LANDING CHARACTERISTICS OF FISHING GEARS IN SMALL-SCALE TROPICAL COASTAL FISHERIES OF PELABUHANRATU BAY, WEST JAVA AND ITS APPLICATION FOR GEAR MANAGEMENT

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ABSTRAK

Dalam rangka pengelolaan alat tangkap berbasis ekologi, beberapa indikator komunitas ikan diusulkan untuk mengkarakterisasi alat tangkap yang digunakan pada perikanan skala kecil di Teluk Pelabuhanratu. Lima alat tangkap dikaji berdasarkan data deret waktu hasil tangkapan bulanan alat tangkap komersial. Hasil analisis menunjukkan bahwa berbagai metode yang digunakan menunujukkan hasil yang saling menunjang. Indeks musim penangkapan, produktivitas dan keragaman indeks ikan yang didaratkan berfluktuasi secara musiman dan mencapai nilai tinggi di musim kemarau. Bagan dan jaring insang, yang tergolong alat tangkap pasif, cenderung memiliki kemiripan karakteristik sepanjang tahun. Kedua alat tangkap yang dikategorikan sebagai alat tangkap multi-target, memiliki periode musim penangkapan yang pendek di musim kemarau dan memiliki tingkat kesamaan hasil tangkapan yang tinggi sepanjang tahun. Alat tangkap pasif lainnya, pancing ulur dan jaring insang tetap, yang dikategorikan sebagai alat tangkap dengan target tunggal, juga menunjukkan karakteristik serupa. Sebaliknya, payang yang dioperasikan secara aktif dan dikategorikan sebagai alat tangkap dengan multi-target, menunjukkan karakteristik yang berbeda dengan alat tangkap lainnya. Berdasarkan fakta tersebut dapat dismpulkan bahwa dinamika kelimpahan ikan bersama-sama dengan kondisi oseanografi, kapasitas perikanan dan kemungkinan adanya interaksi antar alat tangkap telah menyebabkan keberadaan spesies ikan target berubah dinamis secara musiman. Hasil lain dari penelitian ini juga menunjukkan bahwa untuk mencapai perikanan yang berkelanjutan di Teluk Pelabuhanratu, perlu adanya pengurangan penggunaan bagan.

Kata Kunci : indikator komunitas ikan, manajemen alat tangkap, karakteristik hasil tangkapan, dinamika musiman, perikanan skala kecil.

1. Introduction

Increases in the type, number, size and efficiency of gears in multigear-multispecies small-scale coastal fisheries of developing countries have greatly increased the fishing pressure on the available fish stocks. Although some management approaches have been introduced to particularly reduce excessive fishing effort in nearshore traditional fishing grounds, these generally have not been well implemented. As a result degradation of fish abundance and ecology in some areas have not been avoided (Berkes et al. 2001). Research conducted to study this has either been too academic in nature or peripheral to the management questions at hand (Silvestre and Pauly 1997). Hence, information on fisheries management, especially for small-scale fishery in developing countries that lack financial and technical means remains relatively limited.

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). Besides being characterized by great spatio-temporal variation, diversity of gears, diversity of target species, and the scattering of fishing activity along coasts, the fishery also consist of high uncertainty of catch landing (van Oostenbrugge 2002). In addition, diversity of gears used to capture diverse target species has caused technological interactions: ground interactions (Rijnsdorp et al. 2000) and resources interactions (Ulrich et al. 2001). Since the conventional fisheries management modes have not been well implemented in small-scale fisheries of tropical areas (Berkes 2003), especially in reducing excessive gears in multispecies-multigear fisheries, it is necessary to consider an ecological approach by initiate appropriate criteria for gear characterization based on species landing. In previous studies, gears were usually characterized by technical or physical criteria (Ali and Lee 1995, Purbayanto et al. 2000, Almeida et al. 2003). However, several studies on the impact of gears on fish abundance and fishing habitat, which have tended to be conducted individually (Sumpton et al. 1995, Turner et al. 1999, Pet-Soede et al. 2001, Purbayanto et al. 2001), can not be assessed to formulate general conclusions yet. In addition, conservation of biodiversity and maintenance of a "healthy environment", dictate that gears and their reduction should be studied particularly on the inter-relation of gears to target species. However, studies which could explain gear performance e.g. how much species are caught by gears, how the composition of landing is affected by gears, how the fishing season affects gear usage and on the interaction between gears are poorly investigated and rarely have studies been especially in tropical coastal small-scale fisheries.

As with other developing countries, Indonesian fisheries, which comprise mostly of small-scale fisheries, have problems with overcapacity and reduction of excessive fishing effort (Nikijuluw 2002). About 80% of the fishing activities are small-scale and are concentrated in coastal areas targeting about 45 finfish, 7 crustacean and 4 other species groups (seaweeds, turtles, sea cucumber and jellyfish). To exploit these aquatic resources, about 29 types of gears (from traditional to modern technology) are being operated (Sumiono 1997).

In order to help resource managers better understand the performance of different gears, we analysed the characteristics of gears in the multispecies-multigears small-scale tropical coastal fisheries of Pelabuhanratu Bay, Indonesia based on the time series commercial landing data. Since the fisheries activity showed clear seasonal variations both in fishing activity and landings, the characteristics were investigated on a monthly basis using several criteria which explain the inter-relation of gears and target species. The aim of this study is to define the characteristics of landing dynamics of gears in small-scale coastal fisheries of Pelabuhanratu Bay, Indonesia between seasons. More precisely, the objective is to study the seasonal dynamics of the composition, diversity, seasonal pattern and extent of the similarity of landing between fishing gears in small-scale fisheries. We then use these results to recommend management strategies for the reduction of the excessive fishing effort.

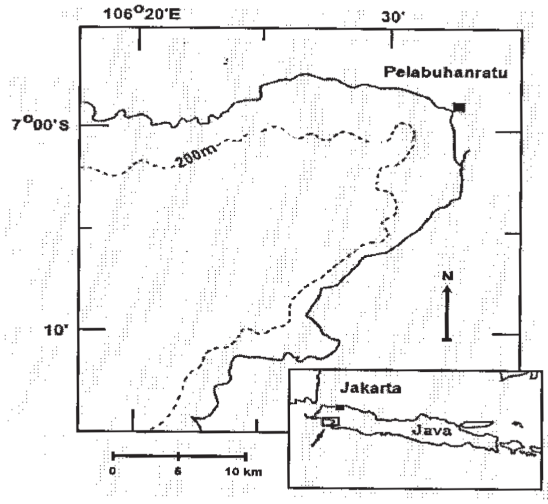

Figure 1. Map of the Pelabuhanratu Bay, West Java Province, Indonesia.

2. Material and Methods

2.1 Source of data and pre-processing

The data used in this paper are from the Local Fisheries Auction Centre of Pelabuhanratu Bay from 1994-2002. The database contains reports of catch and effort by trip for gears with permits from the Pelabuhanratu Fishing Port Office. Prior to data analysis, the data were already separated into small-scale coastal fisheries 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 which do not use boats, or use of boat less than 30 GT.

Based on this working definition, this study was limited to five gears: outboard gillnets, seine nets, fixed gillnets, lift nets and hand lines and their main landing data. The daily records of gears were extracted to obtain time series data, which consist of monthly information on the number of fishing trips (trips/month) and total weight (kg) of gears landing by species.

2.2 Data analysis

In order to analyze the landing characteristics of the gears in Pelabuhanratu Bay throughout the year, several indicators based on the commonly available data were proposed. Here we proposed the indicator which able to measure the general feature of gear landing using time series gear's landing data. Since the study was focused on the fish assemblage, we selected indicators at community level without consideration of individual levels. Catch per unit effort (CPUE) was used to analyze 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. Furthermore, with the assumption that the seasonal pattern of CPUE was not changing every year, 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.

The Shannon Diversity Index (Magurran 1988) was used to analyse the monthly variation of species landing diversity. The index was calculated using monthly landing (kg) by species for each gears as follows:

$$H'_{j,m} = -\sum_{i=1}^{S} p_{j,i,m} \ln p_{j,i,m} \qquad (1)$$

where is the Shannon Diversity Index of species landing by gear j in month m, is proportion of species in month relative to the total catch of species by gears j and S is the number of species landing of gears j. A high index indicates that the landing of gears was distributed evenly among species, and gears have a low selectivity in target species. On the contrary, a low index indicates that the landing of gears is dominated by a single or a few target species and gears have high selectivity for the target species.

Furthermore, based on the monthly landing (kg) of gears, the monthly seasonal indexes (SI) of landing of each gears were computed by the decomposition moving average procedure (Makridakis et al. 1983).

$$SI_m = \frac{1}{K}\sum_{k=0}^{K-1}\frac{x_{m+12k}}{T_{m+12k}} \times 100\% \qquad (2)$$

where is the seasonal index for the month m (m=1 to 12), k = {0,1,2…, K-1} K being the number of seasons for the whole time series, is the raw data of landing (kg) in months , and is the corresponding trend value estimated by centred 12 moving average procedures. By adopting the method of Ulrich and Andersen (2001) the pattern of monthly dynamics of gears was determined by the maximum number of consecutive seasonal index (CSI). If the maximum number of consecutive values of the seasonal index 100 is closer to 12, this indicates that patterns of fishing season of species landing were relatively stable throughout the year, but an index closer to 1 indicates that gears species landing were more seasonal.

The similarities in target species were described by using the cluster analysis. We computed the monthly species composition similarity patterns among gears, based on the Z-score transformed of monthly species landing compositions data (in average catch per trips) (SPSS, Chicago, IL, USA). If the gears clustered into one group, it means that the gears have a similar target species. On the contrary, if gears fall outside of the group it means that the gears are not targeting the same species. The distinctive landing similarity patterns between months were described by hierarchical clustering analysis based on the centroid and squared euclidean distance interval methods (van Tongeren 1995).

3. Results

3.1 Landing composition and variability

The average monthly catch composition by gears is illustrated in Figure 2. Except hand lines and fixed gillnets, small-scale gears operated in Pelabuhanratu Bay have similar target species. Seine nets, lift nets, outboard gillnets and fixed gillnets contribute about 90 % of the small pelagic landings.

The main species composition of seine nets was frigate tuna (45.2 %), little tuna (10.1 %), sardine (0.4 %), hairtail (4 %), ponyfish (21.5 %) and scad (18.8 %). On the other hand the main species composition of outboard gillnets was frigate tuna (35.2 %), little tuna (25.5 %), scad (1.1 %), hairtail (2.1 %), ponyfish (3.9%) and marlin (12.9%) while lift nets is sardine (66.7 %), hairtail (7.5 %), ponyfish (16.2 %) and scad (9.5 %). Except for hand lines and fixed gillnets, landing composition of gears varied among months, and were dependent on species abundance.

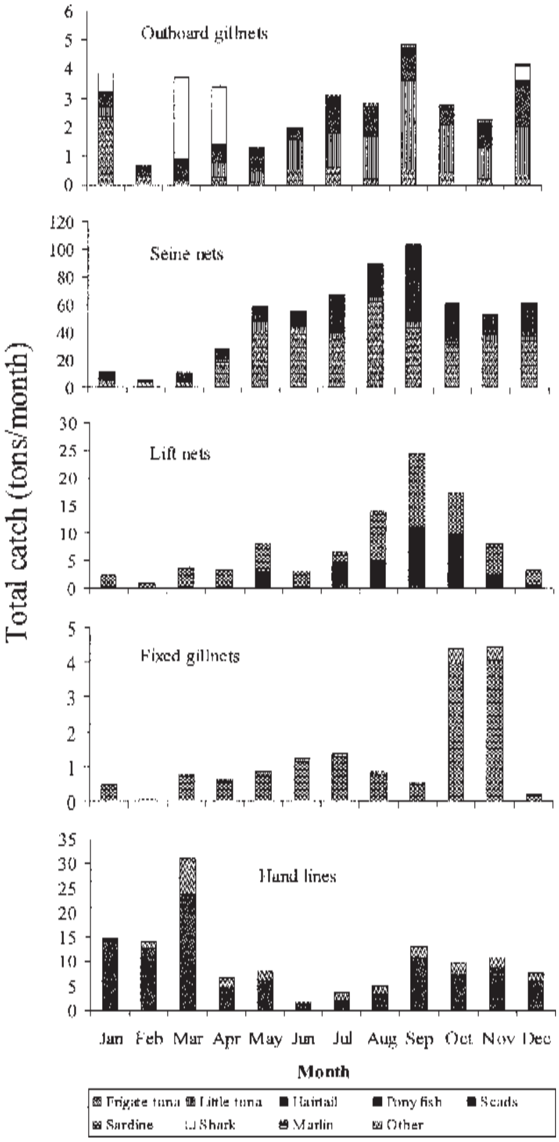

Figure 2. The monthly average of landing composition (%) of gears between 1993-2002

3.2 Landing diversity

In general, species landing of gears in Pelabuhanratu Bay were relatively similar and overlapping with each other. Although about 50 fish species were landed in Pelabuhanratu Bay, the compositions of landing were dominated by only frigate tuna, hairtail and ponyfish. The main landing of seine nets, lift nets and outboard gillnets were relatively similar and tend to have large overlaps, while landing of fixed gillnets and hand lines had relatively small overlaps. The Shannon diversity index analysis of landing composition showed that diversity of species landing of most small-scale gears operating in Pelabuhanratu Bay were changing and varied temporally (Table 1). Three gears (seine nets, outboard gillnets and lift nets) had a wide variation in catch diversity and were categorized as multi-target species gears, where outboard gillnets (H'=0.80) had the highest catch diversity, followed by seine nets (H'=0.67), lift nets (H'=0.32). However, two gears (hand lines and fixed gillnets) that typically focus on targeting a specific species, had a Shannon index of 0 (H'=0) and are categorized as single-target species gear.

Comparing between seasons, the results of the analysis showed that during the rainy season from November to February, most gears had a lower diversity of landings than during the dry season. As the dry season begins, the abundance of some target species increase and fishing activity of most fishermen begins, resulting in an increase of diversity index. During the dry season, the fishery was able to capture several target species of pelagic fish like frigate tuna, little tuna, sardine and ponyfish, while during the rainy season only a few target species are captured.

3.3 Productivity of gears

The productivity of gears to capture target species is presented in Table 2. In general, CPUE of most gears varied temporally. 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.

Table 1. The Shannon diversity index of gears

Month	Total gears	Seine nets	Outboard gillnet	Lift nets	Hand lines	Fixed gillnets
January	0.99	0.46	0.75	0.11	0.00	0.00
February	0.80	0.43	0.46	0.05	0.00	0.00
March	1.00	0.69	0.96	0.08	0.00	0.00
April	1.07	0.70	0.72	0.22	0.00	0.00
May	1.06	0.71	0.98	0.36	0.00	0.00
June	0.82	0.55	0.96	0.23	0.00	0.00
July	0.95	0.65	0.98	0.43	0.00	0.00
August	1.08	0.79	0.86	0.52	0.00	0.00
September	1.22	0.81	0.75	0.72	0.00	0.00
October	1.38	0.79	0.80	0.67	0.00	0.00
November	1.17	0.86	0.71	0.31	0.00	0.00
December	0.96	0.62	0.71	0.17	0.00	0.00

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

3.4 Fishing season of landing

The seasonal index analysis for total landings showed that most of the main landings fluctuated markedly except for marlin which showed stable fishing pattern throughout the year. The hairtail fishing season peaked between October (SI=143) to March (SI=241), while the shark, frigate tuna, little tuna, sardine, ponyfish and marlin peak season started from around May and ended around October or November. Overall, the coastal fisheries fishing season in Pelabuhanratu Bay starts from June and finishes around October or November (Table 3), coinciding with the beginning of the rainy season. Hairtail, frigate tuna, sardine, and ponyfish had 1 fishing season. The fishing season of hairtail was between October-March (CSI=6), frigate tuna between May-October (CSI=6), sardine between September-November (CSI=3), and ponyfish between July-November (CSI=5). Since marlin, little tuna and shark are non-target species, they had more than 2 fishing seasons. Shark had 3 fishing seasons (CSI=2 in June-July and September-October, CSI=1 in December); little tuna had 2 fishing seasons (CSI=5 in July-November, and CSI=2 in April-May); and marlin had 2 fishing seasons (CSI=5, between June-October and CSI=1 in January).

As in the case of total landing, the monthly seasonal index analysis for landing per gears also showed dramatic temporal fluctuation (Table 4). The fishing season of the main target species of each gears showed a relatively longer single season period as compared to non-target species, which had a dramatic short temporal period. The range of consecutive seasonal index (CSI) showed that the main target species had 1 or 2 fishing seasons (CSI=3-5), while the non-target species had 2-4 fishing seasons (CSI=1-5) throughout the year. Most gears have similar main target species in the short main fishing season, between June and October. The fishing season for frigate tuna, the main target species of outboard gillnets and seine nets, was between June to September for outboard gillnets and between May to October for seine nets. Sardine as the main target species of lift nets and fixed gillnets was caught between September to November and May to June. Contrary to other species landings that decrease during the rainy season, hairtail landing which as a specific target species of hand lines showed peak fishing season during this season.

Table 2. The average of catch per unit of effort main target species for each gear between 1993 – 2002.

th	Seine nets							Outboard gillnets								Lift nets					Hand lines	Fixed gillnets
	FGT	LTN	SDN	HTL	PNF	SCD	Total	FGT	LTN	HTL	PNF	SCD	MLN	SDK	Total	SDN	PNF	FTL	SCD	Total	HTL	SDN
r	19.69	1.22	0.96	2.44	5.42	0.00	29.74	1.09	0.94	0.19	0.01	0.00	2.07	0.46	4.76	6.39	0.00	0.24	0.60	7.73	20.47	8.28
ry	13.33	1.56	0.00	0.00	3.12	1.05	19.08	0.03	0.52	0.10	0.11	0.00	1.35	0.07	2.19	3.84	0.21	0.31	0.00	4.36	19.52	12.83
	25.34	15.94	0.31	1.33	11.90	0.54	55.36	1.69	1.62	0.39	0.26	0.01	0.51	0.64	5.32	10.18	0.00	0.26	3.60	14.04	17.05	27.27
	17.32	24.65	0.08	0.85	32.33	0.29	75.52	1.83	4.09	1.57	0.25	0.02	1.75	0.71	7.22	4.97	0.01	2.89	0.21	8.08	9.09	7.84
	25.99	37.82	0.89	0.44	36.16	5.95	87.24	1.51	2.64	0.89	0.11	0.04	1.99	0.39	7.57	15.30	0.67	6.63	12.22	34.81	10.14	7.36
	35.05	6.26	2.53	0.06	10.74	2.45	57.07	4.49	0.94	0.00	0.47	0.01	1.84	1.21	8.96	5.19	0.33	1.82	0.14	7.48	10.09	17.39
	28.56	14.47	0.30	2.92	10.06	4.02	60.34	13.56	4.14	0.00	5.78	1.75	3.30	1.29	27.81	2.53	4.71	10.05	1.60	18.90	7.60	10.94
t	39.50	17.55	0.36	1.57	21.19	12.36	92.52	8.57	7.31	0.00	0.31	0.08	2.38	1.25	19.88	38.23	0.57	4.08	6.10	48.98	9.78	3.16
ber	21.76	7.67	1.31	9.07	30.77	5.70	76.27	13.09	4.63	0.02	9.59	0.14	2.62	1.35	31.44	12.84	3.03	10.76	8.91	35.54	16.87	16.88
er	13.62	4.84	0.00	25.51	21.98	8.64	74.60	8.17	5.02	0.03	3.93	0.07	3.48	1.31	21.81	15.21	1.31	16.81	6.71	40.04	21.90	7.79
ber	25.86	5.25	2.74	16.11	38.40	11.11	99.47	6.06	3.53	0.03	0.50	0.19	3.61	0.92	14.85	14.72	0.40	2.37	3.64	21.13	16.77	16.85
ber	24.45	0.21	2.64	2.64	9.19	4.73	43.85	3.84	3.18	0.00	3.50	0.02	1.09	2.37	12.01	10.47	0.05	1.09	2.41	14.02	6.71	8.37
ge	24.21	11.45	1.01	5.24	17.61	4.74	64.25	5.33	2.57	0.27	1.73	0.19	2.18	0.98	13.65	11.70	0.94	4.78	3.84	21.26	12.98	12.09

3.5 Species composition similarity of gear landing

The results of the cluster analysis showed that the cluster pattern of gears is relatively stable throughout the year. The passive gears (outboard gillnets, fixed gillnets, hand lines and lift nets) grouped into one cluster throughout the year. They had high degrees of catch composition similarity and are clearly stable throughout the year. However, the passive fishing cluster can be subdivided into three clusters; 1) fixed gillnets and lift nets 2) hand lines, and 3) outboard gillnets. On the contrary, seine nets grouped into a different cluster throughout the year, they had low degree of catch composition similarity and are clearly stable throughout the year (Figure 3).

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 gears which are used to capture diverse target species reach peaks levels. Conversely, during the rainy season, 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 from the capture area of the gear, and only hairtail which is targeted by hand lines shows increasing landings. Because of the difficulties in fishing activity and lowered fish abundance, during this period of bad weather conditions

Table 3. The seasonal index (SI) of total main landing

Month	Frigate tuna	Little tuna	Sardine	Hairtail	Ponyfish	Scads	Marlin	Shark
January	20	27	53	139	19	5	170	47
February	15	13	12	130	11	1	41	5
March	13	49	63	241	36	8	92	45
April	57	102	43	45	50	3	58	21
May	144	194	98	51	86	115	67	31
June	166	67	71	13	36	2	162	125
July	121	105	30	34	148	62	118	239
August	240	146	84	61	181	163	131	59
September	207	191	125	59	311	289	122	262
October	108	130	325	143	162	448	119	168
November	51	123	247	175	127	63	86	84
December	57	54	50	110	34	40	33	112

4. Discussion

The productivity and Shannon index analysis showed that both the CPUE and diversity of landing in Pelabuhanratu Bay varied among gears and seasons. Both values of most gears which higher in the dry season than the rainy season indicated that species landing composition of most gears were more diverse and abundant in the dry season than in the rainy season. This process may be influenced by the seasonal dynamic of oceanography factor and/or fishermen behavior factor in allocate their gears seasonally. As Matsuyama et al. (1996) reported, the rainfall levels (159 – 403 mm) and variations of physical properties of waters of Pelabuhanratu Bay are lesser in the dry season than in the rainy season. During the dry season when river discharge is low, sea surface mixed layer near the coast is become shallower, and of rainy season, fishermen tend to reduce the monthly number of fishing trips.

Compared to the main target species, non-target species landing showed more fluctuation. The single consecutive seasonality index of most main target species, which varied from 3 – 6, indicated that these species had a short single fishing season. Conversely non-target species which had more than two consecutive seasonal index and varied from 2 – 4, were more seasonally variable. Since target species fluctuated seasonally, fishermen using multi-target species gears minimize uncertainty of landing by focusing to capture several main target species which have a higher volume of landing and longer fishing season. Seine nets and outboard gillnets were used to capture frigate tuna and little tuna, while lift nets were used to capture sardine. The Shannon index of

Table 4. The seasonal index (%) of main landing per gears

Month	Outboard gillnets						Seine nets						Lift nets				Fixed gillnets	Hand lines
	FTN	LTN	HTL	PNF	MLN	SHK	FTN	LTN	SDN	HTL	PNF	SCD	SDN	HTL	PNF	SCD	SDN	HTL
January	10	32	478	13	170	47	21	24	19	237	22	2	40	1	3	36	26	114
February	17	30	86	76	41	5	16	10	3	1	11	2	17	1	0	0	2	140
March	17	56	108	2	92	45	14	51	5	24	60	37	88	5	5	0	60	164
April	74	27	85	4	58	21	57	119	5	5	58	6	50	2	47	0	16	261
May	41	112	236	4	67	31	151	247	152	37	49	158	96	10	74	127	148	56
June	117	74	3	5	162	125	173	64	372	0	67	7	47	20	49	0	178	56
July	129	208	3	128	118	239	122	109	30	0	143	61	25	364	104	114	111	12
August	297	229	2	35	131	59	241	134	47	23	183	195	81	78	121	254	71	26
September	260	147	46	257	122	262	197	191	45	182	334	281	153	461	298	230	43	19
October	60	119	57	76	119	168	102	122	319	142	78	305	333	185	492	364	168	62
November	92	84	89	580	86	84	50	121	200	441	152	52	222	43	2	40	369	125
December	84	83	8	20	33	112	57	12	4	107	44	94	47	31	4	35	8	166

FTN: frigate tuna, LTN: little tuna, HTL: hairtail, PNF: ponyfish, MLN: marlin, SHK: shark, SDN: sardine, SCD: scads multi-target species gears which varied between 0.05 and 0.86 also indicated that the landing of gears was only dominated by a few target species. Although the gear construction and operation methods of multi-target species gears like seine nets, outboard gillnets and lift nets were able to capture several non-target species, the preference of fishermen using multi-target species gears to capture target species which have higher volume of landing and longer fishing season caused their Shannon index values to became low. In addition, the least monthly variability in value of Shannon diversity index, as in the case of generalist gears (Salas and Gaertner 2004), indicated that the fishermen using multi-target species gears tended to change target species temporally depending on the fishing season of target species. On the other hand, with the value of Shannon diversity index for hand lines and fixed gillnets equaling to 0 throughout the year, this indicates that the landing diversity of hand lines and fixed gillnets were highly specialized. Unlike multi-target species gear fishermen which change target species temporally, the single-target species gear fishermen in adapt to the fishing constrains by reducing the number of monthly fishing trips.

Although fish abundance changed seasonally, the fishermen in Pelabuhanratu Bay did not change their gears. Fishing vessels always remained using similar gears and captured the available species throughout the year. In order to compare productivity of gears in capturing target species, here we calculated CPUE by taking the total monthly weight

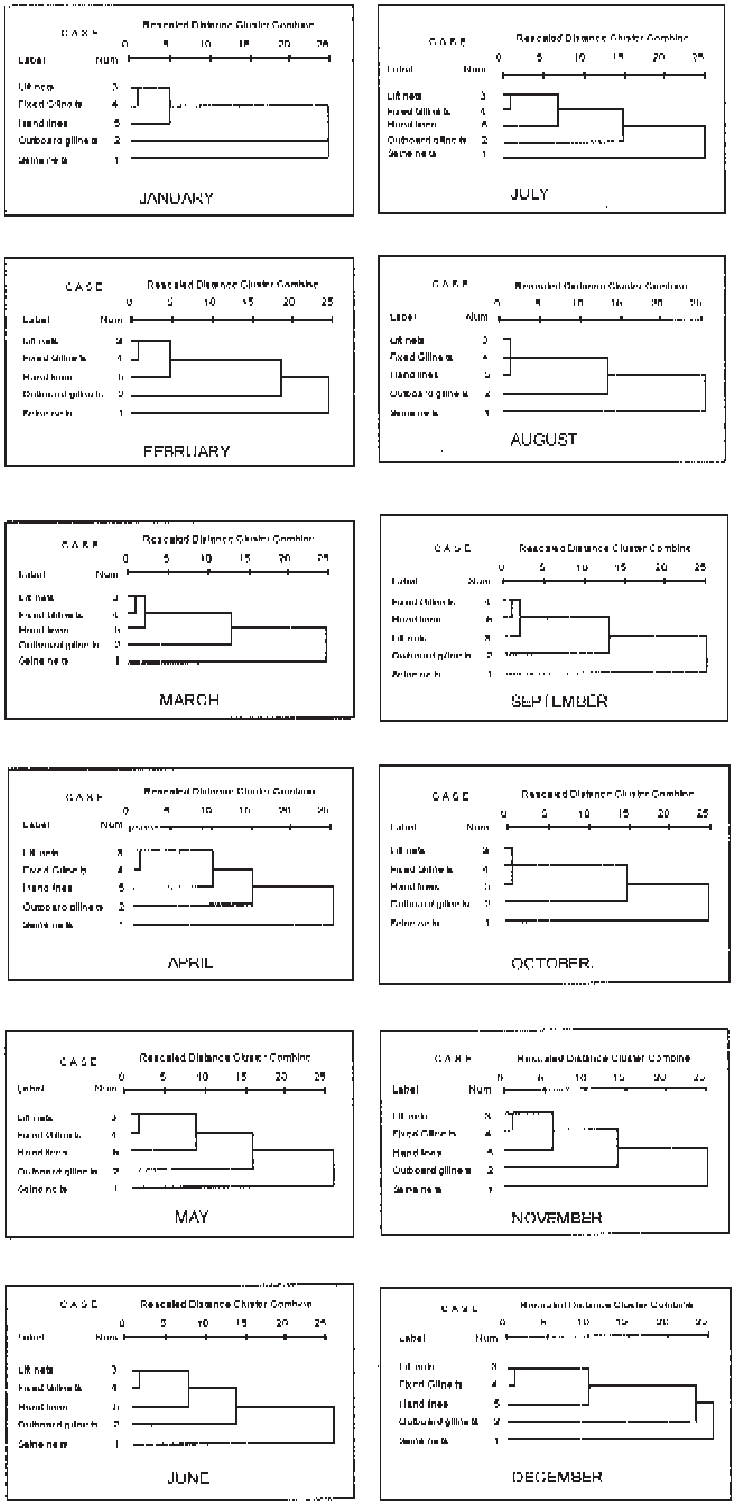

Figure 3. Monthly grouping of gears in Pelabuhanratu Bay by hierarchical cluster analysis using landing composition of gears

(kg) of species landed and dividing by the "unit effort" that refers to the uniformly value between gears. Since the whole small-scale fisheries in Pelabuhanratu Bay are one-day fishing operation, we defined total number of trips per month (trips) as a unit of effort. 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. The higher CPUE of seine nets in capturing target species compared to other gears indicated that the active gears had a higher productivity than passive gears. This is because the fishing capacity of seine nets to move in catching the target species is larger comparing to passive gears. Conversely, limited capacity to operate in distance area and higher degree of overlap on the composition of target species throughout the year between passive gears, as the cluster analysis indicated (Figure 6), caused passive gears have a low productivity.

Beside fish abundance, oceanography and fishing capacity factors, we believed that the possibility of existence of interaction among gears and their main target species have also caused the productivity of gears and overlap on the composition of target species dynamic seasonally. Lift nets and fixed gillnets which capture similar target species (sardine) throughout the year, have stable and showed a high overlap in landing composition throughout the year. From November to July, when hairtail reach peak season, hand lines showed a low overlap to lift nets and fixed gillnets, but from August to October, when hairtail reach low season showed a high overlap to other passive gears. For outboard gillnets, although relatively stable with a low degree of overlap to the other passive gear throughout the year, it's showed the lower overlap to other passive gear from December to January. On the other hand, seine nets which have the highest productivity in capturing frigate tuna comparing to other gears, have a stable low degree of overlap landing composition throughout the year.

5. Conclusion and Recommendation

A number of factors influence the landing characteristics seasonally. These factors include the dynamics of fish abundance, oceanography, fishing capacity and possibility of existence of gear interaction. Although the study can not yet clearly distinguish main factors that affect the mechanism of landing and species diversity dynamics between seasons, results of this analysis shows that the various methods used were in close agreement. Despite being physically different, result of the analysis showed that the gears have similarity in landing characteristics and, based on landing characteristics, could be grouped into four main types; 1) seine nets, 2) outboard gillnets, 3) hand lines, and 4) fixed gillnets-lift nets. This will help fisheries managers to better understand the fishing effort and therefore better manage the fisheries. To balance species abundance and gear management, proportionate reduction of excessive gears can be initiated by reducing gears which have the highest similarity on characteristics. This is because aside from a decrease in the fishing pressure and competitions between gears in fishing operation, the suggestion will also simplify monitoring the dynamics and distribution of gears, and measuring the fishing effort, which are used in stock assessment. In general, most gears landing in Pelabuhanratu Bay overlap with other gears and show similarity among gears. But lift nets, fixed gillnets and outboard gillnets showed a higher landing overlap than the seine nets and hand lines. Besides capturing similar target species in the same season, they also compete throughout the year. In contrary, seine nets and hand lines show different performance characteristics with the other gears. As a consequence, to maintain the sustainability of fishing activity in Pelabuhanratu Bay, reducing the use of fixed gillnet, lift nets and outboard gillnet proportionately are proposed. But, because of competition to seine nets, since 1999 fishermen using outboard gillnets and fixed gillnets have switched their gears to operate hand lines. Based on their experience, fishermen have tended to select gears that minimize their landing uncertainty by switching to the single-target species gear. The switching however has reduced gears competition to capture small pelagic fisheries, but on the contrary this has increased competition in the hairtail fisheries. Using the information provided by the present work, as a consequence, reducing the use of lift nets, which are still used in high numbers, is proposed. In addition, since hand lines showed an increasing trend annually, their development should be controlled. This is because, hand lines which capture the high mean tropic level of fish, as Pauly et al. (2001) stated, have the potential to influence high trophic levels and might to fishing down the food web. This indicated by changing of landing composition in Pelabuhanratu Bay in recent year, the proportion of hairtail to total landing decrease and replaced by ponyfish. For seine nets, since its selectivity is low, we suggest that the gears selectivity should be improved by setting a minimum mesh size for ensuring that fish have spawned at least once before being harvested.? Finally, the possibility of the existence of species interaction as well as gear interaction in small-scale fisheries of Pelabuhanratu Bay should be taken into consideration in fisheries management.

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