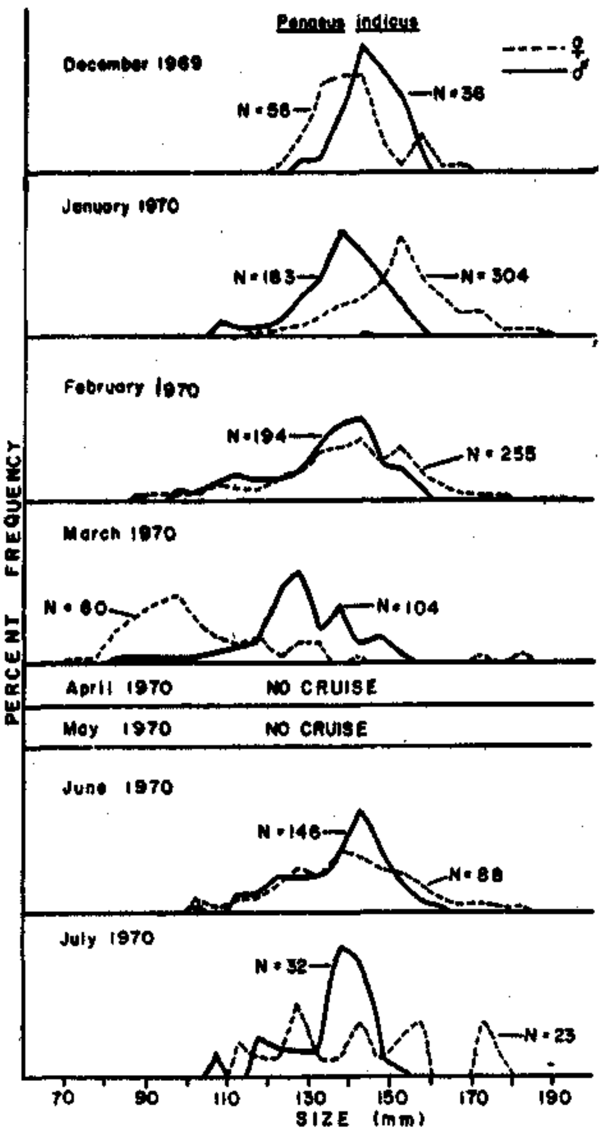

Fig. 8. Monthly length frequency of male and female *P. indicus* taken from five fathoms within Ungwana Bay, 1970.

[11]

presented, it is expected that a standing crop of 50-75 metric tons per annum would be more realistic. The latter figure, based on preliminary estimates, does not in any case infer a harvest or yield of this magnitude. What is represented, is a theoretic density of adult prawn stocks within a given area (the Ungwana Bay Complex of Kenya). Further studies must be carried on by the Kenya Fish Department which will delineate catchability rates, distribution over time and space, and influences of environment on life-cycle patterns. These surveys are needed to arrive at more accurate prawn stock estimates than are presented in this paper. In any case, the possibility of establishing (in the near future) a small but productive commercial fishery seems highly feasible. The world market is constantly looking for such sources of crustacean products and developing nations can benefit greatly if the resource can be exploited and marketed using modern methods.

Although it is advocated that commercial activities begin in the near future, biological exploration must advance with commercial exploitation. Within Kenya's noted that 33% of all *P. indicus* females examined in December, 1969 were in the ripe stage of ovarian development). They appear in 5 fathom catches at lengths of 85-100 mm (T.L). No survey cruises were made in April and May but in June, peak recruitment appears to cease. Although not depicted, similar comparisons of other species indicate the utilization of Ungwana Bay's estuarine environment for nursery grounds.

In efforts to determine utilization of estuarine areas, by offshore Penaeid populations, a post-larval monitoring station was established at the mouth of Kilindini Harbor (Mombasa). Samples were taken weekly during flood tides with a 6-foot beam trawl (Renfro, 1962). Although catches were small during the sampling period, the numbers of post-larvae per tow were consistent and indicated minor utilization of the Mombasa Estuarine Complex (Table 3).

Through studies of this type, the research staff of the Kenya Fishery Department will be able to establish a post-larval index. This index will indicate time periods of peak densities of juvenile prawn stocks in estuarine systems and allow local fishermen to harvest maximum biomass. The latter statement is, of course, contingent on fishing effort.

Table 3. *Weekly catch of* Penaeus sp. *post-larvae*[1] *taken from the Likoni Sand-flat (Mombasa) during June and October* 1970[2]

Date	Water Temp. (°C)	No. of Penaeus sp. post-larvae	Date	Water Temp. (°C)	No. of Penaeus sp. post-larvae
16—6—70	27.1	16	25—8—70	26.0	9
24—6—70	27.5	0	2—9—70	27.0	2
1—7—70	26.0	38	9—9—70	26.5	12
8—7—70	27.0	4	16—9—70	27.5	0
15—7—70	26.5	6	21—9—70	27.0	2
22—7—70	27.0	1	30—9—70	28.0	8
29—7—70	25.5	4	7—10—70	28.5	12
5—8—70	28.5	10	14—10—70	28.0	0
12—8—70	27.5	24	21—10—70	28.8	4
14—8—70	26.0	4	28—10—70	28.5	22
19—8—70	25.4	5			

[1] = less than 25.0 mm in total length.
[2] = Catches taken from 5-minute tows made from shore with hand-drawn beam trawl.

Although not surveyed, the extensive Lamu Estuarine Complex probably produces the majority of Kenya's offshore prawn stocks. In 1969, Lamu District produced 15,377 Kg (heads-on-wts) or 35%, of Kenya's total prawn catch. One hypothesis is that during the February-March emigration period, Penaeid sub-adults follow the NE Monsoon Current into the Ungwana Bay area.

Discussion

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