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Co-existence in Small-pelagic Fish Resources of The South Coast of East Java, Straits of Bali, Alas and Sape - Indonesia

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Abstrak

Perikanan pelagik kecil dari empat ekosistem di Indonesia diperbandingkan, meliputi perairan pantai di sebelah selatan Jawa Timur, Selat Bali, Selat Alas dan Selat Sape. Pengkajian dimaksudkan untuk menentukan ada-tidaknya, dan kalau ada -bagaimana sifatnya, interaksi antar jenis-jenis ikan utama, dan antar ke empat perairan tersebut, sehingga dapat dimanfaatkan dalam mempertimbangkan pengembangan riset dan pengelolaan sumberdaya hayati laut pada masa-masa mendatang. Pengkajian ini menggunakan data tangkapan ikan dengan rentang-waktu 28 tahun, mulai 1976 sampai 2003, yang dikumpulkan dari pusat-pusat pendaratan ikan dan Dinas-dinas Kelautan dan Perikanan tingkat I dan Tingkat II di wilayah studi. Hasil pengkajian menunjukkan dengan jelas adanya ko-eksistensi antar sumberdaya ikan pelagis kecil di ke empat wilayah perairan. Interaksi kelompok jenis antar ke empat ekosistem, serta implikasinya terhadap riset kelautan dan perikanan dibahas pula dalam tulisan ini.

***Kata kunci**: ikan pelagik kecil, indeks osilasi selatan, aliran-deras Indonesia, upwelling*

Abstract

Small pelagic fisheries of four ecosystems in Indonesia are compared, covering the south coast of East Java, Bali Strait, Alas Strait and Sape Strait, to explore potential interactions between major species, and of different localities, of small pelagic components caught, which may then be taken into fisheries research and management considerations. A 28-years catch data time series used for analysis were taken from major fishing harbours, landing places and fisheries offices, and go back as far as 1976-2003. There is a clear co-existence in the overall small pelagic resources within the areas studied. Interactions of the species group between ecosystems and their substantial implication in marine and fisheries research are also discussed in this paper.

***Key words**: small pelagics, southern oscillation index, Indonesian through-flow, upwelling*

Introduction

Flow through from Indonesian archipelagic waters including particularly the Makassar Strait, Java, Flores and Banda Seas, to the Indian Ocean, causes strong upwelling and currents through in the vicinity of the Bali, Lombok, Alas and Sape Straits. Strong wind and current from the Indian Ocean occur mostly northeastward, which further spread the upwelling onto the south coast of Java. Currents in the Lombok Straits are often so fast that setting of nets is impossible, but in the other areas important small pelagic fisheries occur mainly for *Sardinella lemuru* (lemuru, oil sardine), which also catch *Decapterus spp.* (layang, scad), *Rastrelliger spp.* (kembung, Indian mackerel) and *Sardinella fimbriata* (tembang, fringescale sardine). Previous work on the commercially important Bali Strait fishery suggested that El-Nino impacts lemuru landings (Ghofar and Mathews, 1996; Ghofar, 2001) and prices (Mathews *et al*, 2001). Ghofar (2002) also show that lemuru landings alternate with squid landings in the Alas Strait and (Ghofar, in pres) often in the Sape Strait so that high lemuru and low squid landings usually coincide, and vice versa.

Mathews *et al* (2001) suggested that upwelling South of the Bali Strait, determined by the occurrence of cold fronts, varies from year to year and is much stronger in El-Nino years. Upwelling probably causes intensified primary production, which will lead to increased secondary production. High lemuru landings will occur when the timing of upwelling and spawning coincide so that the lemuru larvae are supported by high production. The timing of these events is likely to require a complex interaction between oceanographic and biological events.

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The pelagic ecosystems in the four Straits are exposed to broadly similar environmental conditions, including the strong but variable through flow of waters from the topographically higher archipelagic Seas to the lower Indian Ocean.

This study aims at: (i) identifying possible relationships among small pelagic resources in the south coast of East Java, the Bali, Alas and Sape Strait; (ii) identify whether the fisheries exploiting the same or separate stocks; (iii) identify the implications of the findings to marine and fisheries research.

Materials and Methods

Collection of catch data

Catch data for lemuru and squid are published annually by the Dinas Perikanan Tingkat I (Provincial Fisheries Offices) located in each provincial capital; i.e. at:

- Surabaya for the Province of East Java;
- Denpasar for Bali
- Mataram for Lombok and Sumbawa

Data are collected in each province according to a methodology established by FO and the Indonesian Directorate General of Fisheries in 1976 throughout Indonesia (DGF, 1975). Nevertheless it is ideally necessary to visit each Dinas Perikanan Tingkat II (Fisheries Service) centre of importance to assess the sampling procedures used more exactly. The author had visited Surabaya, and nearby fishing ports in East Java (Muncar, Banyuwangi); Denpasar and nearby Balinese ports (e.g. Pengambengan and Tanjung Antan along the southwest coast); Mataram and Tanjung Luar in Lombok; Bima and Sape in Sumbawa. A 28-year time series catch data were collected and used for analyses.

Analyses

Plots were made to explore potential interactions between small pelagic, its components, and squid catches. Linear correlation models are applied further using least square methods to examine whether there are relationships. Correlation coefficients, *r*, were assessed to determine the extent (strength) of these relationships, using statistical table for *r* (Bailey, 1985). Once a strong relationship is found, regression analysis were applied. Previous studies (Ghofar, 2001; 2002); Mathews *et al*, 2001) suggested the use of the following regression equation:

$$Y = a - b \cdot X$$

- where Y is the small pelagic catches in one area (in metric tons), X is the small pelagic catches in other area (in metric tons), including total small pelagic and two major small pelagic constituent species: layang and lemuru), *a* is the intercept and *b* is the slope of the regressions. Graphical methods were used throughout the analyses.

Results and Discussion

Fig 1 (a) shows the time series for combined (all) small pelagic catch data of the different fisheries. There is a suggestion that small pelagic catches of the different localities may fluctuate in the same directions so that small pelagic catches in one place/fishery are high when small pelagic in other fisheries are also high. So as to determine whether this tendency is real we used least squares regression analysis on the relation between combined small pelagic catches in the south coast of East Java, Bali, Alas and Sape Straits, all of which were significant:

Fig 1 (b) Bali Strait combined small pelagic catches on SE Java combined small pelagic catches: $a = 39176$; $b = 0.633$; $r = 0.43$; $p > 0.05$ at 26 DF (degrees of freedom).

Fig 1 (c) Alas Strait combined small pelagic catches on Bali Strait combined small pelagic catches: $a = 3118.4$; $b = 0.0524$ $r = 0.60$; $p > 0.001$ at 26 DF.

Fig 1 (d) Alas Strait combined small pelagic catches on Sape Strait combined small pelagic catches: $a = 3708.6$; $b = 0.2311$; $r = 0.42$; $p > 0.05$ at 26 DF.

From the above feature, it is shown specifically that the small pelagic catch in South coast of East Java is high when the small pelagic catch in Bali Strait is also high. The small pelagic catch in Alas Strait is high when the small pelagic catch in Bali Strait is high. The small pelagic catch in Sape Strait is high when the small pelagic catch in Alas Strait is high. Similar suggestions are applied when the catches are low.

The relationships as shown in Figure 1 (a-d) can be summarized as the following diagram. Figures in-between the boxes represent coefficient correlations, *r*

This diagram suggests a clear co-existence in the overall small pelagic resources within the areas studied. It can be seen further that correlation coefficient, *r*, is highest (+0.60) for Bali Strait – Alas Strait, and lower values as moving westward (East Java, 0.43) and eastward (Sape, 0.42). This suggests that although

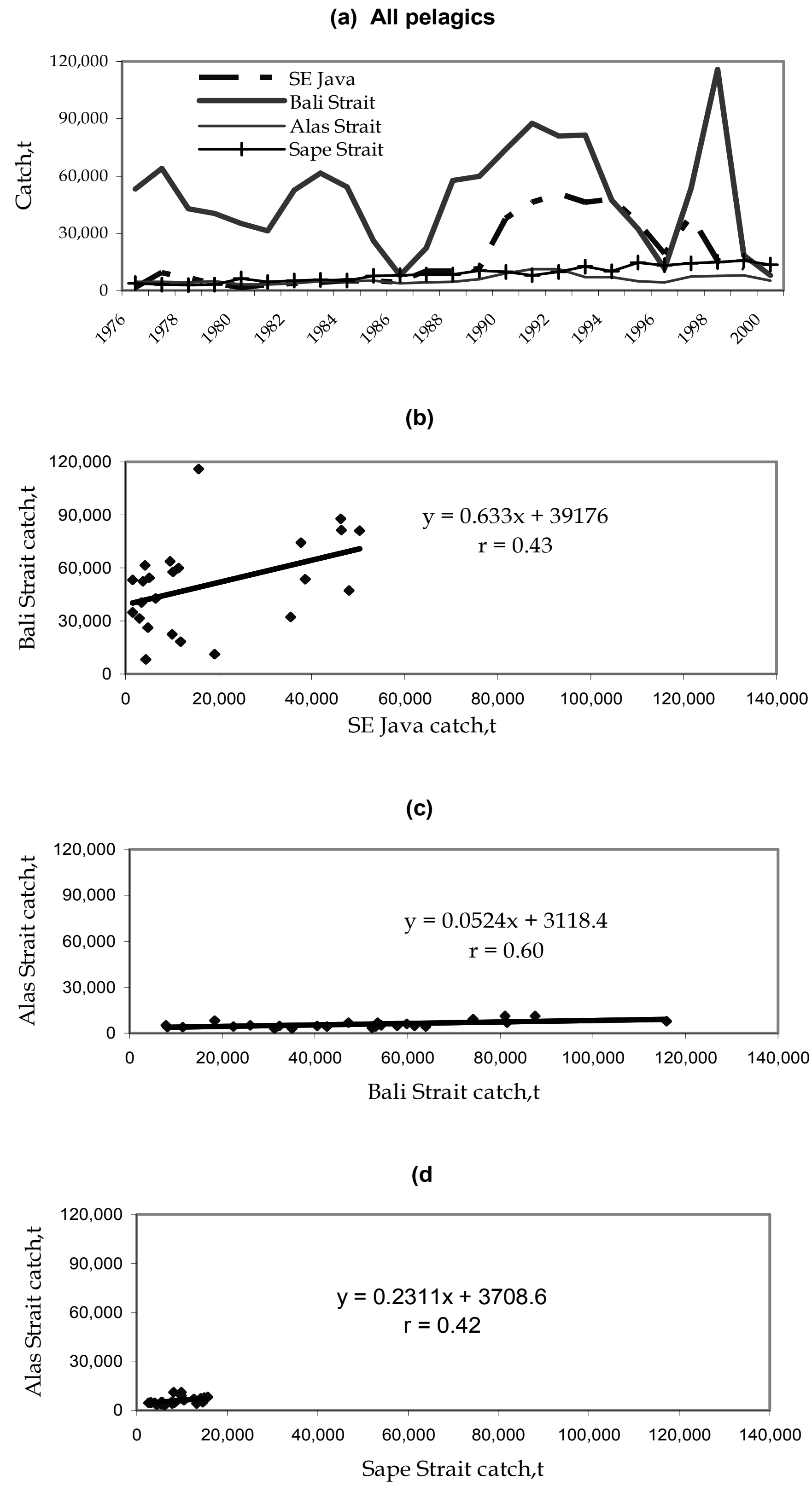


Figure 1 Comparisons of the combined small pelagic catches for south coast of East Java, Straits of Bali, Alas and Sape

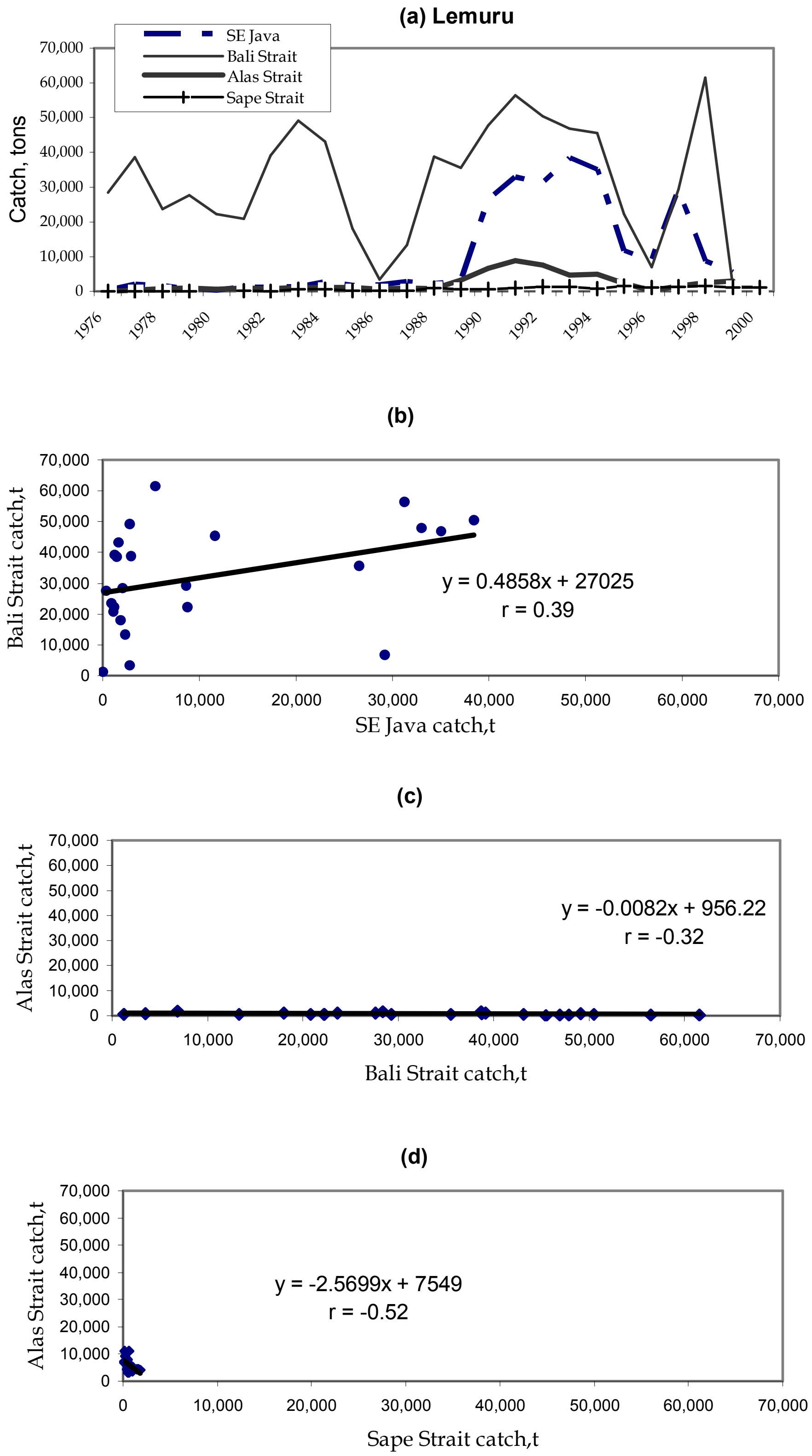


Figure 2 Comparisons of lemuru catches for south coast of East Java, Straits of Bali, Alas and Sape

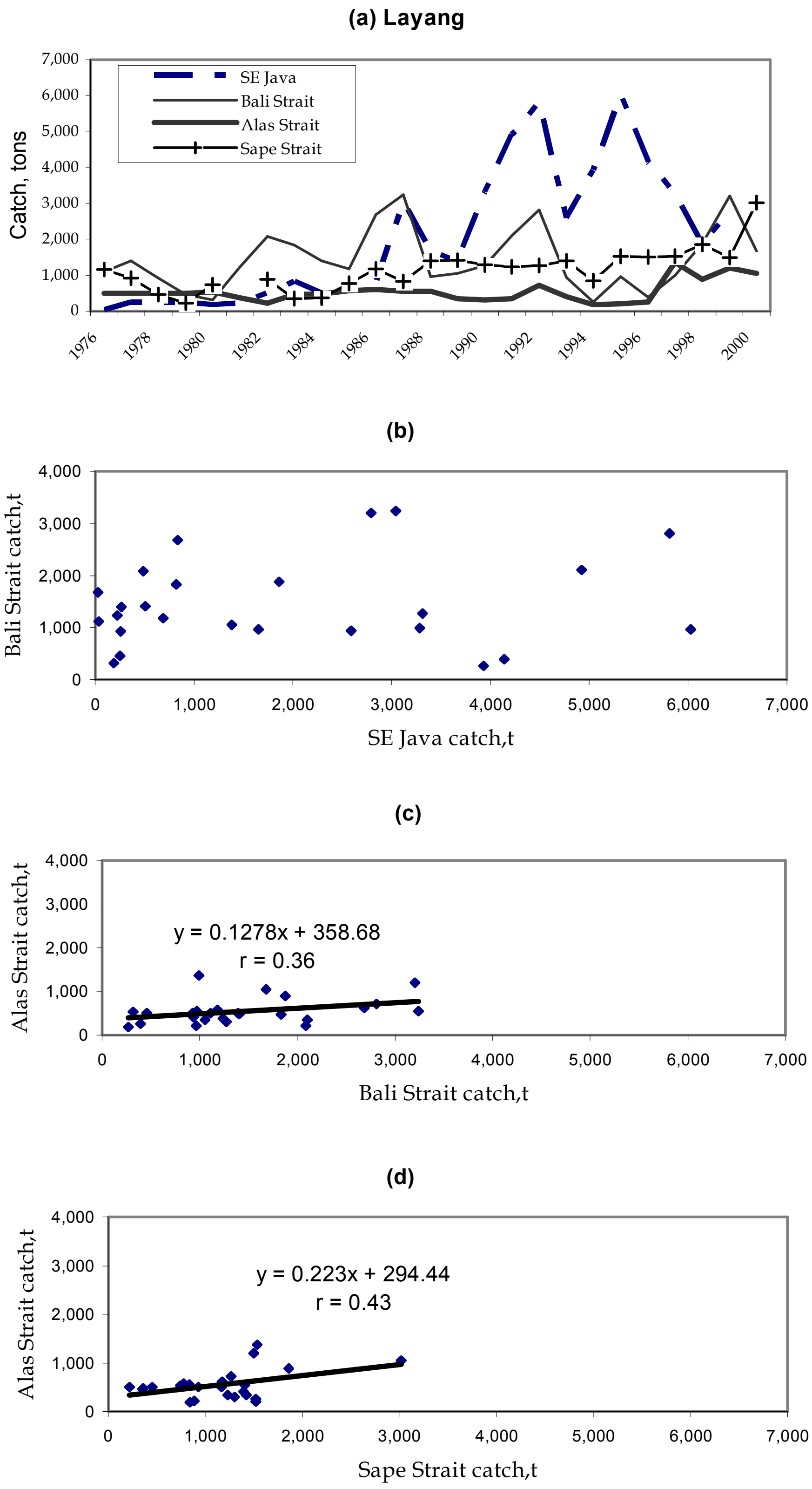
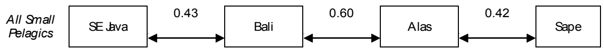
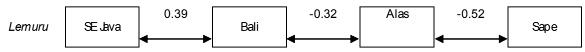


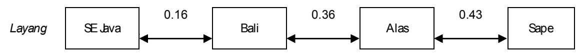
Figure 3 Comparisons of layang catches for south coast of East Java, Straits of Bali, Alas and Sape



The relationships as shown in Figure 2 (a-d) can be summarized as follows:



The relationships as shown in Figure 3 (a-d) can be summarized as follows:



the small pelagic resource is spread throughout East Java coast to Sape Strait, it is concentrated mostly in the Bali Strait. It is likely that the fisheries in the four areas studied are actually exploiting the same small pelagic stock.

Fig 2 (a) shows the time series for lemuru catch data of the different fisheries (note the different ordinates). There is a suggestion that lemuru catches of the SE Java-Bali (Fig 2b) may fluctuate in the same direction so that lemuru catches in SE Java are high when small pelagic in Bali Strait are also high. However, the lemuru catches for the Bali-Alas Straits and Alas-Sape Straits show the opposite features, in which if the catch is high in Bali Strait, it is low in the Alas Strait (Fig 2c). Similarly, high catches in the Alas Strait lemuru usually occur during the low catch years in Sape Straits (Fig 2d). So as to determine whether this tendency is real we used least squares regression analysis on the relation between lemuru catches in the south coast of East Java, Bali, Alas and Sape Straits, all of which were significant:

Fig 2 (b) Bali Strait lemuru catches on SE Java lemuru catches: a =27025; b=0.4858 r=0.39; p>0.05 at 26 DF.

Fig 2 (c) Alas Strait lemuru catches on Bali Strait lemuru catches: a =956.22; b=-0.0082 r=-0.32; p<0.05 at 26 DF.

Fig 2 (d) Alas Strait lemuru catches on Sape Strait lemuru catches: a =7549; b=-2.5699; r=-0.52; p>0.01 at 26 DF.

The above feature suggests that lemuru catch in the south coast of East Java is high when lemuru catch in the Bali Strait is high. The relationships between lemuru catches for Bali Strait and Alas Strait is rather weak (r=0.32; p<0.05), while strong negative relationship is found between "lemuru" of the Alas Strait and Sape Strait.The latter implies that the "lemuru" catch in Alas Strait is low when "lemuru" catch in Sape Strait is high. It is likely that lemuru distributed from south coast of East Java to Sape Strait is not actually a single stock unit. The resources perhaps split into two stocks: one contributing to East Java - Bali, the other to Alas - Sape Straits. It is suggested that further biological studies should be carried out to confirm this.

Fig 3 (a) shows the time series for combined layang catch data of the different fisheries. There is a suggestion that layang catches of the different localities may fluctuate in the same directions so that layang catches in one place/fishery are high when layang in other fisheries are also high. This is particularly evident for the Bali Strait - Alas Strait (Fig 3c), and the Alas Strait - Sape Strait (Figure 3d) layang resources.

There is, however, no relationship between layang catches for Bali Strait - SE Java (Figure 3b).

The least squares regression analysis was employed to examine the relationships between layang catches in the south coast of East Java, Bali, Alas and Sape Straits, and is summarized as follows:

Fig 3 (b) Bali Strait layang catches on SE Java layang catches: the relationship was found to be very weak (r=0.16), as the data are widely scattered

Fig 3 (c) Alas Strait layang catches on layang Bali Strait catches: a =358.68; b=0.1278 r=0.36; p>0.1 at 26 DF.

Fig 3 (d) Alas Strait layang catches on Sape Strait layang catches: a =294.44; b=0.223; r=0.43; p>0.05 at 26 DF.

This feature indicates that layang catches in Bali, Alas and Sape Straits fluctuate in the same direction, which means that catches in any one place is high when the others's catches are also high. However, in these Straits layang do not seems to be the target species; their annual catches are relatively low (a maximum of 3,000 tons, compared to lemuru attaining 60,000 tons; or only about half of annual catches of layang in south coast of East Java, 6,000 tons). It is therefore unclear, as to this point, whether layang in the four areas studied is a single stock unit or two. This requires to be left open for further studies, ideally focusing on its taxonomy and/or genetics.

The Bali Straits lemuru (*Sardinella lemuru*) fishery is the best studied fishery in Indonesia, perhaps even in the whole of South East Asia. Ritterbush (1975) described the lemuru life cycle and the fishery, giving reliable landings data from 1950-73. Venema (1996) summarised results of 26 echo-acoustic surveys carried out by ***RV Lemuru*** in the Bali Straits from 1972-76.

Oceanographically the Bali Straits have more upwelled water and for longer periods, than the other Straits as the throughflow there is weakest while the Lombok Straits are most exposed to throughflow and so contain practically no upwelled water at any time (except South of Nusa Penida and around the south western cape of Lombok). The Bali Straits fisheries are characterised by the highest landings (up to 60,000 t yr^{-1} in strong El-Nino years), and the Lombok Straits by the lowest landings (approaching zero in most years because of the heavy currents and the lack of upwelled waters). The Sape Straits are intermediate between the Bali and Alas Straits with from 2,000 to 20,000 t yr^{-1} of squid and lemuru in recent years. There is evidence, which needs confirmation, that the Alas and Sape Straits receive more upwelled water than the Lombok Straits and less than the Bali Strait

Hendiarti *et al* (1995, 1996), independently investigated the effects of upwelling on Bali Straits lemuru landings, using satellite imagery and data from surveys for ground truthing satellite images. They found that upwelling in 1995 occurred from mid-July to early September: upwelled water along the south-eastern coast of Java and South of Bali and Lombok was around 4-5^{0}C cooler than waters to the North, or outside of the upwelling area. There is temperature difference between upwelled water to the South of Nusa Penida, a small Island located in the Lombok Straits, and surrounding "throughflow" water coming from warm throughflow waters to the North of the Lombok Straits. SST varied considerably over short periods, suggesting that upwelling occurred at varying intensities. Data from other sites showed that upwelling also varied through space and was a very dynamic phenomenon, varying in markedly in intensity through space and time during the study period. Lemuru catches at the fishing port of Banyuwangi and elsewhere in the Bali Straits peaked in the third quarter of each year from 1991-1994, i.e. during the period of peak upwelling.

Mizuno (1995) used bathythermograph data from 40 fisheries training vessels from 1967-86, and current data obtained by observing the drift of buoys on tuna long lines (10-100 km long, 20-200m deep) between shooting and hauling the net, and obtained >15,000 data points. Bimonthly means from 1967-86 showed markedly lower 100 m depth temperatures (18-19^{0}C) South of East Java, Bali, Lombok and Sumbawa (probably not including the Sape Straits) from around June to October (especially in July and August), with little or no 100m temperature differences between these and surrounding waters at other times of year. Currents in the waters characterised by low June-September temperatures showed systematic westward flow along the southern coasts of Java, Bali and Lombok and Sumbawa (perhaps not reaching to the Sape Straits); currents at other times of year were weak or were not westwards. Mizuno argued that the temperature field data indicated strong seasonal upwelling caused by the southeastern monsoon, rising between throughflow water and the coast. The velocity field was consistent with this, suggesting a mean annual throughflow of around 9 Sverdrups (maximum monthly values of 17 to -3 Sverdrups).

Arief and Murray (1996) studied the throughflow of water from the Java Sea and the Flores Seas, which enters the Indian Ocean mainly through the Lombok Straits, and to a lesser extent through the Alas, Sape and (very much less) the Bali Straits. This throughflow is driven by the higher sea levels (ca 20mm; Michida and Yoritaka, 1995) in the West Pacific compared with the Indian Ocean. Current meter observations were difficult to obtain and were often not useful, but sea level fluctuations at Cilacap (approximately 750 km further West along the South Java coast correlated very well (r = 0.87) with sea level changes in the Lombok Straits. Sea level oscillation in the Indian Ocean indicated flows of 50-70 cm.sec/s, equivalent to 2-3 Sverdups, observed directly in 1985 in the Lombok Straits. Lagged regression analysis indicated that Cilacap sea levels lead Lombok Straits currents by 1-2 days, suggesting that coastally trapped internal Kelvin waves were moving from off the coast of West Sumatera, to Cilacap and on to the Indian Ocean South of the Lombok Straits. Such Kelvin waves could influence front formation and upwelling in waters South off South East Java, Bali, Lombok, and perhaps off Sumbawa and the Sape Straits. Unpublished data (Arief, 1995) from the Lombok Straits in 1995 showed that a narrow (750-1,000 m wide), partly tidal, surface current exists between Nusa Penida and the Bali Coast that may reach >12.5 knots. This exceedingly fast current is associated with intense irregular surface chop and wave action, which can make small boat travel risky to the point of foolhardiness. Currents at 100m observed using current meters exceeded 7 knots. There is little fishing in the Lombok Straits : most fishing grounds occur within the protection of the large embayment that defines the West Lombok coast. Perhaps fishermen avoid the extraordinary conditions that may occur in the Lombok Straits for reasons of safety; perhaps also such conditions do not favour the stocks of small pelagic fish normally targeted by small scale coastal fishermen.

Conclusions

There is a clear co-existence in the overall small pelagic resources within the areas studied. Strong relationships were found between overall small pelagic fish resources in SE coast of East Java, the Strait of Bali, Alas and Sape. There is a tendency that small pelagic catches of the different localities may fluctuate in the same directions so that small pelagic catches in one place/fishery are high when small pelagic in other fisheries are also high. The relationships by species, however, varies according to the area.

The correlation coefficient, *r*, is highest (+0.60) for the small pelagics of Bali Strait – Alas Strait, and lower values are evident as moving westward (East Java, 0.43) and eastward (Sape, 0.42). This suggests that although the small pelagic resource is spread throughout East Java coast to Sape Strait, it is concentrated mostly in the Bali Strait. These finding also suggest that the small pelagic resources in the study areas are in co-existence with each others. It is likely that the fisheries in the four areas studies are actually exploiting the same small pelagic stock.

Further assessment into species component indicated that the lemuru resource distributed from south coast of East Java to Sape Strait is unlikely to be actually a single unit stock. The resource perhaps split into two sub-populations: one contributing on to the East Java - Bali fisheries, the other to Alas - Sape Straits fisheries.

Layang, on the other hand, relatively is not a significant contributor to the fisheries of the four areas studied. Further biological and taxonomic studies can be directed: (i) to confirm this hypothesis on lemuru, and (ii) to identify "layang" species and whether the resource consists of a single or more stock(s).

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