J. Mar. Biol. Ass. India, **52** (1) : 1 - 7, January - June 2010

Invited Paper

An evaluation of resource overlaps among fishing gears in the coastal fisheries using multivariate techniques

Len R. Garces and [1]Geronimo T. Silvestre

The World Fish Center - Philippine Country Office, SEMEO - SEARCA, College, Laguna 4031 Philippines.
*[1]Tetra Tech EM Inc., 18th floor, OMM-CITRA Bldg., San Miguel Avenue, Ortigas Center, Pasig City 1605, Philippines. *E-mail: L.GARCES@CGIAR.ORG*

Abstract

Southeast Asian fisheries such as in San Miguel Bay, Philippines operate in a multi-gear and mixed-species situation. Marine capture fisheries in the Philippines are conventionally sub-divided into municipal (small-scale) and commercial (large-scale) based on vessel gross tonnage (GT) and arbitrarily delineated spatially on the basis on area where fishing operations are undertaken. Fisheries management interventions are usually focused on the effort control by fishing gear type or specific fisheries (or species). Catch and effort data have been collected in most of the stock assessment studies, however, there have been limited assessments in differential fishing pressure on various species from available data. The apparent gear interactions and their influence on the high exploitation levels of the major fishery resources have been assessed qualitatively. The approach being illustrated can help management clarify effort reduction or allocation measures and identify which fishing gears should be regulated. Classification (TWINSPAN) and ordination (DCA) techniques commonly used in community structure analysis were utilized to examine the catch composition of 17 dominant fishing gears monitored during 1992 and 1993 and illustrate the extent of competition among the fishing gears in terms of their target species. The results indicate separation of two gear groups i.e., nearshore/coastal and offshore. The fishing gears employed in the nearshore/coastal areas indicate high degree of gear competition due to similarity in target species. The catch composition of the fishing gear group is also presented. Finally, this study provides an example how three fishing gears (*i.e.,* trawl, filter net and gillnet) exploit different size groups of croaker (*Otolithes ruber*), which is one of the dominant species in the Bay.

Keywords: Coastal fisheries management, fishing gear interaction, multivariate analysis, Philippines

Introduction

Recently, it is recognized that most of the coastal/ nearshore fisheries in southeast Asia are overfished (Silvestre *et al*., 2003; Stobutzki *et al*., 2006). Production from coastal capture fisheries has also been declining in some fishing areas. Silvestre *et al*. (2003) have estimated that overfishing in south and southeast Asia has depleted coastal fish stocks by 5 to 30 per cent of their unexploited levels. The overexploited stocks are coastal demersals and small pelagics in Java Sea, Indonesia and Philippines; and demersals, small pelagics and prawns in the Gulf of Thailand (Stobutzki *et al*., 2006).

Most of the fisheries in tropical coastal fishing grounds such as in San Miguel Bay, Philippines operate in multi-gear, multispecies complex. Overfishing has been identified as a serious problem on the sustainability of the resources in the Bay and that demersal fish biomass declined to about 18.5% of their level in the late 1940's (Cinco *et al.,* 1995a). The declines in fish biomass particularly of demersal stocks are presumably due to excessive fishing effort as well as habitat/environmental degradation. The results of the stock assessments in the Bay estimated a mean exploitation rate for the 15 most abundant species in the Bay at 0.65 (Cinco and Silvestre, 1995). This value is above the optimal level prescribed by current theory and suggests very heavy fishing pressure from the mix of fishing methods used in the Bay.

Many Asian countries use "fishing zones" as a spatial management tool to restrict fishing in particular areas. These have been established for a range of reasons, including to manage fishing effort or restrict fishing gears to designated areas (Purwanto, 2003), or to avert conflicts that might arise between different fisheries or sectors (e.g. small-scale and commercial sectors) (Barut *et al*., 2003; Taupek and Nasir, 2003). However, the delineation of these fishing zones is rarely based on a scientific understanding of the spatial structure of the resources. In these cases, the management zones are unlikely to be effective in managing the overall impact from different fisheries on the sustainability of fish stocks.

Marine capture fisheries in the Philippines are conventionally sub-divided into municipal (small-scale) and commercial (large-scale) based on vessel gross tonnage and arbitrarily delineated spatially on the basis on area where fishing operations are undertaken. Municipal fisheries include fish capture operations within 15 km from the shoreline and using boats less than 3 GT and those fishing gears that do not involve water craft. On the other hand, commercial fisheries include fishing operations using vessels greater than 3 GT and operate beyond the fishing areas for municipal fisheries (beyond 15 km from the shoreline to high seas). Current fishing regulations also include temporal and spatial restrictions of some gear types and on target species. In some fishing grounds such as San Miguel Bay, ban on trawl fishing has been enforced since 1998 (under Republic Act 8550 and Local Government Code) as a measure to reduce fishing pressure and to presumably rebuild stock biomass of overexploited fisheries resources.

Technological interactions have been used to analyze multispecies nature of fisheries (see Murawski *et al*., 1991; Pikitch, 1991). The modeling of multispecies fleet interactions (see Laurec *et al*., 1991) as well as effort allocation and optimal fleet analysis (Murawski and Finn, 1986; Cruz-Trinidad and Garces, 1996) have also been carried out. Murawski *et al*. (1991) suggested that interactions among fisheries occur when: (1) small-mesh fisheries discard undersized individuals of target species for large-mesh fisheries; (2) large-mesh fisheries discard animals below minimum landing sizes, and (3) fisheries operation simultaneously or sequentially compete for the same species/age groups. This paper aims to illustrate the third point and we used existing and widely used quantitative techniques to analyze catch composition data from landings.

Multivariate techniques (*e.g*., divisive classification analysis and clustering techniques) were used primarily for fish community and assemblage analysis. Some examples on the applications of ecological community analysis to fisheries situations include: Fager and Longhurst (1968); Martosubroto (1982); Ralston and Polovina (1982); McManus (1986, 1989, 1996); Nañola *et al*. (1990); Federizon (1992); Bianchi (1992, 1996); Bianchi *et al*. (1996); and several contributions by Silvestre *et al*. (2003). This study aims to explore the utility of multivariate techniques using classification (TWINSPAN) and ordination (DCA) to quantitatively assess the extent of gear competition or interaction in terms of species overlaps as exhibited in the catch composition of the various gears. The results of the analysis also examine the effectiveness of gear restrictions currently being implemented to mitigate the overexploitation problems in the coastal fisheries of San Miguel Bay, Philippines.

Material and Methods

Study Area: San Miguel Bay has an area of about 1,115 km^2 and located in the southwestern part of Luzon on the Pacific coast of the Philippines (Fig. 1). The Bay is relatively shallow with mean depth of 7 m and is predominantly characterized by a muddy-sandy substrate (Garces *et al*., 1995a). In 1992-1993, a multi-disciplinary study was conducted by the International Center for Living Aquatic Resources Management (ICLARM, later known as The World Fish Center) under the Fisheries Sector Program (FSP) of the Department of Agriculture and with funding from the Asian Development Bank (ADB). The study aimed to assess the condition of coastal fisheries resources and provide scientific and technical information base for sustainable use and management of coastal fisheries in the Bay (Garces *et al*., 1995b).

The results of resource/stock assessments indicated that 46 distinct types of fishing method/ gear are employed by roughly 5,300 fishers to exploit a highly diverse species complex with annual landings estimated at 17,750 t in 1992 -1993 (Silvestre *et al*., 1995). A total of 171 species belonging to 110 genera and 70 families were observed to occur in the catch (Cinco *et al*., 1995b). The croakers (Sciaenidae), slipmouths (Leiognathidae), penaeid shrimps (Penaeidae), sergestid shrimps (Sergestidae), portunid crabs (Portunidae) and anchovies (Engraulidae) dominated the catch and together contributed 58% to the total catch (Silvestre *et al*., 1995).

In 1992-93, a total of 4,739 units of various types of fishing gear were enumerated in the seven coastal municipalities bordering San Miguel Bay (Silvestre *et al*., 1995). These consisted predominantly of relatively simple, inexpensive fishing gears such as gillnets (2,670 units), hooks & line (316 units), scissor net (245 units), longline (236 units), fish trap (225 units), crab liftnet (164 units) and spear gun (95 units), which collectively account for about 83% of the total number of gear units in the area.

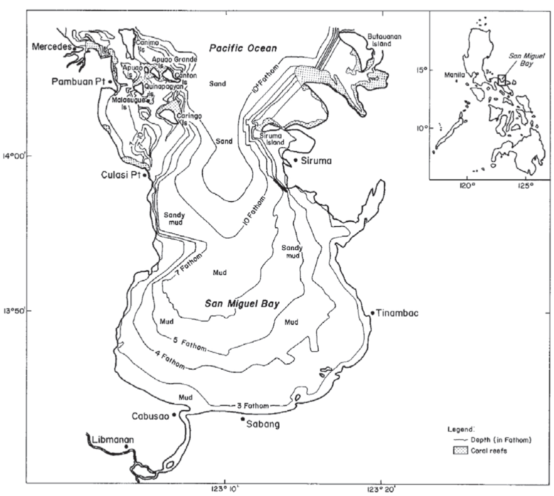

Fig. 1. Map of the study area and dominant river basins

Data Source: Catch composition data used in the analysis were collected during the fish landing (catch monitoring) surveys in San Miguel Bay from July 1992 to June 1993. The data set provides a comprehensive information on the catch composition of 46 fishing gear methods and at refined taxonomic level *i.e*., species or genera. Data recorded during the course of monitoring the landings included (by gear type) the catch landed per trip, species composition of catch, and length composition by species/group. The latter two elements were recorded whenever possible. The choice of landing sites to monitor was purposive rather than random. This involved, among others, the following considerations: (1) the variety of fishing gears found in the landing site or *barangay*, (2) the volume of landings therein, (3) amenability of fishers to provide access to their catch, (4) comparability with the earlier (1980-1981) ICLARM study, (5) availability of enumerator resident in the area and (6) project logistics. The details and description of the catch monitoring survey are given in Silvestre *et al.* (1995).

Data Analysis: Of the 46 fishing gear/methods, only 20 types of gear were monitored during the fish landing surveys. After some preliminary analysis of the data only 16 gear types were included in the data analysis. Gear types such as fish pot, spear gun and liftnets (fish and crab) were excluded in the analysis since these gear types or fishing methods are very selective in target species. No data transformation was done as the percentage species composition of each gear was used in the analysis. The percentage catch composition data given in Appendix I (see Silvestre *et al*., 1995) was used in the analysis and the data varied between 0 and 100%.

Patterns of catch composition among the various gears were analyzed using divisive classification algorithm known as TWINSPAN (Two-Way Indicator Species Analysis; Hill, 1979). This technique gives the hierarchical relationship between group of species or gears. TWIA is a divisive clustering method that classifies sites and species and produces a sorted species-by-gear table, showing hierarchical classification in a binary notation. Input data were in terms of percentage composition of the annual catches by gear.

To validate the results of TWINSPAN, clustering techniques DCA (Detrended Correspondence Analysis) was done. DCA is an ordination method based on the abundance values of the species (Ter Braak, 1990). The program CANOCO was used to run DCA, and the input was catches in terms of percentage and detrending by second order polynomials was applied. All species were given equal weightage in the analysis. The method does not assume linear relationships between species abundance and environmental variables and thus is considered particularly useful in ecological studies (Ter Braak, 1990). Both TWINSPAN and DCA are based on correspondence analysis and hence, it is possible to compare the results directly (van Groenewoud, 1982).

Results and Discussion

The catch composition data for 16 gear types with a total of 59 species/taxa were included in the analysis. The two-way table generated from TWINSPAN and the ordination plots from DCA are given in Table 1 and Fig. 2, respectively. Table 1 shows the 2-way classification of species and gear types/methods which separates fishing methods that are operated in shallower areas (Group A) from those used in deeper waters or target pelagic species (Group B).

Figure 2 illustrates the ordination on the gear type/methods from catch composition data on DCA Axes 1 and 2 with eigenvalues of 0.92 and 0.70, respectively. The DCA outputs validated the TWINSPAN results showing clear separation of fishing gears into two *i.e.*, nearshore and offshore which may be explained by the DCA axis 1. Group A which are employed mostly within the shallower portions of the Bay include gillnets, trawl, pullnet, filternet and fish corral (Fig. 3). Gear types in Group B are long line, ring net and shark gillnet. The second division separates Group A into two, *i.e.*, Group A1 which comprises mainly of trawls, pullnet and fish corrals, shrimp gillnet and filternet. Group A2 consists of all other gillnets except the shrimp gillnet.

Table 2 provides the mean percentage contribution target species/taxa of the gear groups classified by TWINSPAN. The main species/groups that comprise the catch of the fishing gears employed in inshore areas (Group A) include penaeid shrimps, mullets (*Mugil* spp.) and crabs (*Portunus pelagicus*). It is interesting to note that all of these species/groups except crabs are target species by the fishing gears used in coastal/inshore areas. On the other

```
                 1   11   1 1 11
                4412356689071523

 2 Alep  dje    ---1--3---------   00000
 7 Cara  mal    ------3---------   00000
34 Plot  ang    ------2---------   00000
41 Scat  arg    ------2---------   00000
48 Siga  jav    ------1---------   00000
19 Gazz  min    --3-1-2---------   000010
24 Leio  spl    -235313---1-----   000010
 3 Apog  qua    ---2------------   000011
45 Secu  ruc    ---2111---------   000011
47 Serg est     ----55----------   000011
49 Siga  sp     -----2----------   000011
52 Stol  com    -134142---------   000011
55 Tras h f     --4343----------   000011
59 Upen  sul    --23------------   000011
53 Stol  ind    5522132---------   0001
57 Trip  blo    -4--------------   0001
 4 Apog  sp     -1--1-1---1-----   001
21 Lago  sp     -1-21-2---1-1---   001
25 Loli  go     --121----11-----   001
46 Sela  lep    --21-----1------   001
20 Hemi  geo    -1------1-------   010000
29 Otol  rub    51322-2-25511---   010000
23 Leio  equ    -----1---1------   010001
30 Pell  dit    ------2--1------   010001
31 Pena eid     51434432-4215---   010001
42 Scom  com    --111---111-----   010001
51 Sphy  jel    --1-------1-----   010001
56 Tric  hau    --321132153-----   01001
27 Mugi  sp     -12212255211-1--   0101
11 Chir  dor    --1------11-----   01100
15 Dend  rus    1-1---3223411---   01100
40 Sard  per    --22---1112-3---   01100
50 Sill  sih    -3-------21-1---   01100
13 Cyno  sp     ----1----1-1----   01101
35 Port  pel    21122----1255---   01101
36 Pset  eru    ----------1-1---   011100
54 Thry  set    ----1-23311-3---   011100
32 Penn  sp     --------12------   011101
37 Rast  bra    ---------1------   011101
43 Scom  lys    --------1-------   011101
12 Cyno  bil    -----------1----   01111
33 Plat  ind    -----------1----   01111
58 Tylo  sto    -1------1---3---   01111
 1 Alec  cil    -------3------2-   10
18 Form  nig    ---1---1------1-   10
39 Rhyn  dji    -------4-----12-   10
 5 Ariu  sp     -------1-1114413   110
44 Scyl  ser    -----------1-2--   110
28 Mura  cin    ----1121--1-114-   1110
16 Drep  pun    -----------1-42-   11110
 6 Cara  ign    --------------45   11111
 8 Cara  sex    --------------1-   11111
 9 Cara  sp     ----------1---4-   11111
10 Carc  mel    ---------1---54-   11111
14 Dasy  kuh    --------------4-   11111
17 Epin  sp     --------------1-   11111
22 Late  cal    -----1-------53-   11111
26 Mega  cyp    -------------1--   11111
38 Rays  sp     --------------3-   11111

                0000000000000111
                0000000111111
                0011111000011
                  00001
```

Table 1. Two - way table generated from TWINSPAN showing groups A and B.

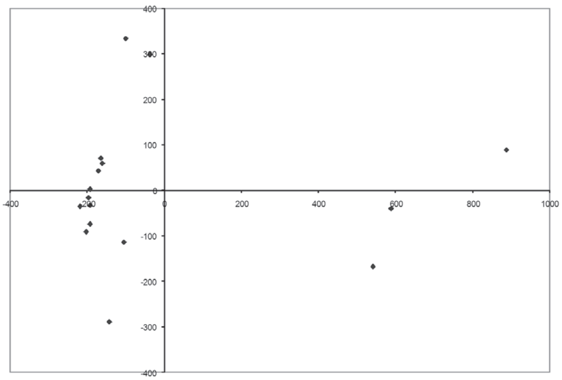

Fig. 2. Ordination plots from DCA

hand, jacks (Carangidae), rays and sharks dominated the catch of the pelagic offshore gears.

Multivariate techniques such as TWINSPAN and DCA have been used primarily for fish community and assemblage analysis. These methods are particularly useful in determining the boundaries of assemblages of fish that can be considered to be "Assemblage Production Units (APUs)" (Tyler *et al*., 1982), and used as the basis for assigning particular parts of the fishery to specific groups of fishers, gear types and harvest pressures.

The results of analysis using classification and ordination techniques on the catch data showed a high degree of gear competition due to similarity of catch composition and target species particularly the small-scale (municipal) fishing gears. This is consistent with the results of ecosystem analysis of San Miguel Bay fisheries by Bundy and Pauly (2001), who concluded that the small-scale fishery sector has a wider-ranging impact on the fishery resources of the Bay than the larger-scale fisheries. Moreover, the analysis provides inputs to the design of management interventions to partition different fisheries or gears based on spatial patterns of fish assemblages.

Figure 3 shows the size composition of *Otholithes ruber* which is one of the most abundant fish species in San Miguel Bay and in the catch of filter net, mini trawl (and presumably small and medium trawl)

Table 2. Catch composition of the gear groups classified by TWINSPAN (in mean percentage composition)

Group A		Group B	
Species/Groups	%	Species/Groups	%
Penaeid shrimps	12.38	*Caranx ignobilis*	35.27
Mugil sp.	11.65	*Carcharinus melanopterus*	16.60
Portunus pelagicus	11.36	*Lates calcalifer*	13.70
Otolithes ruber	9.91	*Arius* sp.	8.83
Stolephorus indicus	8.85	*Muraenesox cinereus*	4.93
Sergestid shrimps	7.79	*Drepane punctata*	4.40
Trichiurus haumela	4.21	*Caranx* spp.	3.53
Leiognathus splendens	3.44	*Dasyatis kuhlii*	3.37
Trash fish	3.10	Rays	2.43
Dendrophysa russelli	2.98	*Rhynchobatus djiddensis*	1.43
Group A1		**Group A2**	
Species/Groups	%	Species/Groups	%
Stolephorus indicus	16.43	*Mugil* sp.	23.25
Sergestid shrimps	14.47	*Portunus pelagicus*	22.26
Penaeid shrimps	13.51	*Otolithes ruber*	14.28
Leiognathus splendens	6.30	Penaeid shrimps	11.07
Otolithes ruber	6.17	*Trichiurus haumela*	6.19
Trash fish	5.76	*Dendrophysa russelli*	4.77
Stolephorus commersonii	5.45	*Thryssa setirostris*	3.51
Trichiurus haumela	2.51	*Arius* sp.	2.16
Portunus pelagicus	2.03	*Rhynchobatus djiddensis*	2.07
Tripodichthys blochi	1.89	*Sardinella perforata*	2.01

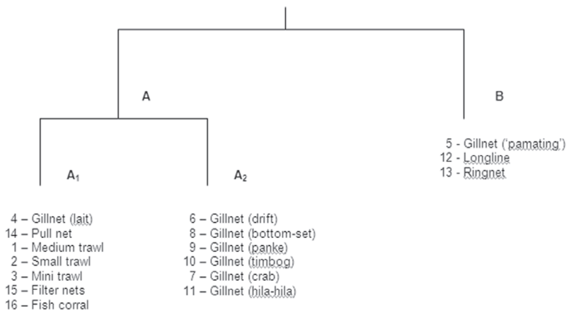

Fig. 3. Results of TWINSPAN classification of 16 fishing gear/method

and gillnets. The length distribution illustrates growth overfishing resulting from gears using small-meshed nets. Exploitation level (E=F/Z) for this species derived from length-based analysis is 0.57 while the mean E for 15 most abundant species in the Bay has been estimated at 0.65, which is above the optimal level prescribed by current theory. The analysis suggests very heavy fishing pressure from the mix of fishing methods used in the Bay (Cinco and Silvestre, 1995). Moreover, it is evident from this example that a single gear ban or restriction may not be a good strategy to mitigate excessive fishing pressure and eventually rebuild stock biomass. There is a need therefore to re-evaluate the policies on gear restrictions and look at re-structuring the fleets or reducing fishing effort both at the municipal and commercial sectors of the fisheries.

The study on determination of optimal fleet configuration for San Miguel Bay using a simple linear programming approach indicated that a reduction of trawl fleet to about 88% from the 1993 level and a corresponding increase of fish corrals up to 520% would result to highest level of benefits of about Php 19.4 million (Cruz-Trinidad and Garces, 1996). Based on the TWINSPAN output, trawls and fish corrals belong to the same group and have very similar catch composition.

Multivariate analysis have the potential to provide valuable inputs into fisheries management, particularly in multispecies fisheries, such as the coastal fisheries in San Miguel Bay, and in other similar fishing areas in southeast Asia. The results of analysis using classification and ordination techniques on the catch data showed a high degree of gear competition, which is evident from similarity of catch composition and target species particularly the small-scale (municipal) fisheries sector. This result could be used to guide the design of management interventions to partition different fisheries or gears based on spatial patterns of fish assemblages. Currently, Fisheries and Aquaculture Resources Management Councils (FARMCs) with support of the local government units and regional office of the national fisheries agency (*i.e.*, BFAR) are managing the coastal fisheries in the Bay.

References

Barut, N. C., M. D. Santos, L. L. Mijares, R. Subade, N. B. Armada and L. R. Garces. 2003. Philippine Coastal Fisheries Situation. *In*: G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R. A. Valmonte-Santos, C. Z. Luna, L. Lachica-Aliño, P. Munro, V. Christensen, D. Pauly (Eds.) *Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries*. WorldFish Center Conference Proceedings, 67: p. 885 - 914.

Bianchi, G. 1992. Demersal assemblages of tropical continental shelves. Dr. Scient. Thesis. U. Bergen, Norway, 217 pp.

Bianchi, G. 1996. Demersal fish assemblages of trawlable grounds off northwest Sumatra. *In*: D. Pauly and P. Martosubroto (Eds.) *Baseline Studies of Biodiversity: The Fish Resources of Western Indonesia. ICLARM Stud. Rev*., 23: p. 123 - 130.

Bianchi, G., M. Badurin and S. Budihardjo. 1996. Demersal assemblages of the Java Sea: A study based on the trawl surveys of the R/V *Mutiara* 4. *In*: D. Pauly and P. Martosubroto (Eds.) *Baseline Studies of Biodiversity: The Fish Resources of Western Indonesia. ICLARM Stud. Rev*., 23: p. 55 - 61.

Bundy, A. and D. Pauly. 2001. Selective harvesting by small-scale fisheries: ecosystem analysis of San Miguel Bay, Philippines. *Fish. Res*., 53: 263 - 281.

Cinco, E. and G. Silvestre. 1995. Population parameters and exploitation ratios of fishes caught in San Miguel Bay, Philippines. *In*: G. Silvestre, C. Luna and J. Padilla (Eds.) *Multidisciplinary Assessment of the Fisheries in San Miguel Bay* (12992-1993). *ICLARM Tech. Rep*., 47 (CD-ROM).

Cinco, E., J. Diaz, R. Gatchalian and G. Silvestre. 1995a. Results of the San Miguel Bay trawl survey. *In*: G. Silvestre, C. Luna and J. Padilla (Eds.) *Multidisciplinary Assessment of the Fisheries in San Miguel Bay* (12992-1993). *ICLARM Tech. Rep*., 47 (CD-ROM).

Cinco, E., J. Diaz, , Q. P. Sia III and G. Silvestre. 1995b. A checklist of fishes caught in San Miguel Bay. *In*: G. Silvestre, C. Luna and J. Padilla (Eds.) *Multidisciplinary Assessment of the Fisheries in San Miguel Bay* (12992-1993). *ICLARM Tech. Rep*., 47 (CD-ROM).

Cruz-Trinidad, A. and L. R. Garces. 1996. Optimal fleet configuration in San Miguel Bay, Philippines: A simple linear programming approach. *In*: A. Cruz-Trinidad (Ed.) *Valuation of Tropical Coastal Resources: Theory and Application of Linear Programming*. *ICLARM Stud. Rev*., 25: p. 78 - 86.

Fager, E. W. and A. R. Longhurst. 1968. Recurrent group analysis of species assemblages of demersal fish in the Gulf of Guinea. *J. Fish. Res. Bd. Canada*, 25(7): 1405 - 1421.

Federizon, R. R. 1992. Description of the subareas of Ragay Gulf, Philippines, and their fish assemblages by exploratory data analysis. *Aust. J. Mar. Fresh. Res*., 43: 379 - 391.

Garces, L. R., Q. P. Sia III, M. J. M. Vega, R. G. G. Ledesma and N. A. Robles. 1995a. San Miguel Bay coastal habitat mapping and assessment using remote sensing techniques. *In*: G. Silvestre, C. Luna and J. Padilla (Eds.) *Multidisciplinary Assessment of the Fisheries in San Miguel Bay* (1992-1993). *ICLARM Tech. Rep*., 47 (CD-ROM).

Garces, L. R., R. A. V. Santos and G. T. Silvestre. 1995b. Multidisciplinary assessment of the fisheries in San Miguel Bay, Philippines. *Coastal Management in Tropical Asia*, 5(1): 3 - 5.

Hill, M. O. 1979. TWINSPAN-A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Section of Ecology and Systematics, Cornell University, Ithaca, New York, 14850, 60 pp.

Laurec, A., A. Biseau and A. Charuau. 1991. Modelling technical interactions. *ICES. Mar. Sci. Symp*., 193: 225-236.

Martosubroto, P. 1982. Fishery dynamics of the demersal resources of the Java Sea. PhD Diss. Dalhousie Univ., 238 p.

McManus, J. W. 1986. Depth zonation in a demersal fishery in the Samar Sea, Philippines. 1st Asian Fish. Forum, Manila,

McManus, J. W. 1989. Zonation among demersal fishes of Southeast Asia: The southwest shelf of Indonesia. *Proc. 6th Symp. On Coastal and Ocean Manag*. p. 1011 - 1022.

McManus, J. W. 1996. Marine bottomfish communities from the Indian Ocean coast of Bali to mid-Sumatra. *In*: D. Pauly and P. Martosubroto (Eds.) *Baseline Studies of Biodiversity: The Fish Resources of Western Indonesia*. *ICLARM Stud. Rev*., 23: p. 91 - 101.

Murawski, S. A., A. M. Lange and J. S. Idoine. 1991. An analysis of technological interactions among Gulf of Maine mixed-species fisheries. *ICES Mar. Sci. Symp*., 193: 237 - 252.

Murawski, S. S. and J. T. Finn. 1986. Optimal effort allocation among competing mixed-species fisheries, subject to fishing mortality constraints. *Can. J. Fish. Aquat. Sci*., 43: 90 - 100.

Nañola, C. L., J. W. McManus, W. L. Campos, A. G. C. del Norte, R. B. Reyes, J. B. P. Cabansag and J. N. D. Pasamonte. 1990. Spatio-temporal variations in community structure in a heavily fished forereef slope in Bolinao, Philippines. *2nd Asian Fish. Forum*, p. 377 - 380.

Pikitch, E. K. 1991. Technological interactions in the US West Coast groundfish trawl fishery and their implications for management. *ICES Mar. Sci. Symp*., 193: 253 - 263.

Purwanto, 2003. Status and management of the Java sea fisheries. *In*: G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R. A. Valmonte-Santos, C. Z. Luna, L. Lachica-Aliño, P. Munro, V. Christensen, D. Pauly (Eds.) *Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries*. WorldFish Center Conference Proceedings 67: p. 793 - 832.

Ralston, S. and J. J. Polovina. 1982. A multispecies analysis of the commercial handline fishery in Hawaii. *Fish. Bull*., 80(3): 435 - 448.

Silvestre, G., E. Cinco, R. Gatchalian and J. Diaz. 1995. Catch and effort in the San Miguel Bay fisheries. *In*: G. Silvestre, C. Luna and J. Padilla (Eds.) *Multidisciplinary Assessment of the Fisheries in San Miguel Bay* (1992-1993). *ICLARM Tech. Rep*., 47 (CD-ROM).

Silvestre, G. T., L. R. Garces, I. Stobutzki, M. Ahmed, R. Valmonte-Santos, C. Z. Luna and W. Zhou. 2003. South and south-east Asian coastal fisheries: their status and directions for improved management - conference synopsis and recommendations. *In*: G. Silvestre, L. Garces, I. Stobutzki, M. Ahmed, R. A. Valmonte-Santos, C. Z. Luna, L. Lachica-Aliño, P. Munro, V. Christensen, D. Pauly (Eds.) *Assessment, Management and Future Directions for Coastal Fisheries in Asian Countries*. WorldFish Center Conference Proceedings, 67: p. 1 - 40.

Stobutzki, I. C., G. T. Silvestre and L. R. Garces. 2006. Key issues in coastal fisheries in South and Southeast Asia, outcomes of a regional initiative. *Fish. Res*., 78: 109 - 118.

Taupek, M. and M. Nasir. 2003. Monitoring, measurement and assessment of fishing capacity - the Malaysian experience. *In*: S. Pascoe, D. Greboval (Eds.) *Measuring Capacity in Fisheries*. *FAO Fish. Tech. Pap*., No. 445, p.127 - 142.

Ter Braak, C. J. F. 1988. CANOCO- A FORTRAN program for canonical community ordination by partial detrended canonical correspondence analysis, principal components analysis and redundancy analysis (version 2.1). Agricultural Mathematic Group, Box 100, 6700 AC Wageningen, The Netherlands, 95 pp.

Ter Braak, C.J.F. 1990. CANOCO-a FORTRAN program for canonical community ordination. Microcomputer Power, Ithaca, NY.

Tyler, A.V., W.L. Gabriel and W.J. Overholtz. 1982. Adaptive management based on structure of fish assemblages of northern continental shelves, p. 149-156. *In:* M.C. Mercer (Ed.) *Multispecies approaches to fisheries management advise. Can. Spec. Publ. Fish. Aquat. Sci.,* 59.

van Groenewoud, H., 1982. The robustness of correspondence, detrended correspondence, and TWINSPAN analysis. Journal of Vegetation Science 3: 239-246.