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Fishing strategy for target species of small-scale fisheries in Pelabuhanratu Bay, Indonesia

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Abstract: In order to have better understanding of the gear employed in small-scale fisheries of Pelabuhanratu Bay, Indonesia, the fishing strategy for target species in relation with species composition and catch composition similarities of five types of gear were studied on monthly basis in a full year cycle. The result of the analyses showed that the fishing activity of fishermen in employed fishing gears related to seasonal pattern of fish landed. The species composition varied between seasons and fishing gear. During dry season, fishermen employed most fishing gear types, exploiting scattered fishing ground and capturing a greater diversity of fish species. In rainy season, catch were less diversified, and more specialized fishing gear (hand lines) were employed more intensively, harvesting hairtail. Using the information provided by the present study, fisheries management strategy was proposed

Keywords: *fishing strategy, small-scale fisheries, species composition, Indonesia*

1. Introduction

Small-scale fisheries, which dominate in developing countries, contribute more than 25 percent of the world catch (FOOD and AGRICULTURE OGANIZATION, 2001). The increasing number, type, size and efficiency of gears in small-scale coastal fisheries of developing countries have greatly increased the fishing pressure on the available fish stocks. In Indonesia, small-scale/artisanal fisheries contributed 94% to the total fishing unit. Since mechanization, modernization and use of other fabricated inputs are taking place, small-scale fisheries are growing steadily in number (PURWANTO, 2003). Like in other developing countries, the rapid expansions of small-scale fisheries in Indonesian fisheries have been facing difficulties with problems concerning overcapacity and with excessive effort capacity (BERKES *et al*., 2001). Several parts in Indonesian waters, especially the western parts of Indonesian waters of highly populated region like northern Java and eastern Sumatra coasts were identified to be affected by overcapacity and are over-exploited (MOUS *et al*., 2005). Fisheries productivity has been decreasing, resulting in increasing levels of impoverishment among small-scale fishers.

Despite the social and economic importance of Indonesian small-scale fishery, there has been no comprehensive analysis of its major features (e.g., species composition in relation to fishing strategy and catch composition similarities between gear types). Most previous studies conducted were academic in nature and peripheral to the management questions at hand (SILVESTRE and PAULY, 1997). In the case of multispecies-multigear fisheries especially in tropical small-scale fisheries, fisheries management is more complicated and difficult (FOOD and AGRICULTURE ORGANIZATION, 1994, PAULY, 1979). This is

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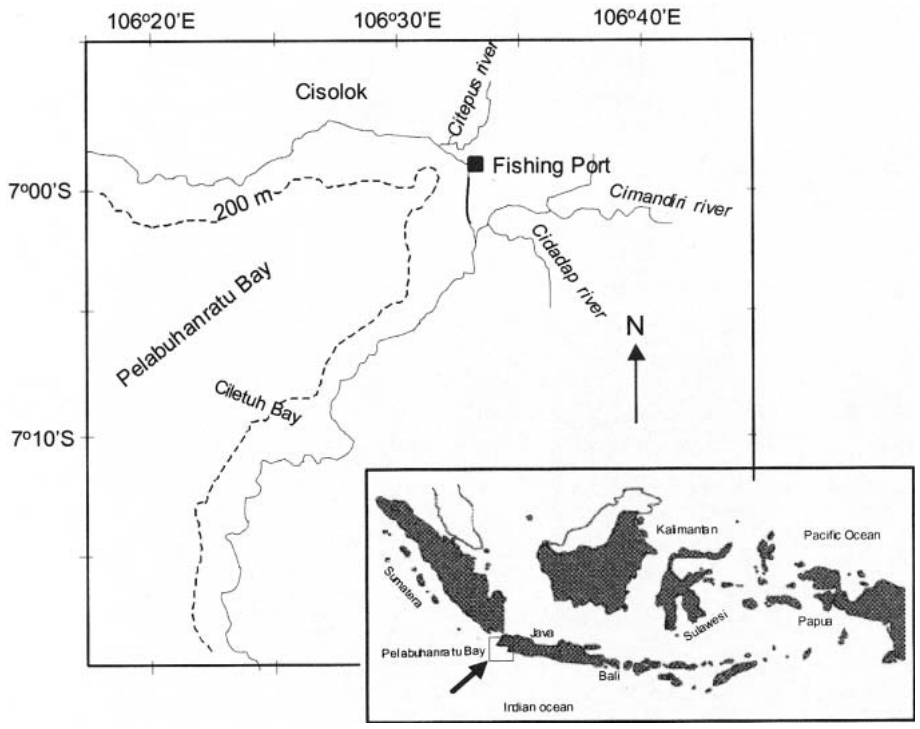

Fig. 1. The map of study area

because diversity of gears (multi-gear) that be used to capture diverse target species (multi-species) in tropical coastal fisheries has caused ecological and technological interactions (RIJNSDORP *et al*., 2000 and ULRICH *et al.,* 2001). In this fisheries, two or more competing or prey-predator species constitute the target species of different fisheries would change the magnitude and direction of the ecological interaction and relative abundance of species and trophic level. In addition, the dynamics of fishing effort could change the population structure, dynamics of the target species and associated bycatch, imposing the negative effect to other fishers and affecting the abundance of incidental species (SEIJO, DEFEO and SALAS, 1998). The gear type employed can affect the efficiency of fish capture, the selectivity and composition of fish resources (STERGIOU, PETRAKIS and POLITOU, 1996). Moreover, the high intensity in capturing top predator (e.g. grouper) by small-scale fisheries has lead to fishing down the food web (PAULY, PALOMARES, FROESE, SA-A, VAKILY, PREIKSHOT and WALLACE, 2001). It has been noted that small-scale fisheries activities have been correlated to reductions in the biomass, abundance, and individual sizes of target fish.

In the present study, fish catch in relation to fishing strategy in the small-scale fisheries of Pelabuhanratu Bay was studied. The study site was chosen because the area shows the common characteristics of Indonesian small-scale and multi-species coastal fisheries. More precisely, the objective of this study is to study the catch compositions, catch abundance and catch composition similarities of gear types. This information would be useful for rational management of the excessive fishing effort in small-scale fisheries.

2. Materials and methods

2.1 Fishery in the study area

Pelabuhanratu Bay is a small bay facing the Indian Ocean on the southern coast of West Java, Indonesia, located at 6° 55′ and 7° 55′ S, and 106° 15′ E and 106° 35′ E (Fig. 1). The fishing activity in the bay is a multispecies-multigears tropical coastal fishery, which represent Indonesian fisheries. Based on the

statistical report of Pelabuhanratu Fishing Port 2002 (WIDODO, *et al.,* 2003), there are 9 main types of gears that are being operated in Pelabuhanratu Bay: hand lines (187 units), seine nets (85 units), inboard gillnets (124 units), lift nets (142 units), long lines (29 units), purse seine (6 units), drift gillnets (44 units), fixed gillnets (19 units) and trammel nets (39 units).

2.2 Source of data and pre-processing

The data used in this paper were based on the Local Fisheries Auction Centre of Pelabuhanratu Bay from 1993 to 2003. The data contained information per fishing boat at a trip level, including catch weights (kg) and values (Rp. Kg^{-1}) by species and gear types. Prior to data analysis, the data were already separated into small-scale coastal fisheries data and others. There is no single definition of what a small-scale fishery is and it varies between countries (PANAYOTOU, 1982). For the purpose of this study, we define small-scale fisheries as fisheries that do not use boats, or use of boat less than 10 gross tonnage (GT). Based on this working definition, this study was limited to five gears: drift gillnets, seine nets, fixed gillnets, lift nets and hand lines and their catch. The daily records of boat activity were extracted to obtain monthly data containing monthly aggregates on the gear level of landed of the species (kg $month^{-1}$) and monthly aggregates of the number of fishing trips (trips $month^{-1}$).

2.3 Data analysis

The analysis of catch composition was conducted both totally and separately for each fishing gear types. To express the seasonal dynamics of catch composition between seasons, catch composition are presented as the average weight (kg) of fish catch per gear types per month in a full year cycle.

Catch per unit effort (CPUE) was used to analyse the monthly productivity of gears on target species. This was done separately for each gear based on monthly catch and effort data of gears. Since fishing trips, which determined fishing intensity varied between fishing gears and months, we computed fishing effort by the number of monthly fishing trips of gears. With the assumption that the seasonal pattern of CPUE was not changing between years, the productivity of gear to target species was calculated as the average CPUE per month. A high CPUE indicates that the gears were productive in the capture of the target species, and vice versa.

We used cluster analysis to classify the monthly dynamics of species composition similarity among fishing gear in a full year circle. Since variable data have different range values, Z-score transformation was applied to eliminate invalid distance measurements (SPSS, Chicago, IL, USA). Furthermore the average monthly transformed data (catch per trips ($kg.trips^{-1}$)) by species for each fishing gear) was computed for this purpose. Distinctive catch similarity patterns between months were described by hierarchical cluster analysis based on the centroid and squared euclidean distance interval methods (VAN TONGEREN, 1995). If some fishing gears clustered into one group, it means that the fishing gears have similar composition of target species. On the contrary, if a fishing gear is out of the group it means that the fishing gear is not targeting the same species.

3. Result

3.1 Fishing activity

Five types of fishing gear were employed in small-scale fisheries of Pelabuhanratu Bay. Based on the relative behaviour of the target species and the fishing gear, fishing gear types can be classified into two main categories: passive and active fishing gear. Since capture of fish base on movement of the target species toward the gear, four fishing gears (e.g. hand lines, lift nets, fixed gillnets and drift gillnets) were categorized as passive fishing gear. While, seine nets, which capture target species based on an aim chase of the target species was categorized as active fishing gear.

Drift gillnets and seine nets were being operated within a few miles from the shore by using an outboard engine on small-scale vessels, for one-day fishing operations. The length of seine nets vessels varied from 9 to 12 meters and 4 to 5 meters for drift gillnets. The main target

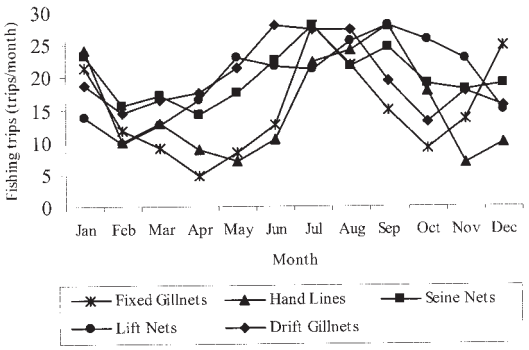

Fig. 2. The monthly average of fishing trips by fishing gear between 1993 and 2003.

species of seine nets is frigate tuna, little tuna, ponyfish and scads. Most similarly with seine nets, the main target species of drift gillnets is little tuna, hairtail, frigate tuna, and shark. Bamboo-platform lift nets (lift nets) were one of the types of gear being traditionally used by fishermen along shallower water of coast of Pelabuahanratu Bay. The average size of platform was 9.8 meters^2, and the box-shaped nets of 8.8 meters^2 × 3.0 meters, with 0.5 centimeter mesh size. The main target species of lift nets is sardine, hairtail, ponyfish and scad. The fixed gillnets are the type of bottom setting in the very shallow water of the bay, for targeting the sardine which concessionary migrates closely near the coast. Hand lines were the most specific and most simple among the types of gear being operated in Pelabuhanratu Bay. Hand lines were operated for one-day fishing along the coast especially in the rocky and coral areas where hairtail usually inhabits. The vessel length and system engine that were being used to operate handlines and fixed gillnets were similar to drift gillnets vessel, 4 to 5 meters with outboard engines of 5 HP.

The average number of monthly trips of gears varied seasonally. During the peak fishing season, most gears were operated every day (25–28 trips month^{-1}) but during the off fishing season, the number of fishing trips falls to 10 trips month^{-1}. In general, the number of fishing trips increased during the dry season and decreased during the rainy season (Fig. 2).

3.2 Catch composition and CPUE

Although about 50 fish species were landed in Pelabuhanratu Bay, the compositions of catch were dominated by only frigate tuna, *Auxis thazard* (34.0%), hairtail, *Trichiurus* spp. (18.1%), and ponyfish, *Leiognathus* spp. (13.6%). Percentage of the main species differed among season and fishing gear. Frigate tuna made up to 45.2 % of seine nets catch and 18.2% of drift gillnets catch. Hairtail contributed up to 90% of hand lines catch and 24.7% of drift gillnets catch. Ponyfish was the only species that was relatively abundant in most fishing gear but contributed highest percentage to lift nets catch (Fig. 3).

From January to March, during the hairtail peak fishing season, most of the fishing gear captured hairtail and contributed about 40 to 60 % of the main catch. On the contrary, during the months of April to December, most fishing gears targeted frigate tuna and increased the contribution of frigate tuna to the total catch of about 30 to 70%. Seine nets, which targeted frigate tuna, took about 78.72% of the total small-scale fisheries catch. On the other hand, lift nets which targeted sardine took about 11.18% of the total catch. While drift gillnets, hand lines and fixed gillnets contributed 5.34%, 3.01% and 1.75% of the total fish catch, respectively (Fig. 4).

Since both fishing trips and species composition dynamics seasonally, CPUE of most gears also showed varied temporally (Fig. 5). Comparing to the other gears, the total CPUE of seine nets, which ranged from 19.08 kg/-trips (in February) to 99.47 kg/trips (in November) was the highest among gears. The average monthly CPUE of seine nets in capturing frigate tuna, little tuna, ponyfish and scads also were higher than the other gears. On average, seine nets were able to capture frigate tuna 24.21 kg/trips, little tuna 11.45 kg/trips, ponyfish 17.61 kg/trip and scads 4.74 kg/trip. Although fixed gillnets showed the highest CPUE in capturing scads, it showed the lowest total CPUE, ranging from 3.18 kg/trip (in August) to 27.27 kg/trip (in March). Hand lines are the most productive gears for capturing hairtail, which on average, could capture at 12.98 kg/trip with a range of

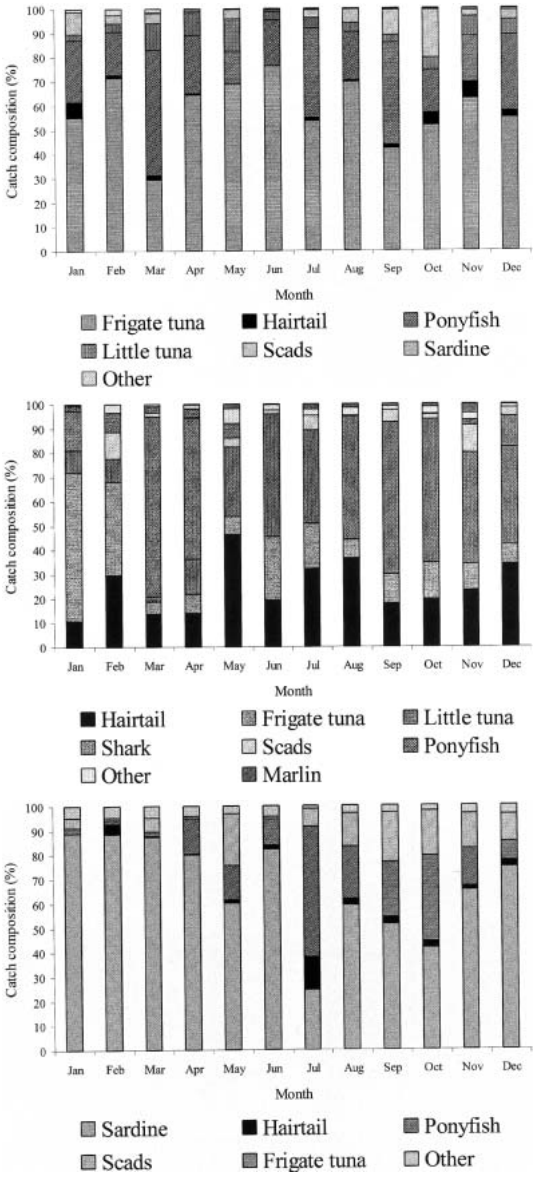

Fig. 3. The monthly average of total catch proportion (%) by fishing gear between 1993 and 2003.

6.71 kg/trips (in November) to 20.47 kg/trip (in January).

3.3 Catch composition similarity

The results of the cluster analysis showed that the fishing gear cluster pattern is relatively stable throughout the year. In general, the fishing gear can be grouped into 2 clusters;

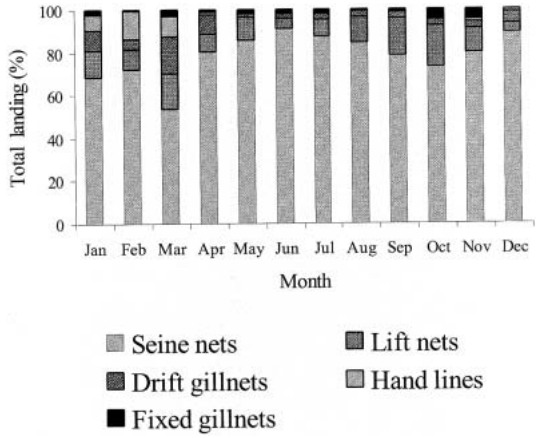

Fig. 4. The monthly average of catch composition (%) of seine nets (a), drift gillnets (b) and lift nets (c).

the passive fishing gear (lift nets, fixed gillnets, hand lines, and drift gillnets) cluster and the active fishing gear (seine nets), the other cluster. However, the cluster pattern of passive fishing gear can be further subdivided into three subgroups: (i) lift nets and fixed gillnets, (ii) drift gillnets, and (iii) hand lines (Fig. 6). Limited capacity of passive fishing gear to move in finding new fishing grounds over a long distance, may have forced the passive fishing gear fishermen to fish for limited fish resources and in limited fishing grounds throughout the year. However, the dynamics of main target species of each gear may have caused the cluster pattern of passive gear changing seasonally. From November to July during fishing season of hairtail, hand lines showed a low similarity to lift nets and fixed gillnets, but from August to October when hairtail reached low season, showed a high similarity. Although relatively stable with a low degree of similarity to the other passive gear throughout the year, during rainy season (from December to January) drift gillnets showed the least similarity to other passive gear and tended to have a similarity to seine nets.

On the other hand, seine net fishing activity, which is dependent on the target species, frigate tuna, clustered into different group throughout the year (Fig. 6). The higher capacity of seine nets to move in catching the

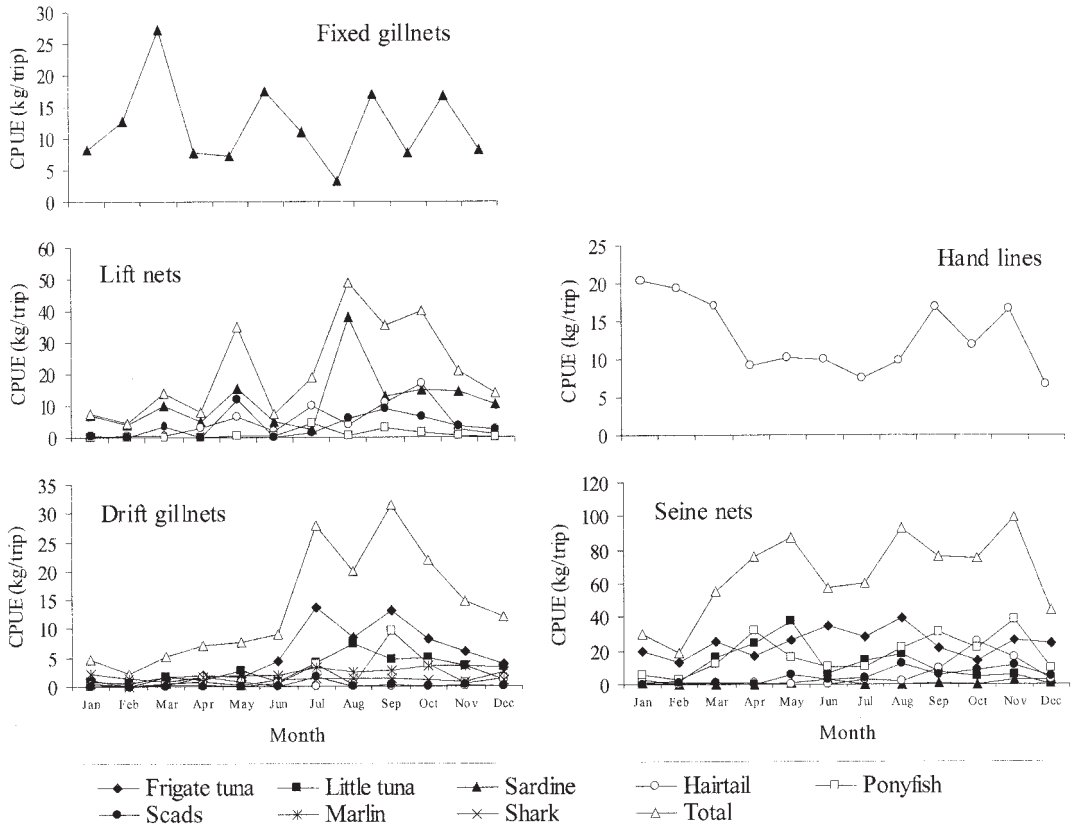

Fig. 5. The monthly average of catch per unit of effort of fishing gear between 1993 and 2003

target species, especially frigate tuna comparing to other gears may have caused the fish catch of seine nets was different from the other fishing gears.

4. Discussion

A number of factors influenced the fish catch of small-scale tropical coastal fisheries seasonally. These factors include the dynamics of fish abundance, oceanography, fishing strategy and possibility of existence of gear interaction. However, study about mechanism dynamics of fish catch between seasons in tropical multispecies-multigear is lack. In the present study, the seasonal dynamics of fish catch (composition and abundance) in relation to fishing strategy is studied.

Catch composition and abundance of fish species in study area showed dynamics seasonally. From the total number of species landed, only eight of which are considered important. Preference of fishermen to capture target species, which have higher volume of fish catch and longer fishing season may have caused the fish catch only dominated by few target species. Although fish abundance changed seasonally, the fishermen did not change their gears. Fishing vessels always remained using similar gears and captured the available species throughout the year. The difference in CPUE between gears, which tends to change temporally, indicated that productivity of gears to capture target species was different with each other and changed temporally relative to the target species abundance fluctuation. Most fishermen increase their fishing trips (Fig.2) during high abundance of most target species in the dry season (Fig. 5) and decrease their fishing trips during low fishing season of most target species in the rainy season. These mean that seasonal fluctuation of fish catch (in volume and composition) has governed fishing

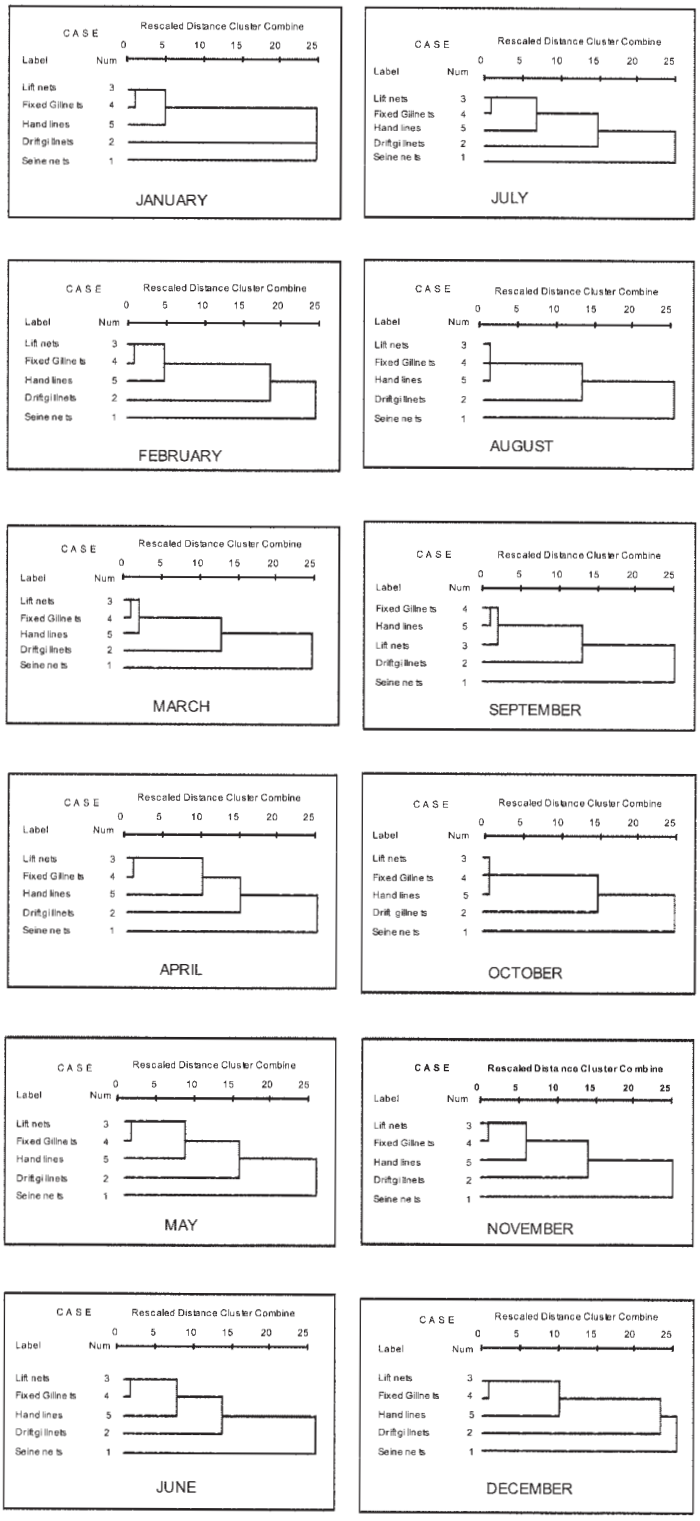

Fig. 6. The Monthly cluster pattern of fishing gear in small scale fiseheries of Pelabuhanratu Bay

strategy of fishermen in capture target species, and vice versa.

Although fishing trips allocation of most small-scale fisheries in study area did not govern by total catch (WIYONO, *et al*., 2006), the result of present study confirmed that the changes in catch composition have governed fishermen to changed fishing strategy. Using the seasonal dynamics of catch composition similarity pattern, the results indicated that there are some differences in fishing strategies for target species between seasons. We expected that the whole of catch composition similarity patterns dynamics were strictly dictated by seine nets and hand lines fishing activity, which depend on their main target species, frigate tuna and hairtail fishing season (WIYONO *et al*, 2006). In addition, the cluster pattern of fishing gear that differentiated into four main groups; 1) seine nets, 2) hand lines, and 3) drift gillnets, and 4) fixed gillnets and lift nets indicated that despite having different physical characteristics, the last group of three fishing gears have similar strategy in capture target species.

The seasonal dynamic of oceanography factor that influenced both fish abundance and fishermen behavior in allocate their gear seasonally might have governed this processes. As MATSUYAMA *et al*. (1996) reported, the rainfall levels (159 - 403 mm) and variations of physical properties of waters of Pelabuhanratu Bay are lower in the dry season than in the rainy season. During the dry season (July-September) when river discharge is low, sea surface mixed layer near the coast become shallower, and fish species diversity is increased. In this period of safe weather condition, the fishing ground become scattered in several locations and fishing season of several gear which are used to capture diverse target species reach peaks levels. The highest capacity of seine nets to move in catching target species especially frigate tuna during this season, caused seine nets clustered into low degree of catch composition similarity to other gears. Conversely, during the rainy season (December-January), when rainfalls, storms and the river discharge increases, the sea surface mixed layer near the coast become deeper and causes both species landing and fish species diversity to decrease. Most of the fish species disappear and fishing ground is limited in the northwestern part of bay (Cisolok waters). Only hairtail, which is targeted by hand lines shows increasing landings. Because of the difficulties in fishing activity, during this period of bad weather conditions of rainy season, fishing activity concentrated in limited area and caused drift gillnets and seine nets which are targeted similar target species have high similarity of catch landing.

To purpose of fisheries management, proportionate reduction of excessive gears can be initiated by reducing the number of gears that have the highest catch composition similarities. The decrease of fishing pressure can contribute to decrease the competitions among gears in fishing operation and simplify the monitoring of the dynamics and distribution of gear, which are used in stock assessment. In general, the landings of most of gears in the present case study overlap with those of other gear, and show the similarity among gears. However, lift nets, fixed gillnets and drift gillnets showed a higher catch composition similarities with the seine nets and hand lines. According to the information provided by the present study, to reducing the fishing efforts of lift nets, which are still used in high numbers, will be proposed.

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