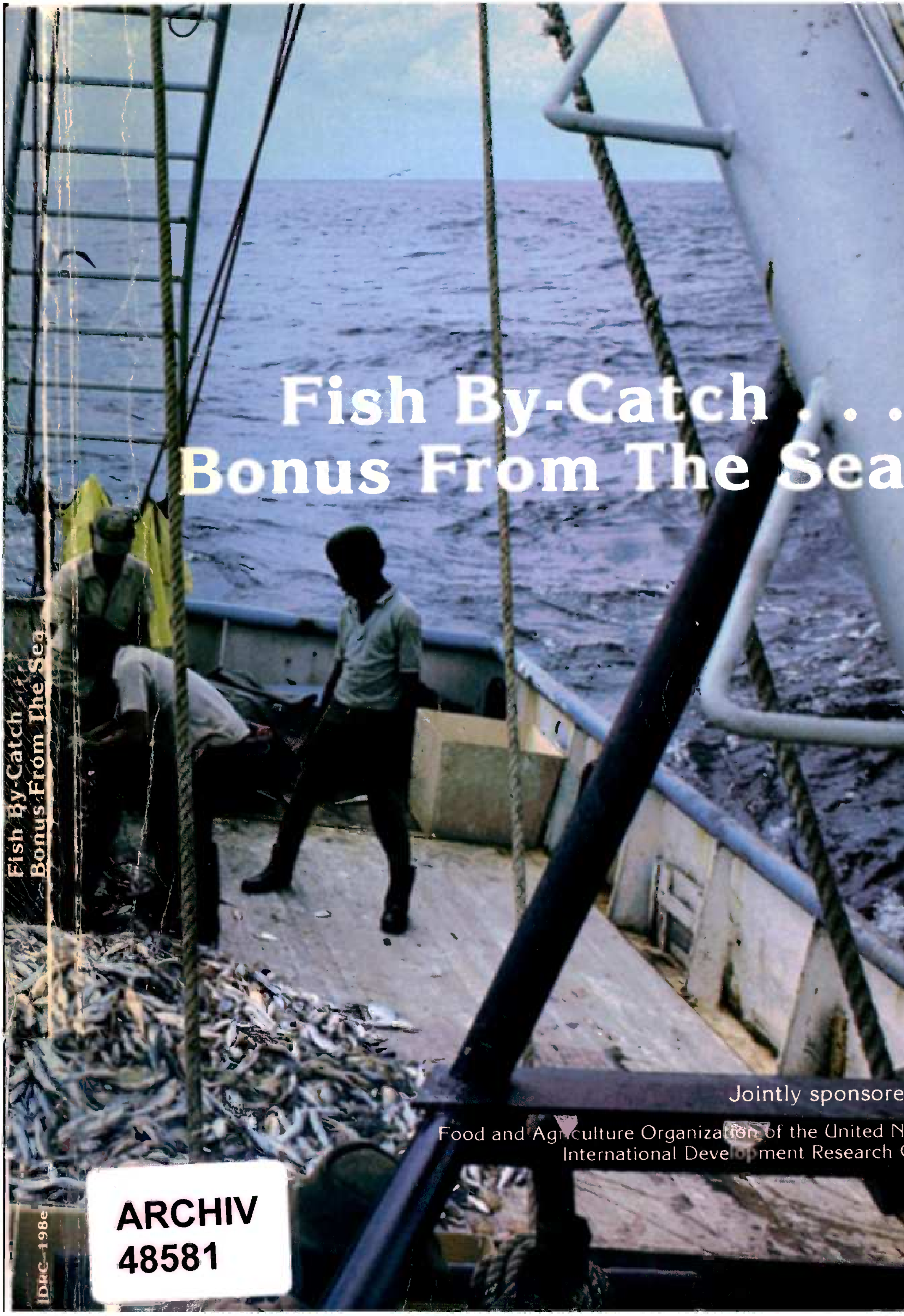

Fish By-Catch . . . Bonus From The Sea

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Report of a Technical Consultation on Shrimp By-Catch Utilization held in Georgetown, Guyana, 27–30 October 1981

Jointly sponsored by:
The Food and Agriculture Organization of the United Nations and International Development Research Centre

Contents

By-Catch from Shrimp Trawling in Guyanese Waters[1]

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Assessment (July–August 1980) of incidental catches of fish by trawlers operating in Guyanese waters showed that the largest quantities of fish are caught in shallow waters (<15 fathoms), whereas the largest quantities of shrimp are caught in deeper waters (22–39 fathoms). The trawlers continue to fish the shallow waters, however, because highly valued, large white shrimp are only found there. At most, these shrimp constitute 5% of the total catch, a percentage that does not offset the vast quantities of fish currently being wasted as discards. A government program to cut the wastes has required that trawlers land some of their by-catch, but, because the shrimp are the target of the trawlers, the crews process them before the fish — a fact that means the fish may wait hours on deck before being frozen. Because the trawlers operate in shallow waters during the day (and deeper waters at night), the quality of the fish deteriorates badly during this time. These findings suggest that the government should ban shrimping activities in the shallow waters and offer incentives for a fleet to catch groundfish for the by-catch processing project that it has launched.

The waters on the continental shelf near Guyana contain a tropical multispecies fishery, with shrimp or prawns (*Penaeus* spp.) as the target of trawling operations. The fish community associated with these shrimp is diverse and abundant. When such fish are taken as by-catch during trawling operations, they are usually discarded at sea. The Guyanese government, with some IDRC aid, has initiated a by-catch use project that could change current practices. However, it requires information on the raw material that is potentially available as the basis for profitable future developments. Providing these data was the aim of this study; the specific objectives were to:

- Estimate, during one shrimping season, the volume and composition of the by-catch taken by the shrimp fleet and its spatial variation;
- Develop a simple sampling scheme that could be used locally to monitor and eventually estimate the catch volumes seasonally; and
- Interpret the baseline data collected and make recommendations for development of the fishery.

Methods

Commercial catches were sampled at sea, the catch per unit effort (CPUE) was computed for individual species, mean length recorded, and weight-length relations were established for species common in the catch. These data were combined with information about operations of the fleet and records of landings as a basis for estimates of fish by-catch during the months of July and August.

Operations records for all vessels of the fleet do not exist, although short-term records for several vessels were found. Records of fleet size, vessel and gear types, and shrimp landings (volume and composition) were obtained from the Fishery Division of the Ministry of Agriculture, from shrimp-company records, and from the government vessel registry. A data-collection program has since been set up so that information on the operations of individual vessels can be used for future analysis of the spatial variations of by-catch. This program relies on captains from a subsample of the fleet to maintain a daily log while at sea.

Twenty-two commercial catches were sampled during July and August 1980 at compass bearings between 350° and 110° near Georgetown, Guyana, and in depths between 10 and 40 fathoms (18–73 m). Sampling coincided with the areas where the fleet was operating.

[1]Summary of a report prepared, on a consultancy basis, for the International Development Research Centre, Ottawa, Canada; the results were presented by W.H.L. Allsopp at the Consultation.

Sampling technique

Timed trawls, after being brought on board, were allowed to settle until the fish stopped moving. Then they were shoveled into a pile. Thus, the species that had moved to the outside of the unmixed pile were reintegrated. A sample was taken from the perimeter toward the centre of the pile and placed in a plastic basket (the type used on all vessels for handling shrimp). The basket was filled and weighed on a spring balance. (After this operation had been performed several times, the mean weight was calculated and used in subsequent monitoring.)

The basket was then emptied on deck and the shrimp in the sample were headed. The tails were placed in a separate container and weighed. The crew headed the balance of the shrimp catch, and the remaining fish and the shrimp heads were shoveled into baskets, weighed, and discarded. Later, the fish sample was sorted according to species or species group and counted. The lengths of the most abundant and valuable fish were measured. Fresh samples of the measured species were taken from the catch and frozen. The weight–length relationships of these 20 species were determined (weighings to 0.10 g on a double-beam balance). The figures for the sample were extrapolated to the total catch. As a measure of the accuracy of the method, the amounts of shrimp estimated for 21 trawls according to this method were compared with actual amounts obtained, and there was no significant difference ($P = 0.090$).

The numbers of each species or species group in each sample were reduced to CPUE expressed as fish/hour. The CPUE was consistent among vessels in the fleet because the boats are similar in power and design. The CPUE was defined for several communities of fish (the method of defining communities was cluster analysis — the best results from 12 different techniques). Two similarity indices (correlation coefficient and Euclidean distance) were used in both standardized and raw form. Clustering was done with the centroid, averaging, and Ward's minimum variance methods. The decision on which methods to accept as the best groupings of samples (i.e., communities) was based on the method's ability to produce replicated results, correlated to depth.

Within communities, the correlated occurrence of different fish with shrimp was examined with the same 12 clustering techniques. This defined the shrimp–fish associations. As no external criteria (i.e., depth) existed to select the most acceptable clusters containing shrimp and fish, the number of times any of the 12 techniques indicated a specific association was used as the measure of association strength. If all 12 techniques clustered a fish species with the shrimp, that species was given a score of 12 and assumed to be a close association. The size of clusters varied with method. Clusters accepted as representing a group were defined on an arbitrary basis, the goal being to reduce the number of associations to fewer than 20 species. Generally, clusters were well defined and easily interpreted subjectively.

The weight estimates of fish catch were limited to 20 species because of time and resource constraints. Species were selected on the basis of high catches, potential as food (based on size and marketability), current use as food in Guyana, and storage quality. The measured weights and lengths of these species were fitted to the weight–length equation by the methods of Pienaar and Thomson. The mean length of the 20 species was established from as many samples as possible. If the fish occurred in more than one community, the samples were pooled. Most species were restricted in their distribution, concentrating in one depth strata.

The proportion of hours spent fishing the various communities during the rainy season was multiplied by the mean number of monthly landings, the mean hours fished per landing, and the weight CPUE of the fish as a basis for estimates on the catch currently available to the by-catch project.

Results

In January 1980, 148 vessels were operating in the fishery. Owned by 12 individuals or companies, all land their catch at one of three processors in Georgetown: Ocean Guyana Ltd, Guyana Fisheries Ltd, and Georgetown Seafoods. The latter two companies own more than 65% of the fleet. Records show a marked decline in the size of the fleet since 1975 (244 vessels). Since 1977, foreign vessels have been excluded from Guyana's territorial waters.

Shrimping continues throughout the year, and, although there is a marked difference in the average number of landings per month,

Although the fish are stored in refrigerated holds, they may sit on deck for as long as 3 hours beforehand.

the variations follow no chronological trend. The number of landings per month for July and August was 124 (8.2 SD, $n = 3$) and 113 (3.3 SD, $n = 3$), respectively. Number of hours fished per trip varies, but, during 13 trips spanning 1980, boats fished an average 465 hours (82 SD). Area fished also varies. Shallow-water (<15 fathoms deep) fishing is generally conducted during the day, and night fishing concentrates in waters 25–40 fathoms deep. Vessels from Georgetown Seafoods are inclined to operate 24 hours, even when inshore fishing is unproductive; they carry more fuel than do Guyana Fisheries vessels, which fish only the offshore grounds when inshore operations are marginal.

Main nets are towed from 1 to 12 hours, and trips last from 3 to 6 weeks, depending on catch, fuel supplies, and mechanical breakdown. Highly valued food fish are retained, but most fish are discarded at sea. The shrimp catch is headed, washed, and soaked in a seawater solution of anhydrous sodium metabisulfite before being frozen. This operation takes 2–5 hours and has priority over fish processing.

Although efforts may be concentrated in a specific area in the short term, they are generally random and along the entire Guyana coast. Although total effort has declined, landings have not declined — an increase in CPUE.

Shrimp landings are lowest during November, December, and January, although the number of landings per month remains fairly constant over the year. Landings increase steadily from February to May then sharply decrease in June, increasing again in July.

The by-catch

The by-catch fish community closest to shore occurs between 9 and 11 fathoms (the 10-fathom community); moving away from shore, one finds a community between 14 and 15 fathoms deep (15-fathom community). The 25-fathom community extends from 22 to 25

Sorting the by-catch.

fathoms, and the most offshore community ranges from 32 to 39 fathoms (the 35-fathom community). During May, June, July, and August the 10-fathom community was fished for 49% of the time, the 15-fathom community 19%, the 25-fathom community 15%, and the 35-fathom community 17% (where n = 946 hours of data collected during the 2 years).

Within communities, 95 species or species groups were identified, but not all species occurred in each community. Species diversity generally increased with depth. However, this finding may reflect differences in the amount of time fished: the samples closest to shore came from short trawls, necessitated by large catches, and, hence, may be artificially less diverse (Table 1). Because clustering was by correlated occurrence, the associated species may have widely different absolute abundances. Many of the species occurred only sporadically in the samples and are of little use for industrial production. The species included marketable, less-marketable, and unmarketable fish (Table 2). The marketable species were those that are already valued in the by-catch, those of sufficient abundance and size to make an immediate contribution, and those valued in other areas. The less-marketable species were those that are less abundant, have poor storage qualities, are small, or have only limited use in other areas. The unmarketable species were poisonous fish or those suspected of being poisonous; they deserve mention, as their presence may be of concern in bulk use of unsorted catches. The CPUEs demonstrated that the abundance of fish declines as the depth of water increases, although the reverse is true for poisonous species.

In contrast, shrimp abundance is lowest in the communities close to shore (9–15 fathoms deep) and greatest in the two offshore communities (22–39 fathoms deep). This finding is even more pronounced than is apparent in the data presented here because the inshore-shrimp count includes seabob (*Xiphopenaeus* spp.), which are small and are discarded. All offshore shrimp are kept. This fact leads to

Table 1. Scores from 12 techniques of cluster analysis of the strength of association between fish species (or species groups) and shrimp.[a]

10-fathom community		15-fathom community		25-fathom community		35-fathom community	
Species	Score	Species	Score	Species	Score	Species	Score
Prionotus rubio	12	*S. plagiusa*	10	*Haemulon steindachneri*	9	*Pristipomoides macrophthalamus*	7
Synodus spp.	12	*Synodus* spp.	9	*P. rubio*	9	Mullids	6
Dasyatis sayi	11	*Dactylopterus volitans*	7	*Rhomboplites aurorubens*	6	*S. brasiliensis*	6
Peprilus paru	9	*Diplectrum* spp.	6	*Acanthostracion guadricornis*	5	*Prionotus stearnsi*	6
Ogcocephalus spp.	8	*E. argenteus*	5	*Haemulon aurolineatum*	4	*Synodus* spp.	6
Gymnarchirus spp.	8	Ophidids	4	*Ogcocephalus* spp.	4	*Monacanthus* spp.	5
Cynoscion virescens	5	*Orthopristis ruber*	3	*Bellator militaris*	4	*Sphoeroides* spp.	5
Pellona harroweri	3	*C. nobilis*	3	*Porichthys porosissimus*	3	*Halutichthys* spp.	4
Oligoplites saurus	2	*Sphyraena guachancho*	1	*Lutjanus synagris*	3	*Ogcocephalus* spp.	4
Diapterus rhombeus	2			*S. guachancho*	3	*P. porosissimus*	3
Cynoscion arenarius	2			*Lutjanus aya*	3	*B. militaris*	2
Ctenosciaena gracilicirrhus	2			*D. rhombeus*	3	*Ariomma regulus*	2
Odontognathus surinamensis	2			*Albula vulpes*	3	*Chilomyctrus* spp.	2
Chloroscombrus chrysurus	1			*D. volitans*	3	*Balistes* spp.	2
Eucinostomas argenteus	1			*Phrynelox scaber*	3	*Lagocephalus laevigatus*	2
Conodon nobilis	1			*Monacanthus* spp.	1	*P. rubio*	1
Haemulon plumeri	1			*Diplectrum* spp.	1	*Chaetodipterus faber*	1
Polydactylus octonemus	1			*Scorpaena brasiliensis*	1	*Rachycentron canadum*	1
Symphurus plagiusa	1			*Halutichthys* spp.	1		
Menticirrhus americanus	1						

[a]The score indicates how many of the 12 techniques showed an association between the particular species (or species group) and the shrimp.

Table 2. Mean CPUE (number of fish/hour for boats with two nets), shrimp production, and fish/shrimp ratios.

	Community							
	10-fathom		15-fathom		25-fathom		35-fathom	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Marketable								
Selene setapinis	4888	8659	16	26	0	0	4	9
Macrodon ancylodon	3570	1451	0	0	0	0	0	0
Harengula jaguana	2377	1555	2	3	0	0	0	0
Bagre bagre	1436	437	0	0	0	0	0	0
C. nobilis	121	135	20	20	0	0	0	0
Pomadasys carvinaeformis	112	163	38	48	0	0	0	0
Menticirrhus americanus	77	154	45	4	0	0	0	0
C. virescens	63	31	0	0	0	0	0	0
Micropogon furneri	58	67	0	0	0	0	0	0
Genytremus sp.	53	61	0	0	0	0	0	0
Nebris microps	48	72	0	0	0	0	0	0
Bothids	0	0	490	210	646	196	251	252
D. volitans	0	0	9	9	452	362	629	437
E. argenteus	0	0	10	7	79	49	5	8
O. ruber	0	0	64	55	33	61	0	0
R. aurorubens	0	0	0	0	58	24	16	25
H. aurolineatum	0	0	0	0	22	18	3	4
H. steindachneri	0	0	0	0	44	29	1	2
Priacanthus arenatus	0	0	0	0	6	8	23	23
P. macrophthalamus	0	0	0	0	0	0	15	25
Fish/shrimp ratio	**13.12:1**		**1.71:1**		**0.68:1**		**0.48:1**	
Less marketable								
P. harroweri	2576	3798	0	0	0	0	0	0
Stellifer rastifer	1833	1086	0	0	0	0	0	0
O. surinamensis	1174	988	0	0	0	0	0	0
Stellifer microps	694	274	0	0	0	0	0	0
Trichiurus lepturus	628	655	0	0	1	2	5	1
Isopisthis parvipinnis	582	298	0	0	0	0	0	0
Anchoa spinifer	505	358	0	0	0	0	0	0
C. gracilicirrhus	394	788	35	40	15	25	0	0
Bairdiella ronchus	167	263	29	58	0	0	0	0
Arius spp.	154	134	0	0	0	0	0	0
P. octonemus	118	123	2	3	0	0	0	0
D. rhombeus	77	154	0	0	5	1	0	0
C. arenarius	77	154	43	40	5	6	1	2
C. faber	64	88	24	36	0	0	2	1
Paralonchurus brasiliensis	55	69	0	0	0	0	0	0
P. rubio	10	19	576	317	58	30	13	18
C. chrysurus	0	0	90	114	2	3	0	0
P. porosissimus	0	0	228	103	93	29	191	184
B. militaris	0	0	0	0	63	55	67	51
Mullids	0	0	49	28	19	12	73	75
Fish/shrimp ratio	**9.46:1**		**2.65:1**		**0.12:1**		**0.16:1**	
Unmarketable								
Sphoeroides spp.	0	0	6.1	4.0	17.0	13.0	28.0	13.0
Chilomyctrus spp.	0	0	0.5	1.0	5.8	3.3	0.4	1.1
S. gauchancho	0	0	2.5	3.4	0.5	1.0	0	0
Shrimp	**976**	**576**	**406**	**140**	**2110**	**495**	**1968**	**924**

wide disparities in the number of fish taken as by-catch for each shrimp kept. By-catch is much greater within the 10-fathom grounds.

The decline in abundance of fish in the deeper communities is duplicated by a decline in weight. Average weight of fish caught each hour from the community nearest shore was twice that from the three offshore communities. Estimates of the monthly weight of useful fish taken as by-catch give some idea of the potential landings (Table 3). The means used in these estimates included error estimates when possible. These figures indicate the vast quantities of useful fish that are discarded as by-catch. Virtually all of this amount during the June–August rainy season is caught between 9 and 14 fathoms where large white shrimp are found. During this study, no white shrimp were observed outside 15 fathoms; they are highly valued but rarely exceed 5% of total production and result in the greatest waste of usable by-catch.

Discussion

The waste of the by-catch in the Guyanese shrimp fishery is enormous and was probably far greater before the national fleet was reduced and foreign vessels were excluded from the exclusive economic zone. Stable shrimp catches indicate highly productive stocks. Although there are no records on the by-catch in the past, fish-stock productivity may be assumed to be high, as it is in other tropical areas.

In waters deeper than 15 fathoms, few useful or even marginally usable fish are found, although these areas are the richest in shrimp and contain the greatest number of unmarketable fish. Thus, the inshore grounds are the most important source of input for any fish-processing facility.

At present, the grounds closest to shore are exploited by a large but poorly equipped artisanal fishery (Chakalall 1980). However, the long, gently sloping, continental shelf puts the 15-fathom grounds well beyond the reach of the artisans. Shrimp trawlers seldom operate in waters less than 9 fathoms deep, and, consequently, a large, relatively unfished band of water exists between the limits of the two fisheries. By-catch from the offshore edge of this band is the richest on the shelf and promises great potential.

Farther offshore, in the 15-, 25-, and 35-fathom communities, the catch of fish is much smaller, and the species tend to be small and spiny, dominated by dactylopterids, triglids, batrachids, and many small (<10 cm) bothids. The main food resources available are lutjanids and pomadasyids. The snappers that are found in this area are small species (e.g., *Rhomboplites* sp.). Grunts are widely used as food throughout the world and are found at all depths; however relatively insignificant numbers are taken at depths of 15 fathoms or more.

Table 3. Potential landings of the 20 desirable fish species. The estimates assume an average 465 fishing hours for each landing and an average 124 landings in July and 113 in August. The hours spent fishing are assumed to be distributed among the communities as follows: 10-fathom 49%; 15-fathom 19%; 25-fathom 15%; and 35-fathom 17%. Common local names are in parentheses.

	Potential monthly landings (t/month)	
Species	July	August
M. ancylodon (bangamary)	8482	7729
S. setapinis (moonshine)	5322	4850
H. jaguana (herring)	2587	2357
B. bagre (catfish)	2460	2241
M. furneri (croaker)	489	446
M. americanus (whiting)	208	190
N. microps (butter fish)	194	176
C. nobilis (annafolk)	188	171
D. volitans (gunnard)	133	121
Bothids (flounders)	128	116
C. virescens (trout)	127	116
P. carvinaeformis (grunt)	121	111
Anisotremus virginicus (annafolk)	56	51
E. argenteus (mojarra)	29	27
Q. ruber (grunt)	27	25
H. steindachneri (grunt)	25	23
R. aurorubens	17	16
H. aurolineatum (grunt)	14	12
P. arenatus	13	12
P. macrophthalamus	3	3

As inshore grounds are capable of producing as much raw material as the by-catch project can handle, they are the logical area on which to concentrate. At present, the by-catch receives second priority to the more valuable shrimp. Consequently, fish remain on deck for hours before receiving attention. This practice is especially a problem near shore because fishing in this area is during daylight when the hot sun speeds spoilage.

The portion of the by-catch that is retained has deteriorated markedly by the time it is finally frozen. If fish are to be kept in good condition, shipboard processing will have to be improved.

One means of obtaining the by-catch in good condition and stopping the waste of fish resources is to ban shrimp fishing within shallow waters (<15 fathoms) and employ small trawlers to collect fish near shore. This approach would obviate the need for catch-transfer methods needed by collector-boat systems. The impact on shrimpers would probably not be significant because the most productive shrimp grounds are off shore. It would eliminate white shrimp from the catch, but they represent only 5% or less of the catch. It would also reduce brown-shrimp production, although the amount is unknown and should be examined.

Collection of samples encompassing a more complete range of depths and a larger area of the coast than was possible in this study is needed so that the fish communities and their spatial variability can be better understood. The fishery is, at present, in an advanced developmental stage and will need a strong data base in the future when more stringent management becomes necessary. This can only be obtained by continued data collection and analysis. In the meantime, some recommendations can be made on the basis of the existing data:

- The by-catch project should continue to concentrate on processing fish from the inshore community and should consider expanding to include catfish, herring, and moonshine.
- A policy of reducing the waste of the by-catch could be easily implemented by the government if it prohibited shrimping in waters shallower than 15 fathoms during the rainy season. The effects of continued wastage can only be determined by a long-term monitoring program.
- Biologic data collection should continue for at least 2 person-years, with increased sample size and coverage of all seasons. In fact, if the effects of wasting the by-catch are to be determined, data collection should continue indefinitely.
- To improve the quality and regularity of fish inputs to the processing facility, the authorities should provide incentives for small trawlers to target specifically on fish in shallow waters near shore.
- Biologic sampling should be done from as many different vessels as possible so that catch statistics reflect a wide range of operating strategies.
- The captains' log program should be continued so that the fleets' distribution among the fish communities can be accurately delineated.
- Data collected for 2 person-years should be subjected to an in-depth analysis.