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The artisanal seine- and lift-net fisheries of the north coast of Java

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Abstract. Small-scale seines and lift-nets account for 30–50% of the fish catch along the northern coast of Java. Beach-seine catches include Sciaenids and Leognathids but the nearshore anchovy *Thryssa* (Engraulidae) is the most common genus. Lift-nets and payang (surface seine) catches are dominated by *Stolephorus*, and the mini purse-seine catches by *Sardinella* and *Rastrelliger*. Mean catch per daily trip is from 25 to 50 kg for lift-nets, about 100 kg for surface seines, and over 200 kg for beach-seines and mini purse-seines.

Information from official statistics, auction-place records and previous research reports and publications is combined with new information about catch-rates and species composition to provide a first step towards developing a management programme for this fishery.

Introduction

The fishery of the northern coast of Java is particularly important because it is one of the largest in Indonesia and is also at the population centre of Indonesia. Artisanal fishing gears account for over 60% of the catch and 30–50% is landed in several seines and related gears. The most important of these are: mini purse-seine, a small version of the purse-seine; payang, a pelagic seine-net with large mesh wings and a small mesh bag; ocean lift-nets, lift-nets fished from bamboo platforms; and beach-seine.

The contribution of these gears to the overall catch is somewhat difficult to assess for several reasons: available data are often limited in detail, data for specific gear types are sometimes combined with those for other gear, and species composition data are often limited.

Several additional factors make the rational management of this fishery difficult. Even under ideal conditions the multi-species, multi-gear nature of the fishery creates problems for the fishery manager. A management action (e.g. a mesh-size regulation) may be suitable for one species but not for others. The social and economic situation on the north coast of Java further complicates management of the fishery. Much of the population is poor and dependent on the sea for a living. Management actions which would limit fishing could also result in increased unemployment and less favourable economic conditions. Any regulations or development programmes must consider this factor.

Methods of data collection

Data used in this analysis are a mixture of data collected by the authors and Indonesia's BPPI (Fishing Development Centre) staff, data obtained from various statistical sources (e.g.

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Results and discussion

Mini purse-seines

Description of fishing gear. Mini purse-seines are made almost exclusively of 1·9-cm (0·75-inch) mesh nylon in spite of an old regulation requiring 2·54-cm (one-inch) mesh. Our data indicate that most mini purse-seines are less than 200 m long, and that the average length is 191 m. Mini purse-seines are normally fished at night while using powerful lamps on small rafts to attract fish. Typically, three–five settings are made per trip. The boats leave at 1600 hours and return early in the morning. Sometimes mini purse-seines are used during the day with fish attraction devices, but this method does not seem to be so common as it is with the larger, offshore, purse-seines. Occasionally, mini purse-seines are used at night without lights during calm periods, but this method is uncommon. The crew on a mini purse-seine boat ranges from 10 to 30 with an average of about 18 people.

The purse-seine fishery, in comparison, is composed of larger boats based at the larger fishing ports which make 5–10-day fishing trips in the Java Sea. Descriptions of this fishery are available elsewhere (Tampubolon 1982). The primary differences between the purse-seine and the mini purse-seine fishery are as follows. The purse-seine fishery employs longer nets and bigger boats. The larger boats permit trips as long as 10 days. In general, the catch per day is somewhat higher than the mini purse-seine, and different, more valuable, species are caught (*Sardinella sirm, Decapterus* and *Rastrelliger*). Also the purse-seines do much of their fishing during the day and make extensive use of fish attraction devices.

Numbers of fishing units. Official reports list 682 purse-seines (including mini purse-seines) for the north coast of Central Java and 1613 for the entire northern coast of Java. However, data at BPPI indicate that there are about 800 purse-seines in Central Java, of which about 450 are large purse-seines. This leaves approximately 350 mini purse-seines in operation on the north coast of Central Java (G. Tampubolon, personal communication). The proportion of mini purse-seines in the other provinces is probably higher.

Total catch. Official statistics do not distinguish between catches of large purse-seines and mini purse-seines. Our data, collected from several locations, indicate a catch per trip from mini purse-seines of between 40 and 900 kg with a mean of 294 kg per one-day trip. The frequency distribution of the catches is skewed, with over 50% of the catches less than 200 kg (Fig. 1). Information independently obtained from auction-place records at the village of Tawang over an 80-day period indicated a mean catch per trip of 291 kg.

Fishing effort and catch per trip for mini purse-seines are very much influenced by the lunar phase, with relatively little fishing and somewhat lower catches occurring during the full moon (Fig. 2). As a consequence only 12–15 trips per month are made with this gear. Even fewer trips will be made during the west monsoon (December–February) when larger waves reportedly cause many fisherman to switch to fishing payang which are easier to operate in rough water.

For Central Java an estimate of 50 400–63 000 trips per year is realistic (350 units, 144–180 trips per year per unit). The average catch per trip from our data is 290 kg, but because of the skewed distribution perhaps 200 kg per trip is a more realistic value. Using that value the total catch from mini purse-seines is about 10 000–18 000 tons or 17–32% of the reported purse-seine catch. These figures are approximate, but nevertheless realistic.

Payang

Description of fishing gear. The payang is a pelagic seine of a significantly different design. Payang examined ranged from 110 to 600 m in length. However, most of them were slightly less than 200 m long and the mean length was 201 m. The payang typically has very large meshes in the wings, usually 20–30 cm or larger. Towards the bag the meshes become progressively smaller to perhaps 2–3 cm near the bag. The bag is usually made from a fine mesh woven plastic or polypropylene material called 'waring', which has mesh openings

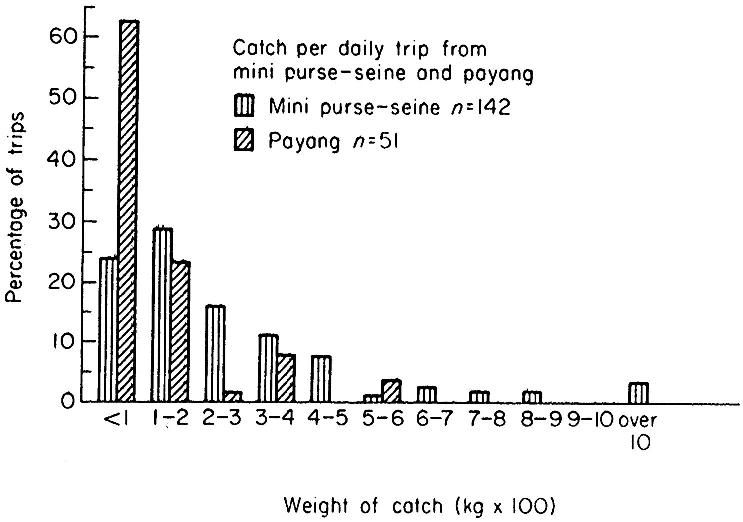

Figure 1. Frequency distribution of weight of total catch from mini purse-seine and payang samples along the north coast of Java during 1983 and 1984.

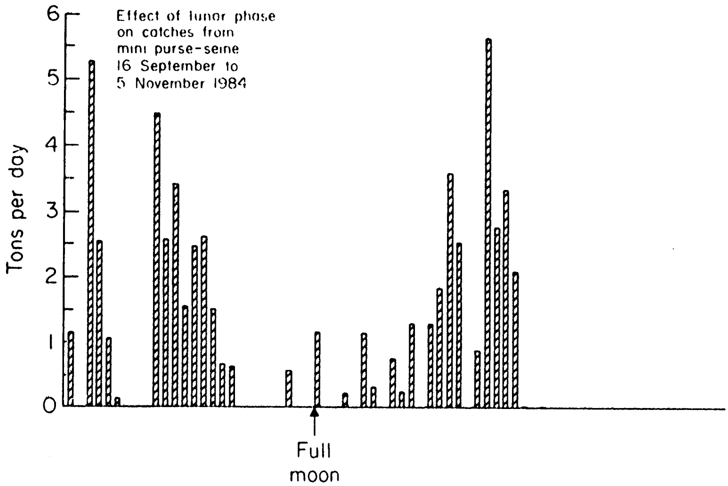

Figure 2. Effect of lunar phase on catches from mini purse-seines. This example is based on auction records from the village of Tawang in Central Java.

2–3 mm across. An unusual characteristic of the payang is that it usually has no head- or foot-rope except in the middle third of the net. The payang is usually fished during the day. Because the large mesh wings make it easier to pull, the payang is usually set 15–20 times per day. The larger versions of the payang require a crew of about 6–20 people with 15 as an average. Usually, the payang is fished near the coast during a one-day trip. However, they are sometimes used on larger boats fishing offshore which make trips of up to 7 days (Subroto 1975). Many of these boats have now switched to fishing purse-seine, so the number of paying vessels fishing offshore is quite small.

There are several sizes and local variations of payang, which results in some confusion in the recording of statistical data. The gear described above is typically called payang, payang gemplo, payang jabur, jabur or payang besar. The official translation to English is 'surface-seine'. In parts of East Java little payang ('payang kecil' or 'payang alit') are used. These are light-weight nylon nets 10–12 m long which catch a mixture of pelagic and demersal fishes. These should be considered a different gear type.

Numbers of fishing units. There are slightly fewer than 500 payang reported for the north coast of Central Java. The value of 1396 listed for 1980 is probably incorrect. There is no way to gauge the accuracy of the total north-coast numbers of 4000–6000 units. Those figures undoubtedly include many of the smaller payang-like gears. It can be assumed that there are about 500 large payang along the northern coast of Central Java which operate relatively close to shore.

Total catch. Official statistical reports give a total catch from payang for Central Java of only 2800 tons for 1982 but about 7000–8000 tons for 1980 and 1981. It is unlikely that the catch changed by that much in one year. Our data indicate a mean catch per trip of 123 kg, but 65% of the trips land less than 100 kg (Fig. 1), thus a catch per trip of 100 kg will be used to estimate the total landings. If it is assumed that there are 500 payang units, and that there are 15–20 trips per month, then the total catch estimate for Central Java is about 9000–12 000 tons per year.

Ocean lift-nets

Description of fishing gear. The ocean lift-nets locally known as 'bagan' are of two basic types. The fixed lift-nets ('bagan tancap') are lift-nets operated from bamboo platforms built in waters as deep as 25 m. Each platform is 8–10 m on a side and stands 4–5 m above the water. A large square net hung from a bamboo frame is fished under the platform at night. The net has a mesh size of 2–3 mm. Several kerosene pressure lamps are used to attract fish. Because they are so dependent on light to attract fish, catches from ocean lift-nets, like those of the mini purse-seines, are very dependent on the lunar phase. The other type of bagan, boat bagan (or 'bagan prahu'), uses the same principle but is a floating platform built on one or two boat hulls (Direktorat Jenderal Perikanan 1975). These are not common on the northern coast of Java.

Numbers of fishing units. It is difficult to determine accurately the number of fixed ocean lift-nets from official reports. It is very unlikely that the 1982 figure of 414 for Central Java is correct, since 1980 and 1981 statistics give numbers of 1981 and 1968. Workers at Diponogoro University (Willoughby *et al.* 1984) counted 391 fixed lift-nets just in the Jepara district in July and August of 1982 in an area of 58 km^2. The correct number of lift-nets is probably more likely to be similar to that reported for 1981, about 1800–2000.

Total catch. From statistical reports, total catch from ocean lift-nets would appear to be between 3000 and 4000 tons per year if the seemingly incorrect 1982 figure of 1000 tons is ignored.

Data reported by Zarochman *et al.* (1982) result in a much higher figure. They reported lift-nets in the Jepara district were used during a 7–8-month period and estimated the yearly number of fishing days at 161–181. They found catch per trip varied considerably, but their data seem to indicate an average value of 50 kg per night. If it is assumed that there are between 1800 and 2000 lift-nets on the north coast of Java then the total annual catch, based on this information, is between 14 490 and 18 100 tons. This figure is considerably higher than that given in the statistical reports.

It is unlikely that 23 trips are made per month as Zarochman *et al.* (1982) reported. Because of the dependence on lunar phase, numbers of trips are probably fewer. Perhaps 15 trips per month would be a more realistic figure.

Our limited data indicated a mean catch per trip of 33 kg and Willoughby *et al.* (1984) reported 26 kg per trip from lift-nets. If a minimum mean catch per trip of 25 kg is assumed, then the minimum total catch estimate would be 4725 tons (105 trips × 25 kg × 1800 units). This is approximately the same as that given in the statistical data. This is realistic but perhaps somewhat low. The total catch from lift-nets for Central Java is probably between 5000 and 12 000 tons per year.

Beach-seines

Description of fishing gear. Beach-seines are by definition seine-nets which are fished close to shore and are pulled onto the beach. In northern Java these nets catch a mixture of small pelagic and demersal fishes. There is considerable confusion over the names used for beach-seines of different types. While this is partly a problem of translation into English, it is quite apparent that it is a problem in local languages as well.

In general, there are three types of beach-seine.

(1) Those with the whole net made from a woven plastic or polypropylene cloth called 'waring' which has a mesh size of 2–3-mm bar measure. Names used for this type include: Bundes, Bundes Waring and Krikit. These small-mesh beach-seines are typically between 100 and 300 m long.

(2) Nets with most of the net made from ¾-inch to 2-inch mesh, but with a bag made from 'waring'. Local names include: Bundes Jotang, Jotang, Payang Jotang, Krakad and Krakat. These nets are typically 600–800 m long.

(3) Nets made entirely of ¾- to 2-inch mesh but otherwise similar to those under (2) above.

Other names used for beach-seine are 'Payang Tarik' and 'Pukat Pantai'. Confusion about the names sometimes results in beach-seine data being recorded in other gear categories. For example, at some fish auction places the name 'Payang Jotang' is used and the catch data are later recorded as having come from payang.

For the purposes of management it is realistic to recognize two types of beach-seine: those made entirely of small-mesh (2–3-mm) 'waring' and those made primarily from larger meshes.

Usually, beach-seines are fished from 8- to 12-m boats with a crew of 15–30 depending on the size of the net. One–five settings are usually made per day depending on the success of the first catch. Usually, the boats leave shortly after dawn and return at between 1200 and 1500 hours, but the landing time varies both from village to village and also with wind and wave patterns. On occasion beach-seines are fished at night.

Numbers of fishing units. Statistical data indicate that the number of beach-seines has been quite constant over the years at about 330–340 units for the whole north coast (which includes the Madura Straits). Data for Central Java for 1982 list 152. However, none are listed for the districts of Kendal and Demak, although we regularly sampled beach-seines at villages in these districts. One fisherman was quite sure that there were only about 45 beach-seines on the whole north central coast, although that is surely an underestimate. The official numbers can be assumed to be correct: between 150 and 200 beach-seine units for the northern coast of Central Java, and perhaps 300–350 for the whole north coast of Java.

Total catch. Official reports list catches from beach-seines for the north coast of Central Java as 617 tons in 1980, 1800 tons in 1981, and 3367 tons in 1982. It is possible but unlikely that the catch from beach-seines has increased this much each year. Catch per trip based on our beach-seine data averaged 212 kg per daily trip (207 kg for fine-mesh beach-seines and 244 kg for larger-mesh seines). Mean catch per trip based on auction records varied from village to village and ranged 57 kg per trip for small-mesh seines at Asemdoyong in 1982 to 318 kg per trip for all size beach-seines at Wonokarto. Our data indicate that a daily catch of between 50 and 700 kg can be expected, with the lower end of this range being most likely. A value of 200 kg per trip is a reasonable one to use for further calculations (Fig. 3).

It is difficult to obtain accurate data concerning the number of trips made per year since many of the beach-seines move with the season. One informant told us that beach-seines tended to be farther west during the east monsoon (June–August). If beach-seines move from one village to another, data from a single auction place will not accurately report the number of trips. Central Java statistics for 1982 yield a figure of 143 trips per unit.

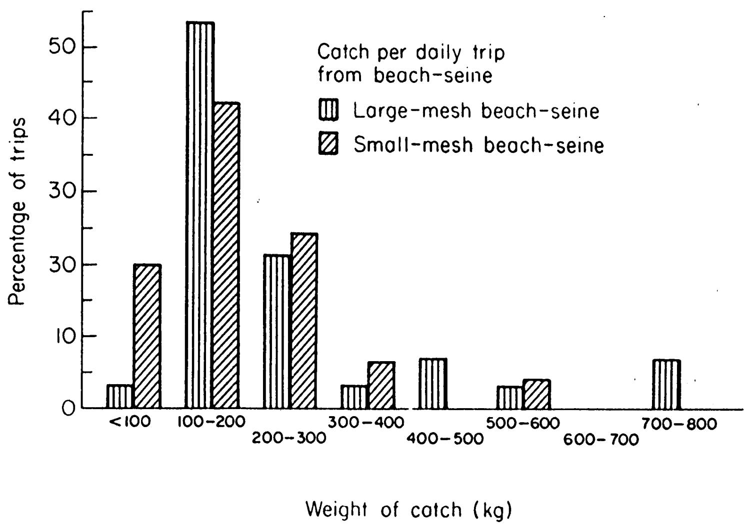

Figure 3. Frequency distribution of weight of total daily catch from large- and small-mesh beach-seines sampled along the north coast of Java during 1983 and 1984.

About 90% of the beach-seine catch is landed between March and November. The catch per trip follows the same trend. If 15–20 trips are assumed to be made per month during this period then it could be concluded that 135–180 trips are made per year.

Catches recorded in our sampling, and data from most auction places, indicate a catch per day of about 200 kg. This would suggest that the total catch per unit each year would be about 27–36 tons. Even if a conservative estimate is taken of 100 kg per trip and only 15 trips per month the yearly catch per unit would be 13·5 tons per year per unit.

From the above data a catch from beach-seine of between 2025 and 7200 tons would thus be expected for Central Java.

Species composition

Pelagic seines. Species composition of large, offshore purse-seine and mini purse-seine is superficially similar. Catches of both types of gear are dominated by *Sardinella*. In spite of this similarity the remainder of the catch in these two fishing gears is quite different. The larger purse-seines catch significantly more *Decapterus* and *Selar*, perhaps because of differences in fishing ground. The remainder of mini purse-seine catches consists of a mixture of other species, especially small Carangidae and Clupeidae (Tables 1 and 2). There are some indications of additional differences between the catches of mini purse-seines and large purse-seines. *Sardinella sirm* dominates catches in large, offshore purse seines while *Sardinella fimbriata* dominates catches in mini purse-seines along with other *Sardinella* species.

The catch composition of the inshore payang is very different from that of mini

Table 1. A comparison of major species groups caught in five types of seine- and lift-nets along the north coast of Java. Data for purse-seines, offshore payang and lift-nets are taken from reports referred to in the text. Some species, shown here as not occurring, may actually be present in those gears

	Fishing gear (in per cent)					
Species group	Purse-seine	Offshore payang	Mini purse-seine	Payang	Lift-net	Beach seine
Sardinella	41·6	33·0	41·9		4·3	2·1
Decapterus	23·0	27·0	5·7			
Selar	17·8	19·8	2·0			
Rastrelliger	14·4	5·9	25·7	3·2		
Stolephorus				47·5	64·5	3·7
Trichiuridae			3·2	19·4		4·8
Scomberomorus				15·4		
Dussumeria			4·9	3·2	3·5	
Squids			4·0		5·4	
Ambassis					7·5	11·7
Leiognathidae					4·4	8·1
Mysidae						9·1
Thryssa						23·5
Sciaenidae						11·1
Triacanthidae						5·33
Other	3·2	14·3	12·6	11·3	10·4	20·6

purse-seines. Almost 50% of the inshore payang catches are *Stolephorus* with a significant catch of Trichiuridae and *Scomberomorus* (Tables 1 and 3). None of these groups are important in the catches of purse-seines and mini purse-seines. However, Subroto (1975) reported that offshore payang have a catch composition very similar to that of the purse-seines (Table 1). Thus the differences between payang and mini purse-seine catches may be due to differences in the fishing ground as well as to differences in the fishing methods and gear. Nevertheless, since most payang fish near shore, the *Stolephorus*/Trichiuridae/*Scomberomorus* catch type is typical of current payang catches.

Table 2. Species composition data collected from 142 mini purse-seines along the north coast of Java between May and October 1984. The catch from an average net was 293·6 kg

Name of fish group	Percentage of total catch	Typical catch (kg)		Lengths			Number of nets catching this group (n = 142)
		Weight	Percentage	mean	min	max	
Clupeidae	49·25						
Sardinella	41·93	99·52	33·89	14·9	11·0	19·0	113
Dussumeria	4·94	10·80	3·68	15·1	9·0	18·0	41
Anodontostoma	0·82	7·06	2·41	16·8	14·0	22·0	10
other	1·56	6·18	2·11	11·1	7·0	18·0	29
Scombridae	28·32						
Rastrelliger	25·74	83·14	28·32	16·6	11·0	22·0	97
Scomberomorus	2·36	7·19	2·45	43·1	20·0	70·0	31
Euthynnus	0·17	0·72	0·25	30·7	28·0	32·0	3
other	0·05	0·23	0·08	15·0	15·0	15·0	1
Carangidae	11·45						
Decapterus	5·73	2·79	0·95	15·8	15·0	16·0	5
Megalaspis	2·13	11·08	3·77	15·5	9·0	25·0	19
Selar	1·98	4·13	1·41	19·2	15·0	23·0	16
Scomberoides	0·84	0·37	0·13	18·0	15·0	21·0	2
Selaroides	0·71	2·49	0·85	12·7	11·0	18·0	14
other	0·06	0·27	0·09	15·5	14·0	17·0	2
squids	3·97	19·49	6·64	13·3	12·0	15·0	45
Trichiuridae	3·17	19·58	6·67	48·6	15·0	70·0	40
Sphyraenidae	1·44	7·85	2·68	27·3	15·0	35·0	24
Formionidae	0·74	3·72	1·27	18·3	12·0	27·0	6
Leiognathidae	0·53	2·09	0·71	9·0	6·0	12·0	18
Stromateidae							
Pampas	0·36	0·83	0·29	15·4	14·0	17·0	5
Engraulidae	0·26						
Thryssa	0·21	0·74	0·25	7·0	7·0	7·0	5
Stolephorus	0·05	0·20	0·07	14·0	14·0	14·0	2
Lactariidae	0·12	0·23	0·08	17·3	15·0	20·0	4
Chirocentridae	0·06	1·32	0·45	28·0	15·0	45·0	4
rays	0·05	0·21	0·07	40·0	40·0	40·0	2
Istiophoridae	0·05	0·18	0·06	–	–	–	1
Sciaenidae	0·03	0·08	0·03	14·8	12·0	20·0	4
Ariidae	0·01	0·01	0·01	13·0	13·0	13·0	1
Mullidae	<·01	0·01	0.01	14·0	14·0	14·0	1
Theraponidae	<·01	0·03	0·01	16·0	16·0	16·0	1
other	0·21	0·95	0·32	10·0	10·0	10·0	13

Comparison of inshore payang and lift-nets. Both payang and lift-nets catch a large proportion of *Stolephorus*, but the remainder of the catches are rather different (Table 1). The significant proportion of *Scomberomorus* and Trichiuridae of the payang is not found in the lift-net catches. Nevertheless, the management of these two types of fishing gear needs to be considered together because of the large *Stolephorus* catches in both gears. Although the payang fish during the day and the bagan at night they are fished in the same area. Although there are no reliable species composition data below the genus level for both gears, it is likely that the same *Stolephorus* species are caught by both. Willoughby *et al.* (1984) reported *Stolephorus heterolobus* as the dominant species in bagan catches in the Jepara district of Central Java.

Species composition of beach-seine catches. Auction-place data and fishery statistics reports provide little information about species composition of beach-seine catches because virtually all the catch is sold and recorded under the category 'other'.

Table 3. Species composition data collected from 51 payang along the north coast of Java between May and October 1984. The catch from an average net was 123·7 kg. Payang are pelagic seine-nets with large meshes (up to 35 cm) in the wings and small meshes (as small as 2 mm) in the bag

Name of fish group	Percentage of total catch	Typical catch (kg)		Lengths			Number of nets catching this group (n = 51)
		Weight	Percentage	mean	min	max	
Engraulidae	48·16						
Stolephorus	47·53	47·75	38·60	5·8	3·0	8·0	42
Thryssa	0·63	0·93	0·75	11·0	9·0	15·0	4
Trichiuridae	19·37	17·80	14·39	58·1	40·0	70·0	13
Scombridae	18·52						
Scomberomorus	15·36	22·49	18·18	49·6	35·0	80·0	15
Rastrelliger	3·16	3·83	3·10	11·9	9·0	17·0	7
Clupeidae	3·98						
Dussumeria	3·20	5·62	4·54	9·9	4·0	15·0	16
other	0·78	2·66	2·15	9·1	6·0	14·0	12
Leiognathidae	2·80	7·22	5·84	7·0	4·0	12·0	18
Carangidae	3·02						
Megalaspis	1·81	2·34	1·90	16·1	15·0	19·0	8
Selaroides	0·86	1·68	1·36	7·5	6·0	8·0	5
Selar	0·08	0·24	0·20	20·0	20·0	20·0	1
other	0·27	0·89	0·72	21·8	12·0	46·0	6
Formionidae	1·74	4·16	3·37	29·7	24·0	35·0	3
Stromateidae							
Pampas	0·87	2·83	2·29	18·9	15·0	25·0	8
Mysidae	0·48	0·58	0·47	1·5	1·0	2·0	2
Ariidae	0·36	0·35	0·28	30·0	30·0	30·0	1
Sciaenidae	0·17	0·65	0·53	16·3	8·0	25·0	4
Nemipteridae	0·09	0·24	0·20	16·7	12·0	20·0	3
Chirocentridae	0·08	0·30	0·25	35·0	35·0	35·0	1
Lactariidae	0·06	0·07	0·06	14·5	14·0	15·0	2
Centropomidae							
Ambassis	0·06	0·11	0·10	6·0	6·0	6·0	1
Theraponidae	0·05	0·14	0·12	14·0	14·0	14·0	1
other	0·18	0·72	0·59	–	–	–	5

The dominant species groups in beach-seines are: *Thryssa*, *Ambassis*, Sciaenidae, Mysidae and other small shrimps, Leiognathidae, and several Clupeidae (mostly *Sardinella*, *Anodontostoma*, *Ilisha*, *Dussumeria*, *Clupeoides*, and *Sprattus*). Species composition varied considerably from seine to seine. Even the most commonly found species (*Thryssa mystax* and *T. hamiltoni*) were found in only 60% of the nets. Small-mesh beach-seines caught considerably more mysid shrimp and *Ambassis*, while the larger-mesh beach-seines were more likely to catch Sciaenidae (Tables 4, 5 and 6).

A fairly large proportion of the beach-seine catch is composed of small species rather than juvenile fish as is sometimes thought. Although there are substantial numbers of juvenile fish present, they do not make up a large part of the catch. Most of the catch is composed of small pelagic or inshore species. However, some Sciaenidae are caught at sizes small enough to be harmful to the overall fishery.

Speciality fisheries

Fishery for juvenile anchovy or 'teri nasi'. In some areas there is a special fishery for small anchovy (*Stolephorus*) 'teri nasi' caught primarily by payang and lift-nets. For example, in the village of Bulu in the Tuban district of East Java in October 1984, about 70 small sailing canoes were fishing for 'teri nasi' with payang. The fish caught were about 2 cm long and weighed 0·11 g each. Typical catches of 15–25 kg per trip contained about 9000 fish per kg. About 12·5 million of these fish were being landed each day. This type of fishery exists at many villages.

The overall effect of such a fishery can be determined only when fishing and natural mortality rates can be compared. Data gathered via interviews and examination of the catch at the village of Bulu (numbers of payang fishing, settings per day, length of net, catch per setting) allowed calculation of very approximate estimates of numbers of anchovy per unit area. By comparing this figure to the catches it was estimated that, at a maximum, about 1·3% of the juvenile anchovy in the area fished were caught per day. The boats were small sailing craft limited to the nearshore (10-km) area. Presumably, the fish population extends over a much wider area, making the actual fishing mortality rate much smaller.

The mysid shrimp ('rebon') fishery. A special industry exists for the catching, processing and marketing of 1- to 2-cm mysid shrimps ('rebon'). The shrimp for this local industry are, to a large extent, caught by fine-mesh beach-seines. These shrimp typically make up about 16% of the total landings from small-mesh beach-seines. They would not be caught if larger mesh-sizes were required. Benefits which might be gained by using larger meshes will have to be weighed against losses incurred in fisheries directed at smaller species such as this.

Relationships among seine- and lift-nets

Relative fishing power. Overall catch data are summarized in Table 7. The relative fishing power of the different types of seine gear can be calculated from these data (Table 8). It is important to remember that the purse-seines (including offshore payang) fish in an entirely different area than the mini purse-seines, payang and lift-nets. From inshore to offshore the fishing grounds are as follows: beach-seines, lift-nets and inshore payang, mini purse-seines (offshore payang) and purse-seines. Also, the lift-nets and mini purse-seines fish at night while the other gears fish during the day. Because of this partitioning of fishing locations and time, and because of the differing species composition of the catches, the relative fishing power calculations have limited use. However, the relative fishing power for selected species

Table 4. Species composition data collected from 28 large-mesh beach-seines along the north coast of Java between May and October 1984. The catch from an average net was 244·9 kg. These beach-seines have 2- to 4-cm mesh in the wings but usually have a 2- to 4-mm mesh in the bag. The percentage of Triacanthidae is higher than would normally be expected since 10 of these nets were sampled during a period of unusual abundance of this family

Name of fish group	Percentage of total catch	Typical catch (kg)		Lengths			Number of nets catching this group (n = 51)
		Weight	Percentage	mean	min	max	
Engraulidae							
Thryssa	23·39	52·06	21·25	13·3	8·0	18·0	16
Sciaenidae	18·32						
Otolithes	0·12	0·32	0·13	–	–	–	1
other	18·20	40·37	16·48	16·3	10·0	22·0	21
Triacanthidae	13·21	58·64	23·94	9·7	9·0	10·0	10
Leiognathidae	12·58	18·78	7·67	8·4	4·0	12·0	13
Trichiuridae	8·84	17·33	7·08	48·8	35·0	60·0	10
Clupeidae	8·10						
Sardinella	3·11	7·26	2·97	13·1	9·0	19·0	8
Anodontostoma	0·44	1·19	0·49	19·0	19·0	19·0	1
other	4·55	12·73	5·20	7·7	6·0	10·0	10
Carangidae							
Selaroides	2·68	9·44	3·86	14·3	12·0	16·0	5
Ariidae	2·28	3·21	1·31	19·8	15·0	25·0	6
Penaeidae	1·46	1·77	0·72	14·0	14·0	14·0	3
Haemulidae	0·83	3·93	1·61	19·3	16·0	22·0	3
Engraulidae	0·82	1·07	0·44	13·0	11·0	15·0	4
Tetradontidae	0·79	0·62	0·26	–	–	–	1
Stromateidae							
Pampas	0·77	2·28	0·93	15·0	15·0	15·0	2
Carangidae	0·88						
Megalaspis	0·29	1·19	0·49	15·0	15·0	15·0	1
other	0·59	2·11	0·86	10·0	10·0	10·0	3
Lactariidae	0·51	1·31	0·54	13·0	10·0	15·0	3
Scombridae	0·42						
Rastrelliger	0·36	0·82	0·34	16·5	15·0	18·0	2
Scomberomorus	0·06	0·17	0·07	40·0	40·0	40·0	1
Formionidae	0·29	0·83	0·34	14·0	14·0	14·0	3
Hermiramphidae	0·15	0·39	0·16	25·0	25·0	25·0	1
Rays	0·12	0·11	0·05	13·0	13·0	13·0	1
Mugilidae	0·11	0·43	0·18	9·0	9·0	9·0	1
Polynemidae	0·07	0·31	0·13	14·0	14·0	14·0	1
Sillaginidae	0·07	0·31	0·13	19·0	19·0	19·0	1
Squids	0·07	0·31	0·13	15·0	15·0	15·0	1
other	3·25	5·53	2·26	–	–	–	8

groups can also be calculated to identify areas where different types of fishing gear might be competing (Table 9). Competition may occur between the mini purse-seines and purse-seines (and offshore payang, which catch the same fish). Competition is also likely to occur between the inshore payang and the lift-nets.

Fishing gear conflicts. Some conflicts among seine gears have been reported. In many situations lift-nets are viewed as destructive. Much of the dislike of lift-nets arises from the fact that their existence limits fishing by other fishing gear. Bamboo remaining from the old lift-nets entangles drift gill-nets, payang and sometimes mini purse-seines, causing a loss of valuable fishing gear. They are also a hazard to navigation. In addition, lift-nets are more

Table 5. Species composition data collected from 45 small-mesh beach-seines along the north coast of Java between May and October 1984. The catch from an average net was 207·9 kg. These nets are made of a fine-mesh synthetic material with mesh openings of about 2 mm by 2 mm

Name of fish group	Percentage of total catch	Typical catch (kg)		Lengths			Number of nets catching this group (n = 45)
		Weight	Percentage	mean	min	max	
Engraulidae	29·77						
Thryssa	23·22	34·33	16·52	11·0	4·0	18·0	28
Stolephorus	6·55	20·71	9·96	6·4	5·0	9·0	12
Centropomidae							
Ambassis	21·05	41·78	20·10	6·0	3·0	8·0	31
Mysidae	16·52	39·10	18·81	1·9	1·0	2·0	22
Clupeidae	10·18						
Sardinella	1·51	3·97	1·91	14·5	14·0	15·0	3
Ilisha	0·62	1·24	0·60	9·5	8·0	12·0	6
Anodontostoma	0·22	1·60	0·77	13·5	9·0	18·0	2
Dussumeria	0·02	0·15	0·07	14·0	14·0	14·0	1
other	7·81	9·51	4·57	8·6	7·0	20·0	12
Sciaenidae	5·62	13·75	6·62	15·1	8·0	20·0	20
Leiognathidae	4·80	9·72	4·68	7·4	4·0	10·0	25
Mugilidae	2·95	7·91	3·80	13·3	8·0	18·0	14
Trichiuridae	1·90	4·01	1·93	32·9	19·0	50.0	11
Ariidae	1·63	4·04	1·95	11·3	8·0	14·0	5
Carangidae	2·04						
Selaroides	1·07	3·17	1·53	12·3	8·0	16·0	4
Megalaspis	0·91	2·66	1·28	16·5	12·0	22·0	6
other	0·06	0·17	0·08	12·5	9·0	16·0	2
Penaeidae	0·81	2·36	1·14	8·0	5·0	10·0	10
Rays	0·40	1·92	0·93	100·0	100·0	100·0	3
Mullidae	0·30	0·75	0·36	10·3	8·0	13·0	4
Nemipteridae	0·21	0·53	0·26	–	–	–	1
Sillaginidae	0·08	0·23	0·11	13·0	12·0	14·0	3
Haemulidae	0·05	0·13	0·06	20·0	20·0	20·0	1
Tetradontidae	0·05	0·11	0·05	–	–	–	1
Lactariidae	0·03	0·04	0·02	4·0	4·0	4·0	1
Theraponidae	0·02	0·05	0·03	12·5	9·0	16·0	2
Hemiramphidae	0·02	0·16	0·08	24·5	14·0	35·0	2
Polynemidae	0·02	0·20	0·10	13·0	13·0	13·0	1
other	1·53	3·49	1·68	–	–	–	12

Table 6. A comparison of major species groups caught in large- and small-mesh beach seines (see Tables 4 and 5)

Species group	Beach-seine (percentages) Large mesh	Small mesh
Thryssa	23·3	23·2
Ambassis		21
Sciaenidae	18·3	5·6
Mysidae		16
Leiognathidae	12	4·8
Clupeidae	7·6	9·3
Triacanthidae	8	
Trichiuridae	8	
Other	22·8	20·1

Table 7. Summary of catch data for major seine gears of the north coast of Java (see text for additional comments)

Fishing gear	Estimated number of units	Estimated catch per day (kg) mean	adjusted[a]	Estimated number of trips low	high	Estimated catch tons per year low	high	official
Purse-seine	450	480		240		51 840		57 844[b]
Mini purse-seine	350	294	200	144	180	10 080	18 522	none[c]
Payang	500	123	100	180	240	9000	14 760	8109
Lift-net	1900	36	25[d]	105	181	4988	12 380	3097
Beach-seine	175	212	200	135	180	4725	6678	2000[e]

[a] see text for reasons for adjustment
[b] combines data for both mini and offshore purse-seine
[c] no separate statistics for mini purse-seine
[d] 25 kg per day is a minimum value
[e] official statistics vary considerably from year to year.

Table 8. Overall relative fishing power (RFP) for five types of artisanal seine and lift-net gear. Yearly calculations are based on intermediate catch per year estimates

Gear	Catch per unit per day (kg)	RFP (day)	Catch per unit per year (tons)	RFP (year)
Purse-seine	480	1·00	115·20	1·00
Mini purse-seine	200	0·42	34·29	0·30
Payang	100	0·21	22·00	0·19
Lift-net	36	0·08	6·52	0·06
Beach-seine	200	0·42	32·57	0·28

Table 9. Relative fishing power (RFP) for four gear types and four species groups which showed significant overlap among fishing gears. Beach-seine catches do not overlap to any great extent with the other gears

	Purse-seine	Mini purse-seine	Payang	Lift-net
Yearly catch per unit (tons)	115·20	34·29	22·00	6·52
*Sardinella**				
Percentage	41·60	41·90		
Catch (tons)	47·92	14·37		
RFP	1·00	0·30		
Decapterus				
Percentage	23·00	5·70		
Catch (tons)	26·50	1·95		
RFP	1·00	0·07		
Rastrelliger				
Percentage	14·40	25·70	3·20	3·20
Catch (tons)	16·59	8·81	0·70	0·21
RFP	1·00	0·53	0·04	0·01
Stolephorus				
Percentage			47·50	64·50
Catch (tons)			10·45	4·21
RFP			1·00	0·40

* There is some evidence which suggests that different species of *Sardinella* are found in the purse-seine and mini purse-seine

visible than other fishing gear because they are relatively permanent and can be seen even when not in use. As a consequence, they are often cited as a destructive type of fishing gear. However, much of the dislike of lift-nets is due to these factors and not to hard evidence that they damage the fishery resource.

In several provinces there are laws or regulations banning ocean lift-nets or limiting their numbers. These regulations are often confusing. In Central Java, for example, licences are given by the Marine Communications Department, although the Fisheries Department considers lift-nets illegal. There is also a national regulation which prohibits lift-nets. The regulations are generally ignored, partly because there is no enforcement, and partly because of the uncertain legal status of such regulations.

Steps towards improved management

Management of any fishery is a matter of reaching an optimal balance between the resource and the fishery exploiting it. Optimality here refers both to the ability of the resource to continue to thrive and provide fish biomass for harvest and to the ability of the fishery to produce food, income, employment and other benefits to society. Management of the fishery must therefore consider both resource-related questions and societal ones.

Resource availability

Management of the fishery must consider the relationship between catches and the available amount of fish. Information about the condition of pelagic fish stocks in the Java Sea is increasing. Several workers (e.g. Tampubolon 1982) have used surplus production models to estimate maximum sustained yield from the pelagic fisheries of the Java Sea, concentrating on the offshore purse-seine fishery. This has been done for both total biomass and for selected species. Although these analyses are useful, they are hampered by limited availability of sufficiently accurate catch statistics. Because of this limitation, catch per unit of effort and effort data are sometimes not obtained independently and total effort is calculated from catch per unit effort and total catch. In such a situation an artificial correlation between catch per unit effort and units of effort can result, limiting the usefulness of the analysis (see Gulland [1983], pp. 72–3).

Another method of obtaining increased information about the fishery resources is species-by-species analysis using length-frequency data. Using methods first described by Pauly & David (1981), species in need of protection or which could be harvested to a greater extent could be identified. Workers in Indonesia have research programmes underway to collect and analyse such data (e.g. Sadhotomo, Banon & Nurhakim 1983).

At present the resource assessment data are insufficiently precise to allow statements to be made about the desirability of increasing or decreasing numbers of, or otherwise regulating, specific types of small-scale fishing gear. However, most workers believe that the inshore waters are overfished and some limitations on fishing gear may be useful. Of course, some of the pelagic species are at least somewhat migratory and may not be so heavily exploited in other parts of their ranges.

Potential management actions

When considering potential management actions in northern Java particular attention must be paid to the potential effect on employment and income. Thus, suggestions to limit severely or ban certain gear types are not realistic. In addition, enforcement capability is extremely limited both from an administrative and from a social point of view. It is not generally acceptable to place restrictions on those who are barely able to make a living. As a consequence, realistic management actions aimed at small-scale fisheries are limited to: (1) development of new fisheries where possible; (2) redirection of existing fisheries; and (3) restrictions which are socially acceptable and can be enforced at the village level. Within these constraints there are some possibilities for management of this fishery.

It may be useful to limit catches of juvenile Sciaenidae in beach-seines, but this must be done while protecting a fishery which catches primarily small (and cheap) fish. Since the very small-mesh beach-seines catch fewer Sciaenids it is the large-mesh beach-seines which might need this regulation. Thus meshes less than 6·3 cm (2·5 inch), for example, might be banned except on nets shorter than 150 m, for instance, which would be required to have the 2–4-mm mesh. No meshes between 4 mm and 6·3 cm would thus be allowed. If necessary, a limitation on the length of both types of beach-seine could be instituted. However, prior to attempting to institute a mesh-size regulation, additional studies of its potential effects should be undertaken.

Much of the north-central coast of Java is suitable for beach-seining, but it would be possible to limit seining in some areas by creating physical obstructions if this were necessary to protect fish in particular areas. Also, waves pose a natural limitation to beach-seining during the west monsoon. This fact could be used as a socially acceptable basis for initiating a closed season for beach-seines if such a closure were desirable. Such a closed season might later be extended.

Both inshore payang and lift-nets should be managed in relation to the abundance and migratory pattern of *Stolephorus* since this genus dominates the catches. From the fishery-resource point of view these two types of gear must be considered together. Unfortunately, there is relatively little information about this genus in the region. The fishery for juvenile *Stolephorus* needs to be investigated more carefully. Is there a benefit in protecting the juvenile fish, or is the fishing mortality at this stage inconsequential compared to natural mortality?

Managing these two gear types may be difficult. Several unsuccessful attempts have been made to control lift-nets. The rationale that lift-nets are any more damaging to the fishery resource than other gear has not been supported. They are fished less often than payang and catch less per trip. A payang requires more crew and thus provides additional employment benefits. At present, it seems that the lack of clear management actions for these gears is not particularly harmful, but first steps should be taken to formulate management techniques for future use. Establishment of lift-net free zones may be a possibility for future management since lift-nets are presently excluded from some areas in the interests of navigation and safety. A limitation on the amount of light which can be used to attract fish might also be investigated.

The introduction of mini purse-seines represented an attempt to redirect the efforts of local fishermen so they would be able to fish farther from shore for a different group of species. To some extent this has been successful, but the mini purse-seine boats still make one-day trips for the most part. The extent to which offshore and mini purse-seines fish the same stocks is not clear. Further redirection of fishing effort may be made possible in some areas by the provision of fish attraction devices. Arrays of these could be placed slightly farther from shore than the current mini purse-seine fishing ground. This would provide an incentive for fishing in new areas farther from shore.

Inevitably, the question of limiting numbers of small-scale fishing units will have to be addressed. It is unlikely that limits on small-scale fishing gear will be successful unless the desire for enforcement lies with the fishermen themselves. Success of enforcement is dependent on an obvious benefit to the fishermen. A ban on trawling gear instituted in 1980 was successful for three reasons: it was based on an unambiguous legal decision (a presidential decree); there were significant benefits to local fishermen (Dudley & Tampubolon 1985); and the trawler owners were not from the local community. Unfortunately, restrictions on small-scale fishing gear will result in less clear-cut benefits, which in turn will make any such restrictions harder to enforce.

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