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Demersal fish assemblages along the Pacific coast of Costa Rica: a quantitative and multivariate assessment hased on the Victor Hensen Costa Rica Expedition (1993/1994)

Matthias Wolff
Center for Tropical Marine Ecology (ZMT) Fahrenheitstraße 1, D-28359 Bremen.Germany.

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Abstract: During two cruise legs with the RV Victor Hensen (December 1993, February 1994), the demersal fish assemblages of the Golfo de Nicoya (GN), Bahía Coronado - Sierpe Terraba (ST) and Golfo Dulce (GD) areas were assessed from nearshore (~20 m) to shelf edge (~200 m) waters. 44 Beam- and 29 otter trawl collections were made on an area of 2 119 405 m², yielding a total of 242 species of fish. Despite the lower number of samples taken, more species were collected by the otter trawl (189 compared to 160), due to a wider area swept. As revealed by the species-area curve and a lognormal - curve constructed from the pooled (log) abundance data, the fish assemblage appeared as well sampled and a theoretical species richness (SR) of ~ 306 was estimated for the whole area. Mean species number per collection and mean biomass per area were much lower in the GD - area (9.3 species, 0.36g /m²) compared to the ST (15.4, 0.81g /m²) and GN (17.3, 0.74 g/m²) areas, indicating a depauperate fish assemblage in the former. Lowest species numbers and biomass were found in the central deep part of GD with increasing values towards the sill area at the opening of the gulf and towards the shallow stations above the thermocline. Average biomass was an order of magnitude higher in the interior part of GN compared to the other areas with values up to 18.1 g/m². Based on results of a multivariate analysis of the collections, the GN area can be divided into (1) an interior shallow area above the thermocline (<50 m) characterized by scianids, sea catfishes, stingrays, flatfishes, sea robins, (2) an outer part (>100 m) characterized by cods, scorpionfishes, gobies, cutlassfishes, serranids, anglerfishes and flatfishes and (3) a transition zone of the central and lateral parts with a mixed species assemblage with carangids, pufferfish, snappers, several flatfish species and the lizardfish as common elements. Characteristic for the deep basin of GD were small species of the genera *Cynoscion* and *Porichthys*. These occurred in low densities, suggesting a reduced carrying capacity of this deep basin for fish biomass in terms of food and oxygen. Species occurring at the shallow stations of GD are also found at a similar depth in the other areas, but many species are missing, namely ariids and many scianids found in the GN area. The species assemblage of the ST area resembles that of GN. Ariids, however, are missing here too. Biotic station parameters like species richness, biomass, abundance and production were not significantly correlated with abiotic parameters (temperature, oxygen, nutrients) suggesting that other habitat factors not evaluated in this study like habitat heterogeneity, distance to the open ocean, current regime and food availability probably are important factors for the structure of the fish assemblage.

Key words: Fish assemblage, fish diversity, biomass, Costa Rica, multivariate analysis.

The study reported here forms part of a research program between the Center for Tropical Marine Ecology (ZMT), Germany and the Center for Marine and Limnological studies (CIMAR), University of Costa Rica, Costa Rica. The program was initiated with the employment of the German RV Victor Hensen in Costa Rican shelf waters from December 1993 to February 1994 (Wolff & Vargas 1994).

In the study areas Golfo de Nicoya, Bahía Coronado -Sierpe Térraba and Golfo Dulce, (see Fig. 1), beam trawl and otter trawl hauls were conducted from nearshore waters (about 20 m) to the shelf edge (about 200 m) in order to sample the demersal fish and macrofauna along this depth gradient and to investigate (1) if there were areas with commercially important concentrations of fish and invertebrate species, (2) if certain areas/stations could be characterized by assemblages of a particular set of species, (3) if and how the two gulf systems (Golfo de Nicoya and Golfo Dulce) and the

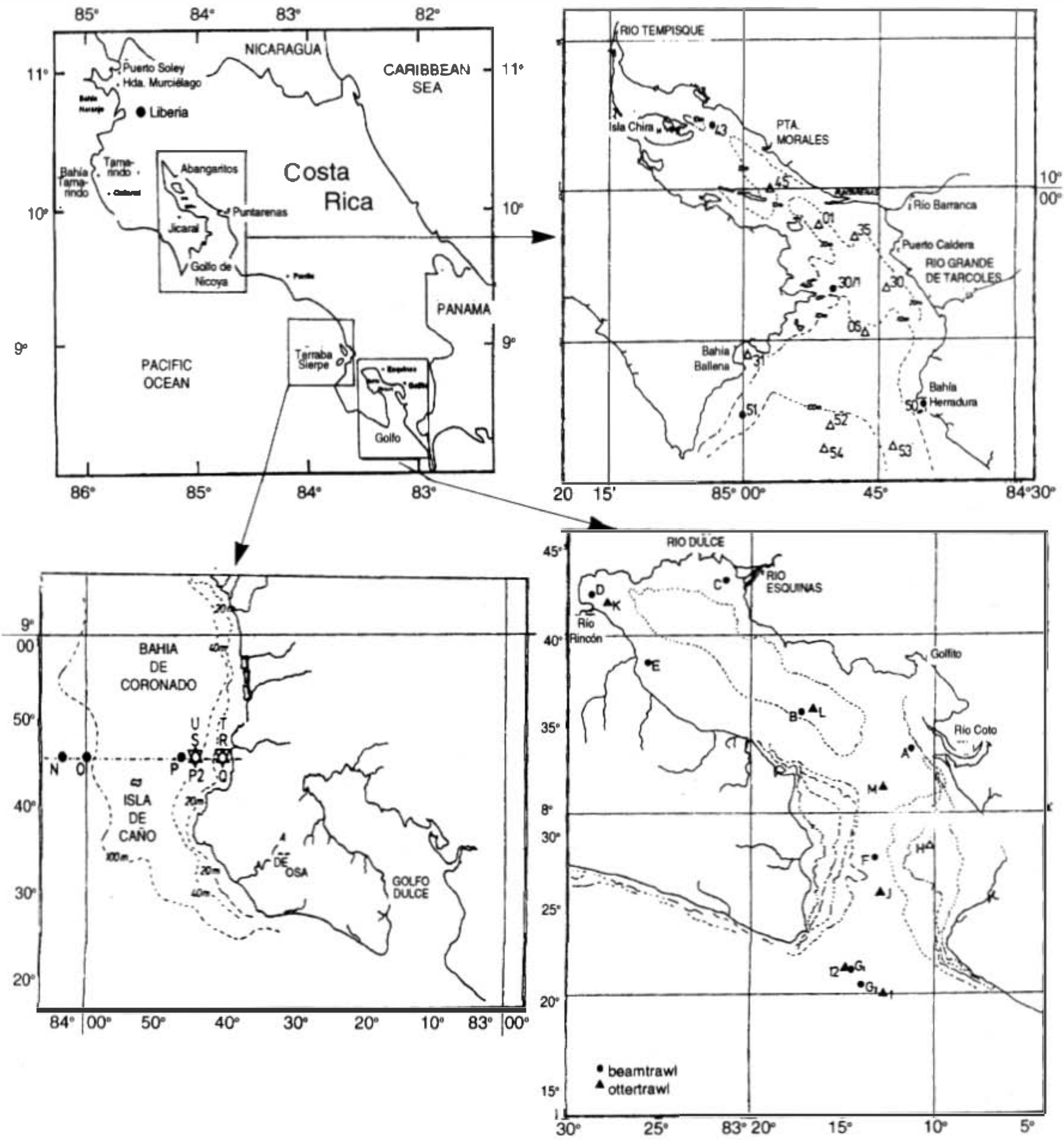


Fig. 1. Study areas with sampling sites (upper left: overview; upper right: Golfo de Nicoya; lower right: Golfo Dulce; lower left: Bahía Coronado-Sierpe-Térraba).

Bahía Coronado - Sierpe-Térraba estuary differ in their species composition, abundance and biomass and how differences relate to oceanographical conditions, water depths, coastal mangrove cover and season. As the Golfo de Nicoya area had been surveyed ten years before by the American RV Skimmer, our findings on fish assemblage structure in this gulf could be compared with these data. The other two areas, however, had not been surveyed previously and our results represent the first quantitative assessment of the demersal fauna in these areas.

MATERIAL AND METHODS

Sampling: Beam trawls and otter trawls were employed to sample the smaller fish and macroinvertebrates as well as the bigger fish.

At the stations (Fig. 1), 15 min beam trawl hauls (mesh size 1cm) were conducted at an average towing speed of 1.5 knots. The catch was separated into fish and invertebrates, and the total weight of all specimens of each species was registered (in some rare occasions subsamples had to be taken). The length frequencies of the abundant species (> 10/sample) were recorded. Most taxonomic identification of the fish species was done on board by Prof's William Bussing and Myrna López (CIMAR) based on a fish guide published by Bussing & López (1993). A complete list is presented in Bussing and López (1996). Unidentified species (the majority represented by invertebrates) were numbered for later identification and preserved in 4% formalin.

On those sampling stations where coral pieces, tree trunks or stones appeared in the beam trawl, the otter trawl was not employed because of the danger of damage-otherwise the sampling stations of the beam trawl were repeated with the otter trawl (mesh size 2.5 cm), that was towed for 30 min at an average speed of 2.5 knots. The catch was then analysed as described for the beam trawl. The beam trawl (opening width: 3 m) swept an area of approx. 2084 m^2, while the otter trawl (opening width: 35 m, head rope:27.5 m; foot rope: 34 m) swept an area of approx. 81 025 m^2 per tow. During the first leg, the otter trawl was heavily destroyed on a coral reef in the Golfo Dulce area (st. I, see Fig. 1), but sampling was continued using an identical spare trawl. At another occasion (st. 51, Fig. 1) the beam of the beam trawl broke and had to be repaired. The number of samples taken by the ottertrawl was lower during the second (11) than during the first leg (18).

Data processing: For the data analysis the following steps were done:

1. For each sample (station), a species list was elaborated containing biomass (Bm^{-2}), abundance (number) (Am^{-2}), and a descriptor (Pm^{-2}) which combines biomass and number. This descriptor is given by P = (B/A) 0.73 * A (Warwick & Clarke 1993) and represents a measure for production.

2. For an overview on the number of species caught in the whole study area and their respective contributions to the total abundance and production, the species were ranked and a log-normal - plot was established with the pooled data of both legs, from which the theoretical species richness (SR) was calculated.

3. A species - area curve was established from the beam trawl and otter trawl catches and from all samples combined by plotting the cumulative species number against the number of samples taken.

4. The heterogeneity of the biomass distribution within the study area was shown by a histogram, in which the number of samples was plotted against their respective biomass values.

5. To visualize the bathymetrical distribution of biomass, the samples were grouped into the following depth ranges (10-59 m, 60-109 m, 110-159 m, 160-209 m, 210-259 m) to relate average biomass per station to water depth.

6. A station/species matrix was constructed for the beam trawl and otter trawl samples for both cruise legs separately and a similarity matrix using the Bray Curtis index was computed with the fourth-root transformed data by the use of the PRIMER software following Clarke & Warwick (1994). For this matrix the descriptor "P" (s. above) was used. Prior to the calculations, the original species matrix was reduced such that the remaining species accounted for about 95% of the sum of the total P -values, eliminating the very rare species and those having very low P -values.

7. The group average linkage algorithm was used to construct station and species clusters from the similarity matrix.

8. Species indicative for particular groups within the dendrograms were identified using the SIMPER (Similarity percentage) - routine of the PRIMER - package.

9. A "station parameter table" was constructed for the abiotic data of all beam trawl and otter trawl samples taken during both legs. To do so, for each station, bottom temperature, oxygen, water depth, phosphate and nitrate were considered.

10. A correlation matrix was calculated to find out if and how our biotic summary parameters for each station (biomass, abundance, production, dominance) correlate with the above-mentioned abiotic station descriptors.

RESULTS AND DISCUSSION

Species richness, spatial and bathymetrical distribution of biomass: Table 1 contains the list of all species collected during the study

TABLE 1

Complete list of species collected during the cruise along with their respective frequency of occurrence based on Bussing and López (1996)

species	f	species	f	species	f	species	f
Achirus klunzingeri	3	*Cynoscion squamipinnis*	1	*Microgobius erectus*	5	*Rhinobatos leucorhynchus*	3
Achirus mazatlanus	6	*Cynoscion stolzmanni*	1	*Monolene danae*	2	*Rhynchoconger nitens*	9
Achirus scutum	5	*Dasyatis longus*	8	*Monolene maculipinna*	10	*Rypticus bicolor*	2
Albula nemoptera	2	*Decodon melasma*	3	*Mulloides dentatus*	2	*Rypticus nigripinnis*	1
Alphestes multiguttatus	1	*Diapterus aureolus*	3	*Muraena argus*	2	*Sciadichthys troschelii*	1
Aluterus monoceros	1	*Diapterus peruvianus*	5	*Mustelus lunulatus*	6	*Scomber japonicus*	1
Anchoa exigua	1	*Diodon histrix*	3	*Myrichthys aspetochirus*	1	*Scorpaena histrio*	2
Anchoa ischana	4	*Diodon holocanthus*	1	*Myrichthys tigrinus*	1	*Scorpaena mystes*	1
Anchoa lucida	3	*Diplectrum eumelum*	7	*Narcine brasiliensis*	5	*Scorpaena russula*	13
Anchoa nasus	2	*Diplectrum euryplectrum*	8	*Nebris occidentalis*	1	*Selar crumenophtalmus*	2
Anchoa starksi	1	*Diplectrum labarum*	6	*Neobithytes stelliferoides*	6	*Selenaspis dowi*	3
Anchoa walkeri	1	*Diplectrum macropoma*	10	*Neophistopterus tropicus*	6	*Selene brevoortii*	1
Anchovia macrolepidota	1	*Diplectrum maximum*	1	*Ophichthys ramiger*	1	*Selene oerstedii*	4
Ancylopsetta dendritica	1	*Diplectrum pacificum*	6	*Ophichthys sp. A*	4	*Selene peruviana*	8
Anisotremus dovii	3	*Diplectrum rostrum*	1	*Ophichthys sp. B*	2	*Serranus aequidens*	2
Anisotremus pacifici	1	*Diplobatis ommata*	4	*Ophichthys sp. C*	1	*Serranus psittacinus*	2
Antennarius avalonis	6	*Echiophis brunneus*	1	*Ophichthys sp. D*	1	*Sphaeroides annulatus*	10
Argentina aliceae	5	*Engyophrys sanctilaurentii*	9	*Ophioscion sciera*	1	*Sphoeroides lobatus*	11
Arius dasycephalus	1	*Epinephelus acanthistius*	1	*Ophioscion typicus*	2	*Sphoeroides trichocephalus*	3
Arius kessleri	2	*Epinephelus cifuentesi*	1	*Ophisoma macrurum*	1	*Squatina californica*	1
Arius osculus	1	*Epinephelus exsul*	1	*Ophisoma prorigerum*	5	*Stellifer chrysoleuca*	1
Arius platypogon	2	*Epinephelus niphobles*	3	*Ophistognatus rhomaleus*	1	*Stellifer furthii*	1
Arius sp. A	1	*Etropus crossotus*	2	*Opisthopterus aequatorialis*	1	*Stellifer illecebrosus*	4
Arius sp. B	1	*Etropus peruvianus*	2	*Opisthopterus dovii*	3	*Stellifer mancorensis*	1
Arothron hispidus	1	*Eucinostomus argenteus*	7	*Paralabrax loro*	2	*Stellifer oscitans*	2
Auxis sp.	1	*Eucinostomus currani*	1	*Paralichthys woolmani*	2	*Stellifer zestocarus*	1
Bairdiella armata	1	*Eucinostomus gracilis*	5	*Paralonchurus dumerilli*	4	*Syacium cf longidorsale*	4
Balistes polylepis	1	*Fistularia commersoni*	1	*Paralonchurus rathbuni*	3	*Syacium latifrons*	11
Batrachoides sp.	1	*Gerres cinereus*	1	*Paranthias colonus*	1	*Syacium ovale*	9
Bellator gymnostethus	5	*Gobiesox milleri*	1	*Peprilus medius*	1	*Symphurus atramentatus*	8
Bellator loxias	3	*Gobioides peruanus*	1	*Peprilus snyderi*	7	*Symphurus callopterus*	16
Bellator xenisma	11	*Guentherus altivela*	1	*Perissias taeniopterus*	1	*Symphurus chabanaudi*	11
Bollmannia chlamydes	23	*Gymnothorax equatorialis*	7	*Peristedion barbiger*	11	*Symphurus elongatus*	10
Bollmannia sp. nov.	2	*Gymnothorax sp. nov.*	7	*Peristedion crustosum*	6	*Symphurus gorgonae*	8
Bollmannia stigmatura	11	*Haemulon scudderi*	1	*Physiculus nematopus*	15	*Symphurus leei*	6
Bregmaceros bathymaster	5	*Haemulopsis elongatus*	1	*Physiculus rastrelliger*	1	*Symphurus melanurus*	2
Brotula clarkae	2	*Haemulopsis leuciscus*	2	*Pikoe longilepis*	1	*Symphurus melasmatotheca*	1
Calamus brachysomus	2	*Haemulopsis nitidus*	2	*Pliosteostoma lutipinnis*	1	*Symphurus oligomerus*	7
Caranx caballus	2	*Hemanthias peruanus*	5	*Polydactylus approximans*	6	*Symphurus undecimplerus*	3
Caranx caninus	3	*Hemanthias signifer*	10	*Polylepion cruentum*	1	*Symphurus williamsi*	8
Caranx otrynter	3	*Hemicaranx leucurus*	1	*Pomadasys branickii*	3	*Synchiropus atrilabiatus*	15
Caranx speciosus	3	*Himantura pacifica*	1	*Pomadasys macracanthus*	1	*Synodus evermanni*	18
Caranx vinctus	4	*Hippoglossina bollmani*	0	*Pontinus furcirhinus*	3	*Synodus scituliceps*	21
Cathorops furthii	1	*Hippoglossina tetrophthalmus*	5	*Pontinus sierra*	17	*Synodus sechurae*	10
Cathorops steindachneri	1	*Hoplopagrus guntheri*	1	*Pontinus sp. nov.*	1	*Torpedo tremens*	2
Cathorops tuyra	1	*Ilisha furthii*	1	*Porichthys greeni*	16	*Trachinotus paitensis*	4
Caulolatilus affinis	3	*Isopisthus altipinnis*	6	*Porichthys margaritatus*	24	*Trichiurus nitens*	10
Cetengraulis mysticetus	2	*Kathetostoma averruncus*	6	*Prionotus albirostris*	2	*Trinectes fonsecensis*	2
Chaetodipterus zonatus	1	*Larimus acclivis*	1	*Prionotus horrens*	8	*Trinectes sp. nov.*	1
Chiloconger labiatus	3	*Larimus pacificus*	1	*Prionotus ruscarius*	7	*Umbrina bussingi*	5
Chlorophtalmus mento	4	*Lepophidium microlepis*	1	*Prionotus stephanophrys*	2	*Umbrina xanti*	1
Citharichthys gilberti	6	*Lepophidium negropinna*	2	*Prionotus teaguei*	3	*Urolophus concentricus*	1
Citharichthys platophrys	14	*Lepophidium prorates*	5	*Pristigenys serrula*	1	*Urotrygon aspidura*	1
Coelorhynchus scaphopsis	1	*Lophiodes caulinaris*	14	*Pronotogrammus eos*	11	*Urotrygon chilensis*	6
Coryphaenoides leucophaeus	1	*Lophiodes spilurus*	5	*Pronotogrammus multifasciatus*	1	*Urotrygon munda*	1
Cyclopsetta panamensis	11	*Lutjanus argentiventris*	1	*Psedomyrophis micropinna*	4	*Urotrygon nana*	2
Cyclopsetta querna	10	*Lutjanus guttatus*	10	*Pseudobalistes naufragium*	1	*Urotrygon rogersi*	1
Cynoscion albus	1	*Lutjanus peru*	2	*Pseudupeneus grandisquamis*	2	*Zalieutes elater*	16
Cynoscion nannus	4	*Menthicirrhus panamensis*	1	*Pyopterus aureolus*	1	*Zapteryx exasperata*	5
Cynoscion phoxocephalus	6	*Menticirrhus nasus*	5	*Raja equatorialis*	3		
Cynoscion reticulatus	2	*Merluccius angustimanus*	1	*Raja velezi*	8	**sum: 242 species**	

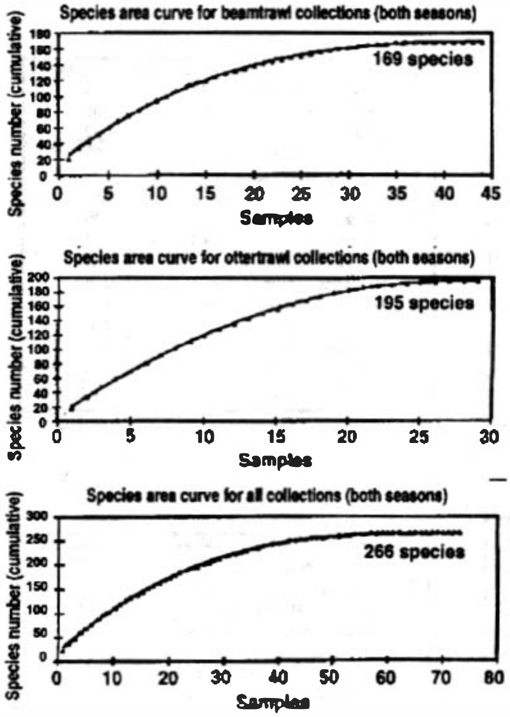
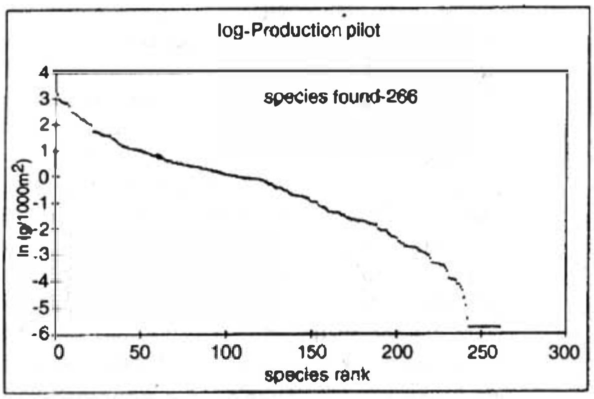


Fig. 2. Species-area curves for the beamtrawl-, ottertrawl- and the combined collections of both sampling dates.

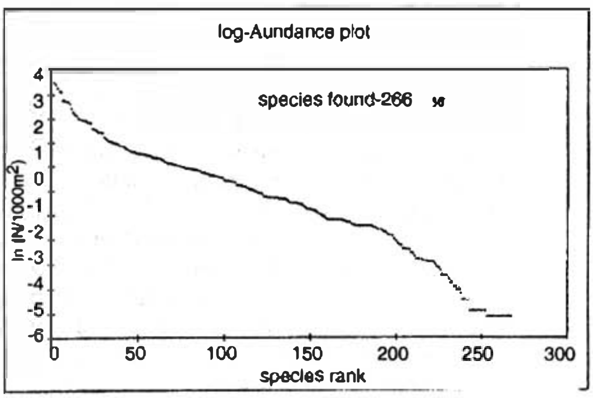
with their respective frequencies of occurrence. Fig. 2 shows the species area curves constructed from the beam trawl - and otter trawl collections and for all collections pooled. The number of fish species collected (242) exceeds that reported by Bartels *et al.* (1983), who found 214 species during a 17 day and 3 night sampling programme with the RV Skimmer in 1979/1980. This difference can be explained through the wider area covered by our cruise (2 119 405 m² compared to about 750 000 m²), the wider depth range (10-261 m compared to 8-60 m) but also through the different gears used. As seen in Fig. 2, more species (195) were collected by the otter trawl than by the beam trawl (169), which was to be expected as the total area swept was about 25 times larger. The difference in cumulative species number between the two gears is not large, however, reflecting a higher species density of smaller fish that dominated the beam trawl catches. Fig. 3 shows the ranking of all species collected during both seasons according to the logarithm of their abundance and production values and the normalized log-normal - plot derived from these data with the estimate of the theoretical species richness in the total area. The names of the most dominant species in rank order are also given. Judging from the fit of the lognormal - curve and the species-area curve discussed above, the demersal fish species assemblage can be regarded as well sampled. The theoretical estimate of total species richness (SR~306) for the whole area therefore seems reasonable. It must be emphasized, that this number concerns the demersal fish assemblage, as although some pelagic fish were caught during the lowering and lifting of the fishing gear, most fast swimming pelagics are missing in the catches. This was apparent in the GD area, where large shoals of medium - sized tunalike fish were frequently seen in the surface waters, but not a single specimen was caught by the net.

It is difficult to compare species richness between the study areas because of the different numbers of collections made in each. However, if we calculate the mean species number per collection in each area from the data of table 4 (GD: 9.3, ST: 15.4 and GN: 17.3), GD appears as significantly poorer in species than the other two areas. As to be expected, the lowest species numbers were found in the central deep (and at least in part anoxic) part of GD, while numbers increased towards the sill area at the gulf's opening and towards the shallow stations above the thermocline. Highest numbers were found at the shelf edge outside the gulf. This pattern is not repeated in the other study areas, where both shallow stations and deep shelf edge stations had (at an average) comparatively higher species numbers (Table 2).

The bathymetrical and spatial distribution of biomass (Table 2, Fig. 4) reveals a general concentration of fish biomass in two depth ranges: a shallower water (10 - 60 m), above or around the thermocline and a deep-water (160 -210 m) area around the shelf edge, with relatively little biomass found in between (60 -160 m). This is interesting as Bartels *et al.* (1984) found a general decrease in fish biomass from the shallow upper gulf to the deeper stations in the center of the gulf. They, however, did not sample the shelf edge stations considered in the present study. Apparently, the shelf edge region contains a different faunal group (see also "description of faunal assemblages" further below) adapted to cool and little oxygenated waters.



rank	species	g/1000ml	% of total production
1	Synocus sciculiceps	24,32	4,44
2	Pontinus sierra	20,05	3,66
3	Himantura pacifica	18,75	3,42
4	Pontinus furcithinus	17,89	3,27
5	Porichthys margaritatus	17,49	3,19
6	Syacium ovale	17,14	3,13
7	Symphurus callopterus	16,92	3,09
8	Arius osculus	15,60	2,85
9	Physiculus nematopus	12,15	2,22
10	Hemanthias signifer	12,11	2,21
11	Anisostremus dovii	11,97	2,19
12	Syacium latifrons	10,97	2,00
13	Porichthys greeni	10,92	1,99
14	Citharichthys platophrys	10,14	1,85
15	Diapterus peruvianus	9,27	1,69



rank	species	g/1000ml	% of total production
1	Porichthys margaritatus	6,39	7,11
2	Pontinus sierra	4,64	5,16
3	Synchiropus atrilabiatus	4,27	4,75
4	Syacium ovale	3,68	4,09
5	Bollmannia chalmydes	3,21	3,57
6	Symphurus callopterus	3,17	3,53
7	Synodus sciculuceps	2,19	2,43
8	Physiculus nematopus	2,15	2,39
9	Syacium latifrons	2,19	2,33
10	Neophistopterus tropicus	2,08	2,31
11	Synodus evermanni	1,91	2,13
12	Symphurus oligomerus	1,59	1,77
13	Syacium sp.	1,35	1,50
14	Monolene maculipinna	1,21	1,35
15	Symphurus atramentatus	1,16	1,29

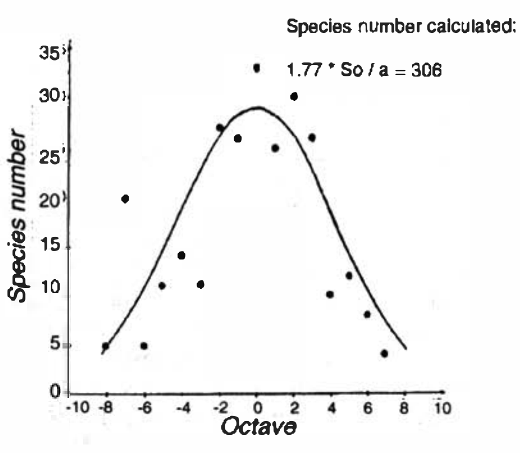


Fig. 3. Species rank plots (top: log production vs. species rank; center: log abundance vs. species rank; lower graph: calculated lognormal curve for estimation of theoretical species richness).

TABLE 2

Station parameter table containing biotic (species richness, biomass, abundance, production and dominance) and abiotic (depth ,temperature,oxygen,nitrate and phosphate) station descriptors

Beamtrawl

Station	water depth [m]	temperature [°C]	oxygen [%]	species richness	Biomass [g/m²]	Abundance [n/m²]	Production [g/m²]	dominance	NO3	PO4
A1	107	17	2	3	0,1368	0,0466	0,0943	0,3923	15,70	2,60
B1	191,4	16	0	6	0,3053	0,4543	0.3366	0,9823	3.30	7.90
B2	192	16	0	2	0,0872	0,0010	0,0222	0,4992	17,95	2,22
C1	42	20	22	6	0,6811	0,0965	0,2735	0,5548	24,80	0,15
C2	48	20	22	2	0,0254	0,0024	0,0133	0,5199	11,40	2,30
D1	32,5	23	15	10	0,4632	0,0250	0,1741	0,3107	8,76	1,14
D2	25	24	15	11	1.0052	0.0240	0.3132	0,1144	9,81	1,03
E1	50	19	12	11	0,1869	0,0158	0,0778	0.1901	17.20	3,10
E2	40	20	12	2	0,0468	0.0010	0,0148	0.4999	13.70	1,77
F1	73	15	10	13	1,1322	0,0293	0,2258	0,2771	20,80	2,00
F2	75	15,5	10	2	0,0240	0,0024	0,0124	0,5199	16,83	0,74
G1	200	16	2	21	3,1990	0,3715	1,3577	0.3534	2,47	2.21
G2	200	13	2	22	1,9940	0,1550	0,9786	0,1433	21,26	1,46
H2	15	27	100	7	1,4620	0,0198	0,2266	0.5551	0,20	0,16
N1	164	14	8	23	1.2921	0.0802	0,5211	0,1189	23,76	1,98
N2	186.5	13	10	20	2.4324	0,0945	0,9240	0,1424	28,90	2,13
O1	109.9	14	10	8	0,2381	0,0182	0,0765	0.1828	23,19	1,83
O2	103,3	18.2	40	20	0,8051	0,0811	0,3742	0,1718	19,60	1,53
P(2)1	50,2	18.2	40	15	0,9880	0.0931	0,4110	0,2090	12,70	1,21
P2	48	26	75	12	1,1135	0,1275	0,5559	0,2612	17,21	1,61
Q1	21,1	26	75	10	0,3857	0,0341	0,1439	0,3152	0,86	0,27
Q2	21	26	75	12	0,5611	0,0725	0,2116	0,2971	0,15	0,16
T1	19,7	26	75	2	\	0,0019	\	0,6295	0,86	0,27
U1	50,1	26	75	6	0,0163	0,0038	0,0108	0,1875	12,70	1,21
bk01/1	36,3	26	50	13	1,2346	0,0212	0,2937	0,1271	4,51	0,51
bk01/2	33	26	50	19	0,3910	0,0293	0,1445	0,1432	\	\
bk06/1	43	19,5	50	3	0,0053	0,0034	0,0038	0,5509	8,83	0,74
bk06/2	43	19.5	50	16	0,8671	0,1200	0,4269	0,2875	\	\
bk30/1	28.9	22	50	11	0.1483	0,0182	0,0711	0,2908	10.32	1,29
bk30/2	31	22	50	4	0,1013	0,0182	0,0603	0.5396	\	\
bk31/1	21,7	25	80	12	1.1470	0,0456	0.3856	0.4854	1.88	0,40
bk31/2	22	25	80	11	0,4348	0,0240	0,1800	0,3768	4,40	0,65
bk35/1	14,8	26	70	18	1,0869	0,0667	0,4735	0,1207	3,41	0,65
bk35/2	19	26	70	14	1.0874	0,0653	0.4553	0.1940	\	\
bk43/2	10	27	60	25	11,4650	0,1044	2,3031	0,1035	\	\
bk45/1	13,2	29	75	7	3,0391	0,0062	0,4219	0.1716	5.79	0.66
bk45/2	15	27	50	9	0,1544	0,0120	0,0732	0,2544	\	\
bk50/2	32	24	55	18	0,5068	0.1512	0.3394	0,1837	\	\
bk51/1	58,5	16	25	11	0,0866	0,0211	0.0469	0,2293	3,49	0,56
bk51/2	64	16	25	20	0.6345	0,1497	0.3581	0,4651	12.23	1.12
bk52/1	117,6	15	10	3	0,0022	0,0014	0,0018	0,3333	8,52	0,72
bk52/2	118	15	10	15	0,6100	0,0014	0,0029	0,2769	0.00	1,96
bk53/1	85	14	10	6	0.0130	0,0048	0,0084	0,2400	22,53	1.75
bk53/2	83	14	10	9	0,0893	0,0187	0,0513	0.2715	11,36	0,81
bk54/1	228	12	2	9	0,0910	0,0005	\	0.1712	27,18	2.24
bk54/2	228	12	2	15	0,9721	0,0994	0,4897	0,2935	\	\

Continued

Continued Table 2

Ottertrawl

Station	water depth [m]	temperature [°C]	oxygen [%]	species richness	Biomass [g/m²]	Abundance [n/m²]	Production [g/m²]	dominance	NO3	PO4
H1	12,3	27	75	17	0,257	0,0011	0,0485	0,1625	2,51	0.24
H2	23	14	5	20	0,6692	0,0019	0.1088	0,1472	\	\
I1	261,5	14	5	16	0,0791	0,0018	0,0232	0,1195	2,47	2.21
I(2)1	235	14	5	9	0,8518	0,0244	0,3031	0,2816	2,47	2.21
I(2)2	210	16	10	21	0,036	0,0006	0,0098	0,3313	21,26	1,46
J1	52,5	20	15	21	0,7552	0,002	0,1069	0,1562	2,47	2.21
K1	53.8	16	0	8	0.2031	0,0101	0,0889	0,7416	8,76	1,14
L1	194	16	0	6	0,0575	0,0072	0,0249	0,3059	2,5	4,44
M1	122,8	16	5	13	0,2961	0,0127	0,1199	0,3356	14,7	2,1
M2	82	14	8	15	0.1781	0,0004	0,0294	0,1105	16,83	0,74
R1	20,1	26	75	15	0.0364	0,0003	0,0077	0,0865	0,86	0,27
S1	21,3	26	75	19	0,2373	0,0009	0,0464	0,0852	12,7	1,21
gn01/1	47	26	50	21	0,826	0,0044	0.1747	0,1637	4.51	0,51
gn06/1	43,7	19.5	50	20	2,8793	0,0136	0.4996	0,1611	8.83	0.74
gn06/2	44	19.5	50	22	0,9941	0,0053	0,1425	0.147	\	\
gn30/1	31.5	22	50	23	1,8418	0,0117	0.2642	0,1291	10,3	1.28
gn31/1	22,7	25	80	34	0,3418	0,0071	0,0882	0,2292	1.88	0,4
gn31/2	22	25	80	39	2,1915	0,0126	0,3635	0,3172	\	\
gn35/1	14,5	26	70	19	1,6863	0,0128	0,3905	0.1608	3,41	0.65
gn45/1	13,2	29	75	33	18.0702	0,1185	2,2856	0,2457	5.79	0,66
gn45/2	18	7	50	29	0,6006	0,0277	0,148	0,6423	\	\
gn52/1	97,7	15	10	27	0.6569	0,21	0.2067	0.2967	8.52	0,72
gn52/2	109	15	10	19	0,1178	0,0045	0,0438	0,2153		1,96
gn53/1	80	14	10	27	0,3091	0,0369	0,0662	0,2111	22,53	1,75
gn53/2	80	14	10	30	0,2698	0,0049	0.0637	0.2462	11,36	0,81
gn54/1	199	12	2	8	0,1505	0,0088	0.0645	0,8449	27,18	2.24
gn54/2	239	12	2	25	0,5086	0,004	0.1187	0.1946	\	\

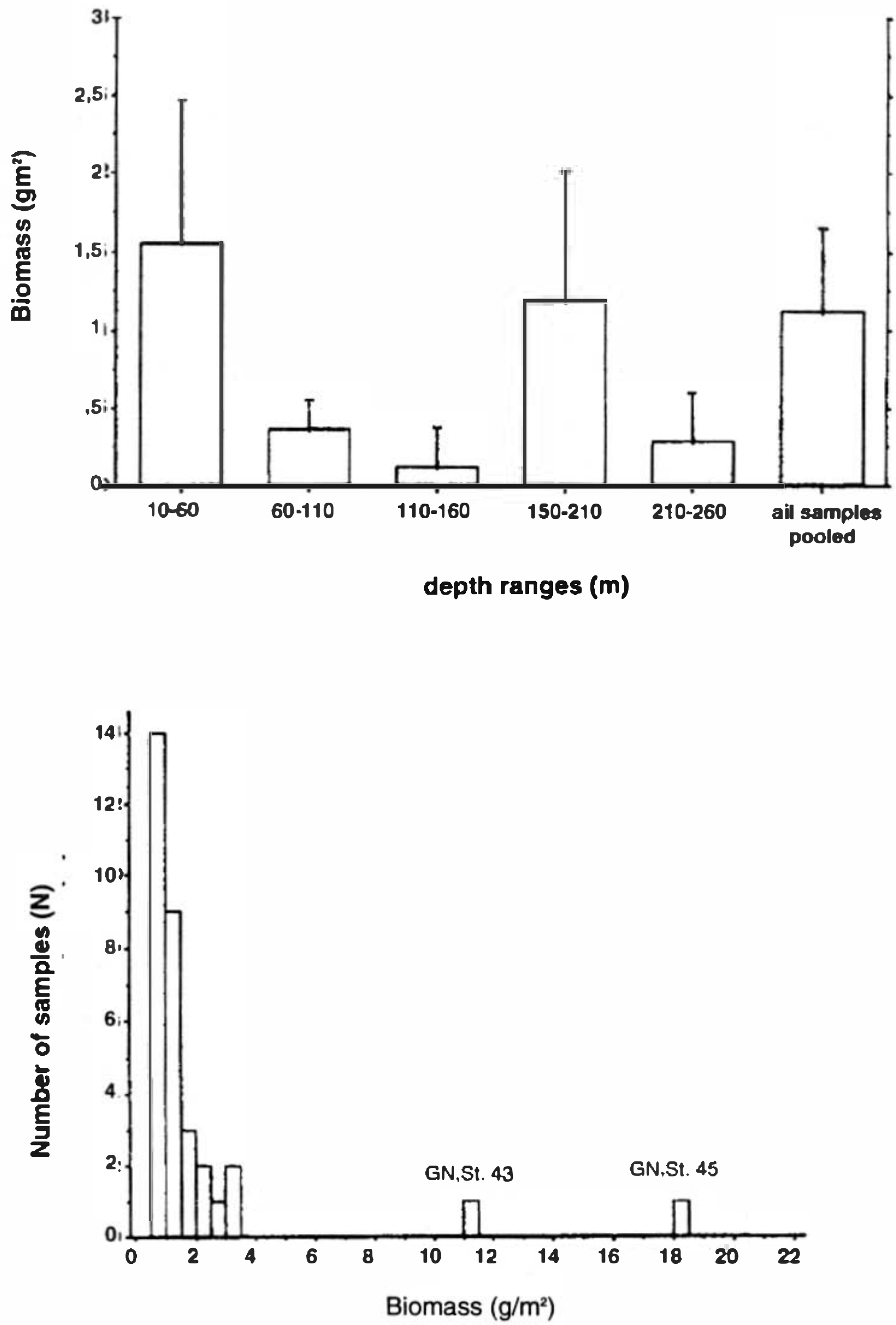


Fig. 4. Bathymetrical distribution of fish biomass (upper graph) and frequency of samples vs. biomass (lower graph) in the study area.

TABLE 3

Correlation matrix established from the station parameters of Table 2

Correlation matrix

	waterde...	tempera...	oxygen	speciesr...	biomass	abundance	production	dominance
waterdepth	1							
temperat...	-,72	1						
oxygen	-,732	,872	1					
speciesri...	-,034	,07	,231	1				
biomass	-,151	,293	,225	,387	1			
abundance	,139	-,125	-,191	,113	,215	1		
production	-,018	,192	,11	,388	,898	,465	1	
dominance	,015	-,205	-,149	-,42	-,16	,283	-,167	1

Biomass is very heterogeneously distributed in the study area, with most samples comprised of low values (0.5 -1.5 g/m²). The general biomass distribution among the 73 samples taken underlines the above-mentioned pattern of species richness: average station biomass of GD was less than half (0.36g /m²) of what was found in the GN and ST areas (1.5 and 0.81 g/m² respectively). The biomass (and species richness) values of stations 43 and 45 of the interior part of GN are an order of magnitude higher, however, (18.1 and 11.5 g/m² respectively) indicative for a much richer fish assemblage in this shallow nutrient loaded more estuarine part of the gulf, which confirms the findings of Bartels *et al.* (1984). Species characteristic for estuarine environments, like ariids, scianids, stingrays, several flatfishes as well as small engraulids contribute to the fish diversity and biomass at these stations.

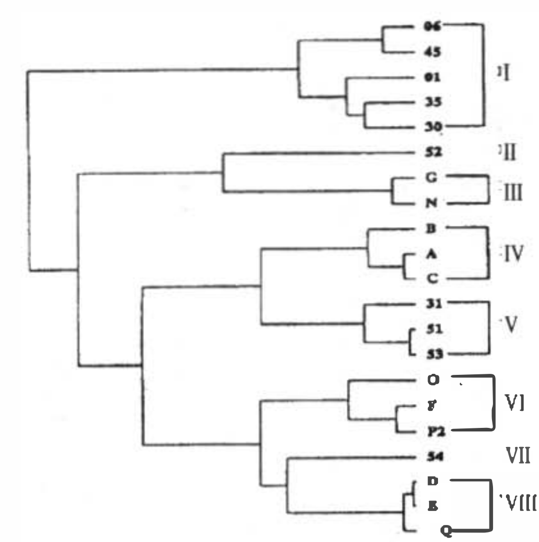
Our biomass/area estimates are rather low when compared with the literature for other tropical shelf areas: Browder (1993) reported about 4.3g/m² as an average for the demersal fish biomass of the shelf of the Gulf of Mexico. For the Southwestern gulf of Mexico Arreguin-Sanchez *et al.* (1993) reported values of about 7.6 g/m², while Mendoza *et al.* (1993) give values of about 3 g/m² for the Northeastern shelf of Venezuela excluding carangids. DePaula *et al.* (1993) report values around 8 g/m² for the Mozambique coast. These are higher than our averages but in the order of magnitude of our values for the interior and central part of GN.

The correlation matrix established from the biotic and abiotic summary parameters of all 73 stations is given in Table 3. It shows that biomass, abundance, production, species richness and dominance is not strongly correlated with any one of the abiotic variables measured, which has also been found by Rojas *et al.* (1994) who studied fish assemblages at three shallow water stations adjacent to mangrove areas within the GN. This indicates that other habitat factors not evaluated in this study like habitat heterogeneity, distance to the open ocean, current regime and food availability are likely important factors for the structure of the fish assemblage.

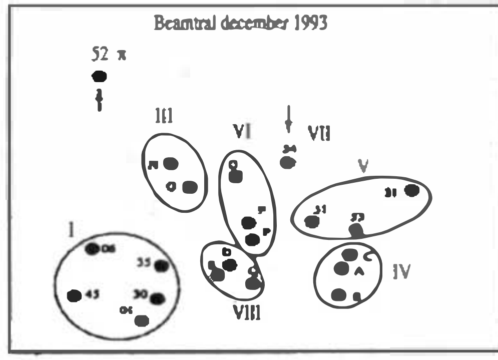
Description of faunal assemblages: Contrary to Bartels *et al.* (1983) who first subdivided their study area (GD) by clustering the abiotic factors and then related species occurrence with environmental parameters, we started the procedure by "letting the species tell their story" first (Clarke & Warwick 1994), in order to find areas of common faunal structures. By doing so we did not start with the preconception that our environmental variables measured determine the faunal structure.

Figs. 5 a, b and 6 a, b show the station dendrograms and MDS-plots derived from the beam trawl and otter trawl catches in December 1993 and February 1994 based on the data of Table 4, which gives the reduced (95%) station - species matrix from the beam trawl and otter trawl collections used for the multivariate analysis. By using the SIMPER algorithm of the PRIMER software, the species accounting for the groupings within the dendrograms were determined and are included in the figures. In

Beamtrawl, December'93 (59 species represents 95% of total production)



BRAY-CURTIS SIMILARITY (RANKED)



Species accounting for similarity of groups:
Beamtrawl Dec'93

I: Symphurus elongatus
Ophioscon typicus
Syacium ovale
Menthicirrus nasus

II: Physiculus nemanopterus

III: Lophiodes caulinares
Pontinus sierra
Monolene maculipinna
Physiculus nemanopterus

IV: Porichthys margaritatus
symphurus atramentatus

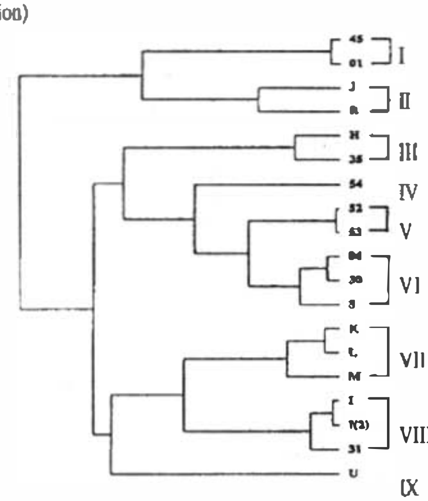
V: Syacium latifrons
Porichthys margaritatus

VI: Citharichthys platophrys
Synodus scituliceps
Synodus evermanni

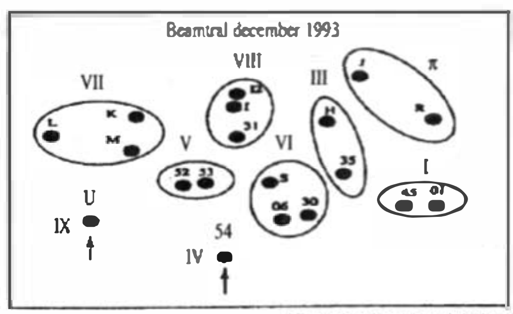
VII: Prionotus albirostris

VIII: Achirus mazatlanus
Sphoeroides annulatus
Synodus scituliceps
Synodus evermanni
Cyclopsetta panamensis

Ottertrawl, December'93 (79 species representing 95% of total production)



BRAY-CURTIS SIMILARITY (RANKED)



Ottertrawl Dec '93

I: Cynoscion albus
Dasyatis longus
Isophistus alupinnis
Paralonchurus dumerilli
Polydactylus approximans
Prionotus horrens
Rhinobates leucorhynchus
Anchoa sp
Arius dovii
Arius troschelli

II: Dasyatis longus

III: Eucinostomus argenteus
Pseudopeneus vancolensis

IV: Trichiurus nitens

V: Trichiurus nitens
Raja velezi
Hemanthias peruanus
Diplectrum Eumelum
Citharichthys platophrys
Caulolatilus affinis
Hippoglossina ertaophthalmus
Mustelus lunulatus
Pomadasys branicki
Synodus scituliceps

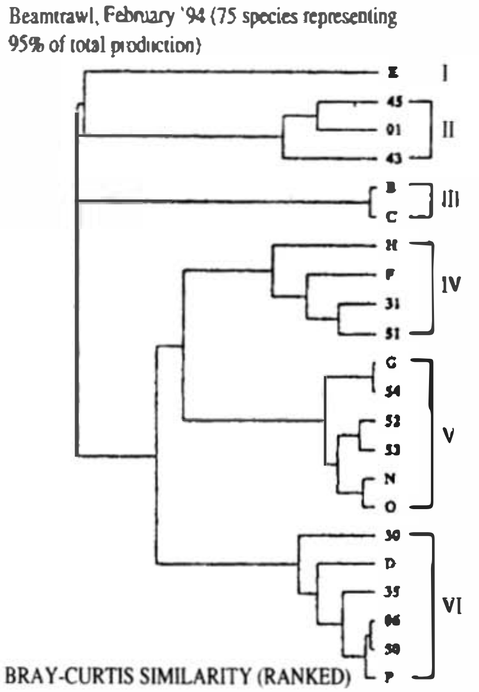
VI: Lutjanus guttatus
Synodus scituliceps
Trichiurus nitens (6,30)
Selene peruviana (6,30)
Leopophidium prorates (6,30)
Isophistus altipinna (6,30)
Cyclopsetta querna (6,5)

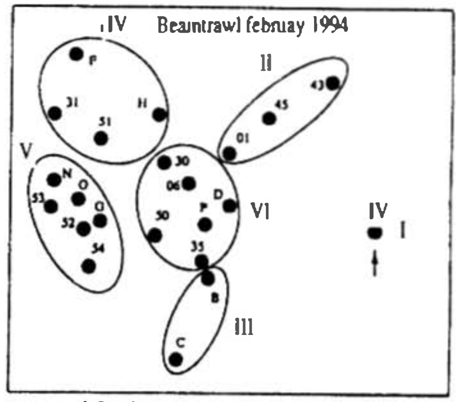
VII: Cynoscion nannus (L,M)
Diplectrum labarum (K,M)
Eucinostomus gracilis (K,L)

VIII: Argentina alicea
Bolimannia stignatura
Pontinus sierra
Physiculus namaopterus

IX: Leopophidium prorates
Ophichthidae
Porichthys margaritatus

Fig. 5. Station dendrograms and MDS-plots for beamtrawl (a) and ottertrawl (b) collections during December (species responsable for groups are given in the lower right of the figure).





Beamtrawl Feb'94

I: Diplectrum macropoma

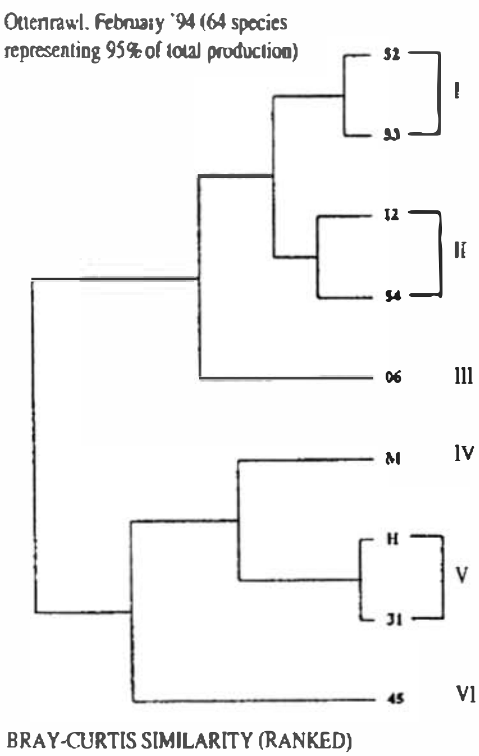
II: Cynoscion phoxocephalus
Arius kessleri (45,43)
Prionotus horrens (01,43)
Stellifer sp. (45,43)

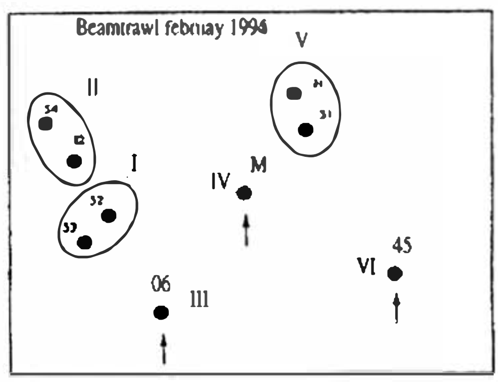
III: Cynoscion nannus

IV: Syacium latifrons
Pontinus sierra (31,51)
Synchiropus atrilabiatus (H,51)
Zalieutes elater (31,51)

V: Symphurus callopterus
Physiculus nemaopterus
Pontinus sierra (G,53-54)
Monolene maculipinna (G,H,O,52)
Synchiropus atrilabiatus (G,53,54,O)
Zalieutes elater (52,53,N,O)

VI: Porichthys greeni
Porichthys margaritatus
Bollmannia chlamydes (D,6,30,50,P)
Synodus evermanni (B,6,50,P)
Gymnothorax equatorialis (D,6)
Sphoeroides annulatus (30,P)





Ottertrawl Feb '94

I: Citharichthys platophrys
Synodus evermanni
Peristedion barbiger
Lophiodes caulinaris
Hemanthias signifer
Bollmannia stigmatura

II: Lophiodes caulinaris
Peristedion barbiger
Pontinus sierra
Umbrina bussingii

III: 14 species, first 5:
Selene peruviana
Peprilus snyderi
Cyclopsetta querna
Prionotus sp.
Syacium ovale

IV: 9 species, first 5:
Mustelus lunulatus
Dasyatis longus
Epinephelus niphobles
Raja velezi
Peprilus snyderi

V: 9 species, first 5:
Caranx otrynter
Caranx speciosus
Lutjanus guttatus
Narcine brasiliensis
Sphoeroides annulatus

VI: 17 species, first 5:
Neopisthopterus tropicus
Paralonchurus dumerilli
Dasyatis longus
Arius dovii
Achirus scutum

Fig. 6. Station dendrograms and MDS-plots for beamtrawl (a) and ottertrawl (b) collections during February (species responsible for groups are given in the lower right of the figure).

TABLE 4

Species-station matrices of the beamtrawl and ottertrawl collections of both sampling dates used for the multivariate analysis (a,b: beamtrawl and ottertrawl collections in December respectively; c,d: beamtrawl and ottertrawl collections in February respectively)

Beamtrawl December 1993

Production (95%, 59 Arten)	A	B	C	D	E	F	G	bk31	bk51	bk52	bk53	bk54	bk06	bk45	bk01	bk35	bk30	N	O	P2	Q
Achirus klunzingeri	0	0	0	0	0	0	0	0,1786	0	0	0	0	0	0	0	0	0	0	0	0	0
Achirus mazatlanus	0	0	0	0,0062	0,0131	0	0	0	0,0020	0	0	0	0	0	0	[illegible]	0	0	0	0	[illegible]
Bollmannia chlamydes	0	0	0	0,0103	0,0058	0	0	0	0	0	0	0,0052	0	0	0	0	0	0,0082	0,0044	0	0
Camaron tigre	0	0	0	0	0	0	0,0293	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camarones	0	0,3205	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camarones rojos	0	0	0	0	0	0	0,0592	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camarones sp.II	0	0	0,0701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chiloconger labiatus	0	0	0	0	0	0	0,0055	0	0	0	0	0	0	0	0	0	0	0,0167	0	0	0
Citharichthys gilberti	0	0	0	[illegible]	0,0022	0	0	0	0	0	0	0	0	0	0,0151	0	0	0	0	0	0,0297
Citharichthys platophrys	0	0	0	0	0	0,1340	0	0	0	0	0	0	0	0	0	0	0	0	0,0258	0,1022	0
Cyclopsetta panamensis	0	0	0	0,0128	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0,0013	0	0	0	0
Cyclopsetta querna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0069	0,0163	0	0	0,0470	0
Cytorectus gilbertae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0418	0	0	0	0	0
Decodon melasma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0154	0	0	0
Diplectrum euryplectrum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0293	0	0	0	0	0
Diplectrum labarum	0	0	0,0652	0	0	0,0172	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diplectrum macropoma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0013	0,0303
Diplobatis ommata	0	0	0	0	0	0	0	0,0390	0	0	0	0	0	0	0	0	0	0	0	0	0
Etropus crossotus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0347	0	0	0	0	0
Galatheidae	0	0	0	0	0	0	0,5597	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gymnothorax	0	0	0	0	0	0,0290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Longimanus fasciatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0187	0	0	0
Lophiodes caulinares	0	0	0	0	0	0	0,0112	0	0	0	0	0	0	0	0	0	0	0,0646	0,0459	0,0309	0
Menticirrhus nasus	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0022	0,0172	0	0	0	0	0	0
Menticirrhus panamensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0224	0	0	0
Monalerie maculipinna	0	0	0	0	0	0	0,0226	0	0	0	0	0	0	0	0	0	0	0,0224	0,0068	0	0
Monolene sp.	0	0	0	0	0	0	0	0,0205	0	0	0	0	0	0	0	0	0	0	0	0	0

Continued Table 4

Monalene maculipinna	0	0	0	0	0	0	0,0020	0	0	0	0	0	0	0	0	0	0	0,0234	0,0068	0	0
Monolene sp.	0	0	0	0	0	0	0	0,0205	0	0	0	0	0	0	0	0	0	0	0	0	0
Narcine brasiliensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0716	0	0	0	0	0	0
Neobithytes stelliferoides	0	0	0	0	0	0	0,0007	0	0	0	0	0	0	0	0	0	0	0,0083	0	0	0
Ophioscon typicus	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0168	0,0335	0	0	0	0	0	0
Ophisoma parigena	0	0	0	0	0	0	0,0197	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paralonchurus dumerilii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0415	0	0	0	0	0	0
Physiculus nematopus	0	0	0	0	0	0	0,0127	0	0	0	0	0	0	0	0	0	0	0,0615	0	0	0
Pomadasys nitidus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0019	0,0358	0	0	0	0	0
Pontinus fusarinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,6394	0	0	0
Pontinus sierra	0	0	0	0	0	0	0,3024	0	0	0	0	0	0	0	0	0	0	0,0134	0	0	0
Porichthys greeni	0	0	0	0	0	0	0,0009	0	0	0	0	0	0,0017	0,3699	0,0045	0,0003	0,0013	0	0	0	0
Porichthys margaritatus	0,0361	0,0051	0,0111	0	0	0	0,0900	0	0,0019	0	0,0022	0	0	0	0	0	0	0	0	0,0682	0,0096
Prionotus albirostris	0	0	0	0	0	0,0044	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0448	0
Prionotus stephanophrys	0	0	0,0521	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pronotogrammus eos	0	0	0	0	0	0	0,0072	0	0	0	0	0	0	0	0	0	0	0,0935	0	0	0
Pronotogrammus multifasciatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0252	0	0	0
Scorpaena russula	0	0	0	0,0107	0	0,0042	0	0	0,0016	0	0	0,0006	0	0	0	0	0	0	0	0,0028	0,0019
Sphaeroides annulatus	0	0	0	0,0032	0,0050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0281
Sphaeroides lobatus	0	0	0	0,0000	0,0024	0	0	0	0	0	0	0	0	0	0	0	0,0013	0	0	0	0,0216
Syacium latifrons	0	0	0,0065	0	0	0	0	0,1276	0,0297	0	0,0024	0	0	0	0	0	0	0	0	0	0
Syacium ovale	0	0	0	0	0	0,0048	0	0	0	0	0	0	0,0022	0	0	0,1007	0	0	0	0	0
Symphurus oligomeras	0	0	0	0	0	0	0,0201	0	0	0	0	0	0	0	0	0	0	0,0371	0	0	0
Symphurus atramentatus	0,0999	0,0033	0,0632	0	0	0,0116	0,0000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Symphurus callopterus	0	0	0	0	0	0	0,0719	0	0	0	0	0,0148	0	0	0	0	0	0	0	0	0
Symphurus chabanaudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0053	0,0294	0,0239	0,0053	0	0	0	0
Symphurus elongatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0028	0,0043	0,0324	0	0	0,0028	0,0058
Symphurus leei	0	0	0	0	0	0	0	0,0082	0	0	0	0	0	0	0	0	0	0	0	0,0147	0
Symphurus melanurus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0331	0	0	0	0	0
Synodus evermanni	0	0	0	0	0	0	0	0	0,0045	0	0	0	0	0	0	0	0,0000	0,0050	0,0090	0,0040	0,0021
Synodus scituliceps	0	0	0	0,0825	0,0219	0,0315	0	0	0	0	0	0	0	0	0	0,1107	0	0	0	0,0812	0
Synodus sechurae	0	0	0	0,0245	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0061
Urotrygon chilensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0637	0	0	0	0	0	0
Urotrygon mundus	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0230	0	0	0	0	0	0	0

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Production (95%, 82 species)																			
	H	I	I(2)	J	K	L	M	gsn31	gsn52	gsn53	gsn54	gsn06	gsn45	gsn01	gsn35	gsn30	R	S	U
Achirus scutum	0,0001	0	0	0	0	0	0	0	0	0	0	0	0,0353	0	0	0	0	0	0
Anchoa lucdia	0	0	0	0	0	0	0	0	0	0	0	0	0,0087	0	0	0,0092	0	0	0
Anchoa sp.	0	0	0	0	0	0	0	0	0	0	0	0,0145	0,0910	0,0003	0,0031	0	0	0	0
Anisostremus pacifici	0	0	0	0	0	0	0	0	0	0	0	0	0,0069	0	0	0	0	0	0
Argentina aliceae	0	0,0017	0,0102	0	0	0	0	0,0012	0,0008	0	0	0	0	0	0	0	0	0	0
Arius dasycephalus	0	0	0	0	0	0	0	0	0	0	0	0	0,1937	0	0	0	0	0	0
Arius dowi	0	0	0	0	0	0	0	0	0	0	0	0	0,0415	0,0031	0	0	0	0	0
Arius troschelii	0	0	0	0	0	0	0	0	0	0	0	0	0,0084	0,0043	0	0	0	0	0
Arothron hispiculus	0	0	0	0	0	0	0	0,0063	0	0	0	0	0	0	0,0214	0	0,0018	0	0
Bollmannia stigmatura	0	0,0001	0,0001	0	0	0	0	0,0003	0,0005	0	0	0,0054	0	0	0	0	0	0	0
Calamus brachysomus	0	0	0	0	0	0	0	0,0136	0	0	0	0	0	0	0	0	0	0	0
Carangoides otrynter	0,0036	0,0005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0061	0
Caranx speciosus	0	0	0	0	0	0	0	0,0110	0	0	0	0	0	0	0	0	0	0	0
Caranx vinctus	0,0163	0,0113	0,0011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caulolatilus affinis	0	0	0	0	0	0	0	0	0,0064	0,0011	0	0	0	0	0	0	0	0	0
Cetengraulis mysticetus	0	0	0	0	0	0	0	0	0	0	0	0	0,0245	0	0	0	0	0	0
Chaetorypterus sonatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0251	0	0	0	0
Chlorophtalmus mento	0	0,0001	0,0231	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Citharichthys platophrys	0	0	0	0	0	0	0	0	0,0047	0,0034	0	0	0	0	0	0	0	0	0
Cyclopsetta querna	0	0	0	0	0	0	0	0	0	0	0	0,0222	0	0	0,0005	0,0141	0	0,0081	0
Cynoconticeps coniceps	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0963	0	0	0
Cynoscion albus	0	0	0	0	0	0	0	0	0	0	0	0	0,0304	0,0797	0	0	0	0	0
Cynoscion nannus	0	0,0006	[illegible]	0	0	0,0068	0,0743	0	0	0	0	0	0	0	0	0	0	0	0
Cynoscion phoxocephalus	0	0	0	0	0	0	0	0	0	0	0	0	0,1040	0	0	0	0	0	0
Cynoscion stolzmanni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0099	0	0	0
Cynostium reticulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0173	0	0	0	0
Dasyatis longus	0	0	0	0,0158	0	0	0	0	0	0	0	0	0,0979	0,0019	0	0	0	0	0
Diapterus aureolus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0300	0	0	0	0
Diapterus peruvianus	0	0	0	0	0	0	0	0	0	0	0	0	0,0162	0,0000	0,1372	0,0073	0	0	0
Diodon histrio	0	0	0	0,0073	0	0	0	0,0014	0	0	0,0000	0	0	0	0	0	0	0	0
Diplectrum eumelum	0	0	0	0	0	0	0	0	0,0121	0,0043	0	0	0	0	0	0	0	0	0
Diplectrum euryplectrum	0	0	0,0042	0	0	0	0	0	0	0	0,0002	0	0,0039	0,0099	0	0	0	0	0
Diplectrum labarum	0	0	0	0	0,0085	0	0,0335	0	0	[illegible]	0	0	0	0	0	0	0	0	0
Bucinostomus argenteus	0,0040	0,0009	0	0	0	0	0	0,0006	0	0	0	0	0	0	0,0154	0	0	0	0
Bucinostomus aureolus	0	0	0	0	0	0	0	0,0000	0	0	0	0,0065	0	0	0	0	0	0	0
Bucinostomus gracilis	0	0	0	0	0,0778	0,0069	0,0000	0,0155	0	0	0	0	0	0	0	0	0	0	0
Gymnothorax equatorialis	0	0	0	0	0	0	0	0,0010	0	0	0,0077	0	0	0	0	0	0	0	0

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Hemanthias peruanus	0	0	0	0	0	0	0	0	0,0234	0,0017	0	0	0	0	0	0	0	0	0
Hemanthias signifer	0	0	0,0007	0	0	0	0	0	0,0162	0	0	0	0	0	0	0	0	0	0
Himantura pacifica	0,0103	0	0	0	0	0	0	0,0000	0,0000	0	0	0	0	0	0	0	0	0	0
Hippoglossina tetraophthalmus	0	0	0	0	0	0	0	0,0025	0,0097	0,0028	0	0	0	0	0	0	0	0	0
Ilisha furthii	0	0	0	0	0	0	0	0	0	0	0	0	0,0071	0	0	0	0	0	0
Isophistus altipinnis	0	0	0	0	0	0	0	0	0	0	0	0,0030	0,0302	0,0095	0	0,0052	0	0	0
Lepophidium prorates	0	0	0	0	0	0	0	0,0030	0	0	0	0,0007	0	0	0	0,0015	0	0	0,0020
Loligo sp.	0	0	0	0	0	0	0	0	0,0501	0	0	0	0	0	0	0	0	0	0
Lutjanus guttatus	0	0	0	0	0	0	0	0,0001	0	0	0	0,0023	0,0005	0	0	0,0122	0	0,0039	0
Menticirrhus nasus	0	0	0	0	0	0	0	0	0	0	0	0	0,0120	0	0	0	0	0	0
Menticirrhus panamensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0221	0	0	0	0	0
Monalene maculipinna	0	0,0024	0,0092	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mulloides dentatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0072	0	0	0	0
Mustelus lunulatus	0	0,0000	0,0051	0,0639	0	0	0	0	0,0025	0,0063	0	0	0	0	0	0	0	0	0
Neobithytes stelliferoides	0	0	0,0342	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ophichthyidae	0	0	0	0	0	0,0026	0	0	0	0	0	0	0	0	0	0	0	0	0,0040
Opisthopterus dovii	0	0	0	0	0	0	0	0	0	0	0	0	0,0009	0	0	0,0064	0	0	0
Opistopherus equatorialis	0	0	0	0	0	0	0	0	0	0	0	0	0,0470	0	0	0	0	0	0
Paralonchurus dumerilii	0	0	0	0	0	0	0	0	0	0	0	0	0,0505	0,0091	0	0	0	0	0
Peprilus medius	0	0	0	0	0	0	0	0	0	0	0	0,0280	0	0	0	0	0	0	0
Peprilus snyderi	0	0	0	0	0	0	0	0	0,0285	0	0,0081	0,0283	0,0045	0	0	0	0	0	0
Physiculus nematopus	0	0,0016	0,0410	0	0	0	0	0,0112	0	0	0	0	0	0	0	0	0	0	0
Polydactylus approximans	0	0	0	0	0	0	0	0	0	0	0	0	0,0199	0,0027	0,0167	0,0036	0	0	0
Pomadasys branickii	0	0	0	0	0	0	0	0	0,0092	0,0009	0	0	0	0	0	0	0	0	0
Pomadasys leuciscus	0	0	0	0	0	0	0	0	0	0	0	0	0,0379	0	0	0	0	0	0
Pontinus sierra	0	0,0010	0,0773	0	0	0	0,0039	0,0103	0	0	0	0	0	0	0	0	0	0	0
Porichthys margaritatus	0	0	0	0	0	0	0,0023	0,0012	0,0011	0	0	0	0	0	0	0	0	0,0006	0,0026
Prionotus horrens	0	0	0	0	0	0	0	0	0	0	0	0	0,0068	0,0068	0	0,0006	0	0	0
Pronotogrammus eos	0	0,0012	0,0171	0	0	0	0,0002	0,0001	0	0,0001	0	0	0	0	0	0	0	0	0
Pseudopeneus vancolensis	0,0009	0	0	0	0	0	0	0,0001	0	0	0	0	0	0	0,0072	0	0	0	0
Raja velezi	0	0	0	0	0	0	0	0	0,0159	0,0255	0	0	0	0	0	0	0	0,0023	0
Rhinobatos leucorhyncus	0	0	0	0	0	0	0	0	0	0	0	0	0,0210	0,0069	0	0	0	0	0
Selene oerstedii	0,0019	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0056	0	0	0,0123	0
Selene peruviana	0,0005	0	0	0	0	0	0	0	0	0	0	0,0662	0,0354	0,0000	0,0243	0,0097	0	0	0
Sphaeroides annulatus	0,0001	0	0	0,0096	0,0001	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sphaeroides lobatus	0	0	0	0,0284	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synodus sciculuceps	0	0	0	0	0,0010	0	0	0	0,0052	0,0070	0	0,0193	0	0	0,0080	0,0076	0	0,0019	0
Trachinotus paitensis	0	0	0	0	0	0	0	0,0026	0	0	0	0	0	0,0162	0,0130	0,0143	0	0	0
Trichiurus nitens	0	0,0021	0	0	0	0	0,0001	0	0,0156	0,0029	0,0470	0,0025	0	0	0	0,0487	0	0	0
Trinectes fonsecensis	0	0	0	0	0	0	0	0	0	0	0	0	0,0148	0	0	0	0	0	0
Umbrina bussingii	0	0	0	0	0	0	0,0006	0	0,0067	0	0	0	0	0	0	0	0	0	0

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Production (95%, 68 species)	B	C	D	E	F	G	H(bk)	bk31	bk51	bk52	bk53	bk54	bk06	bk45	bk01	bk35	bk30	bk43	bk50	N	O	P
Achirus klunzingeri	0	0	0	0	0	0	0	0,0172	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achirus scutum	0	0	0	0	0	0	0,0028	0	0	0	0	0	0	0,0173	0	0	0	0	0	0	0	0
Anisotremus dovii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,3269	0	0	0	0
Antennarius avalonis	0	0	0	0	0	0	0	0	0	0,0088	0,0041	0	0	0	0	0	0	0	0	0,0448	0	0
Arius kessleri	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0077	0	0	0	0,011	0	0	0	0
Arius osculus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,4837	0	0	0	0
Arius sp, a	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,25	0	0	0	0
Arius sp, b	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0281	0	0	0	0
Bellator gymnostethus	0	0	0	0	0	0	0	0	0,01	0,0028	0	0	0	0	0	0	0	0	0	0	0,0139	0
Bollmannia chlamydes	0	0	0,0026	0	0	0,0165	0	0	0	0,0716	0	0,006	0,0286	0	0	0	0,0029	0	0,0013	0	0	0,0682
Bollmannia stigmatura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0055	0,0809	0
Catherops tuyra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,2578	0	0	0	0
Chlorophthalmus mento	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0179	0	0
Citharichthys platophrys	0	0	0	0	0	0	0	0	0	0,0892	0	0	0,0013	0	0,0007	0	0	0	0	0	0	0
Cyclopsetta panamensis	0	0	0	0	0	0	0,1451	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyclopsetta querna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,001	0	0	0	0	0	0,0163
Cynoscion nannus	0,0212	0,0067	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cynoscion phoxocephalus	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0024	0,0217	0	0	0,0206	0	0	0	0
Diapterus aureolus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0008	0	0	0	0	0	0	0
Diplectrum macropoma	0	0	0,0151	0,0129	0	0	0	0	0	0	0	0	0	0	0,002	0	0	0	0	0	0	0,0074
Diplectrum sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0262
Engyophrys sanctilaurentii	0	0	0	0	0	0	0	0	0,017	0	0	0	0	0	0	0	0	0	0	0	0,0105	0
Etropus crossotus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0295	0	0	0	0	0	0
Etropus sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0226	0	0	0	0	0	0
Eucinostomus argenteus	0	0	0,0219	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gymnothorax equatorialis	0	0	0,0533	0	0	0	0	0	0	0	0	0	0,0056	0	0	0	0	0	0	0	0	0,0107
Gymnothorax sp.	0	0	0	0	0	0,0163	0	0	0,02	0	0	0	0	0	0	0	0	0	0	0,0327	0,0125	0
Haemulon scuderi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0676	0	0	0	0
Haemulopsis leuciscus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,04	0	0	0	0
Hemanthias signifer	0	0	0	0	0	0	0	0,0057	0	0	0	0	0	0	0	0	0	0	0,0104	0,3331	0,0013	0
Himantura pacifica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,5734	0	0	0	0
Hippoglossina tetraophthalmus	0	0	0	0	0	0	0	0	0,021	0	0	0	0	0	0	0	0	0	0	0	0	0
Kathetostoma averruncus	0	0	0	0	0	0,0096	0	0	0	0,0113	0	0	0	0	0	0	0	0	0	0	0	0
Lophiodes spinulus	0	0	0	0	0	0,0066	0	0	0	0	0	0,0377	0	0	0	0	0	0	0	0	0	0
Monolene asaedai	0	0	0	0	0	0,0123	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0072	0	0
Monolene maculipinna	0	0	0	0	0	0,0759	0	0	0	0,002	0	0	0	0	0	0	0	0	0	0,0815	0,0245	0

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Monolene maculipinna	0	0	0	0	0	0,0759	0	0	0	0,002	0	0	0	0	0	0	0	0	0	0,0815	0,0245	0
Myrichthys sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0208	0	0	0	0	0	0	0
Neobithytes stelliferoides	0	0	0	0	0	0,0348	0	0	0	0	0	0,0018	0	0	0	0	0	0	0	0	0	0
Ophichthys sp.	0	0	0	0	0	0,0083	0	0	0	0	0	0,029	0	0	0	0	0	0	0	0	0	0
Ophioscion sciera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0433	0	0	0	0
Ophistoma prorigerum	0	0	0	0	0	0,0112	0	0	0	0	0	0,0365	0	0	0	0	0	0	0	0	0	0
Perissias taeniopterus	0	0	0	0	0	0	0	0	0,026	0	0	0	0	0	0	0	0	0	0	0	0	0
Physiculus nematopus	0	0	0	0	0	0,1472	0	0	0	0,0028	0,0035	0,0425	0	0	0	0	0	0	0	0,0641	0,0155	0
Physiculus rastrelliger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0175	0	0
Pikae longilepis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,018	0	0
Polydactylus approximans	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,027	0	0	0	0	0	0	0
Pontinus furcirhinus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0588	0	0
Pontinus sierra	0	0	0	0	0	0,2353	0	0,012	0,023	0	0,0152	0,0159	0	0	0	0	0	0	0	0	0	0
Porichthys greeni	0,001	0	0,0111	0	0	0,0066	0	0	0	0	0	0	0,0173	0,001	0,0031	0	0,0021	0	0	0	0	0
Porichthys margaritatus	0	0	0	0	0	0	0	0	0	0,0019	0	0	0,1463	0	0	0,005	0,0453	0	0,049	0	0	0,1704
Prionotus horrens	0	0	0	0	0	0	0	0	0	0	0	0	0,0531	0	0,0073	0	0	0,002	0	0	0	0
Pronotogrammus eos	0	0	0	0	0	0,1495	0	0	0	0,0062	0	0	0	0	0	0	0	0	0	0,0201	0,0091	0
Raja equatorialis	0	0	0	0	0	0	0	0	0	0	0	0	0,025	0	0	0	0	0	0	0	0	0
Rhynchoconger nitens	0	0	0	0	0	0,0214	0	0	0	0	0	0,0156	0	0	0	0	0	0	0	0	0,0149	0,0038
Scorpaena russula	0	0	0	0	0	0	0	0	0,002	0	0	0	0,0032	0	0	0,0003	0	0	0,0294	0	0	0
Seiadeaps troschelli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0491	0	0	0	0
Sphaeroides annulatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0646	0	0	0	0	0	0,0345
Sphaeroides lobatus	0	0	0	0	0	0	0,0381	0	0	0	0	0	0,0011	0	0,0101	0	0	0	0,0042	0	0	0,05
Stellifer illecebrosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0071	0	0	0,0335	0	0	0	0
Stellifer sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0004	0	0	0	0,047	0	0	0	0
Syacium latifrons	0	0	0	0	0,0078	0	0,0184	0,1113	0,065	0	0	0	0	0	0	0	0	0	0	0,0028	0	0
Syacium ovale	0	0	0	0	0	0	0	0	0	0	0	0	0,0569	0	0	0,1656	0	0	0,0993	0	0	0,1171
Syacium sp.	0	0	0	0	0	0	0	0,0047	0,005	0	0	0	0	0	0	0	0	0	0	0	0	0,0663
Symphurus callopterus	0	0	0	0	0	0,0094	0	0	0	0,1242	0,006	0,2406	0	0	0	0	0	0	0,0064	0,0019	0,0684	0
Symphurus chabanaudi	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0356	0,0114	0	0	0,0261	0	0	0	0
Symphurus elongatus	0	0	0	0	0	0	0	0	0	0	0	0	0,0166	0	0	0	0	0,0055	0	0	0	0
Symphurus gorgonae	0	0	0	0	0	0,0012	0	0	0	0	0	0,0008	0	0	0,0026	0,0141	0	0	0	0,0005	0,0021	0
Symphurus leei	0	0,0066	0	0	0	0,0066	0	0	0	0	0	0,0418	0	0	0	0	0	0	0	0	0	0,0091
Symphurus oligomerus	0	0	0	0	0	0,1804	0	0,0016	0	0,0055	0,0045	0	0,0005	0	0	0	0	0	0,0026	0,0874	0	0
Synchiropus atrilabiatus	0	0	0	0	0	0,0032	0,0016	0	0,115	0	0,0171	0,0021	0	0	0	0	0	0	0,0013	0	0,0157	0
Synodus evermanni	0	0	0,0068	0	0	0	0	0	0,019	0	0	0	0,0037	0	0	0	0	0	0,0396	0	0,0776	0,0067
Synodus scituliceps	0	0	0,0326	0	0	0	0,0168	0	0	0	0	0	0,0637	0	0,0041	0,1286	0	0	0,0711	0	0	0,1366
Synodus sechurae	0	0	0	0	0	0	0	0,0101	0	0	0	0	0	0	0	0	0	0	0	0	0	0,0344
Torpedo tremens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zalieutes elater	0	0	0	0	0	0	0	0,0016	0,013	0,0029	0,001	0	0	0	0	0	0	0	0	0,0135	0,0024	0

Production (95%, 64 species)									
	I1(gsn)	I2	M	gsn31	gsn52	gsn53	gsn54	gsn06	gsn45
Achirus mazatlanus	0	0	0	0,0008	0	0	0	0	0,0049
Achirus scutum	0	0	0	0	0	0	0	0	0,0064
Albula nemoptera	0,0066	0	0	0,021665	0	0	0	0	0
Ancylopsetta dendritica	0	0	0	0,0047	0	0	0	0	0
A isostremus dovii	0	0	0	0,0418	0	0	0	0	0,0016
Ariusdovii	0	0	0	0	0	0	0	0	0,0062
Arius platypogon	0,0015	0	0	0,0262	0	0	0,028	0	0
Arius troschelii	0	0	0	0	0	0	0	0	0,0043
Bollmannia stigmatura	0	0	0	0	0,0024	0,0002	0	0,0002	0
Calamus brachysomus	0	0	0	0,0519	0	0	0	0	0
Caranx otrynter	0,0225	0	0	0,0075	0	0	0	0	0
Caranx speciosus	0,0104	0	0	0,008	0	0	0	0	0
Caranx vinctus	0	0	0	0,0086	0	0	0	0	0
Citharichthys platophrys	0	0	0	0	0,0031	0,0108	0	0,0007	0
Cyclopsetta panamensis	0,0019	0	0,0007	0,0111	0	0	0	0	0
Cyclopsetta querna	0	0	0	0	0	0	0	0,013	0,0017
Cynoscion albus	0	0	0	0,0047	0	0	0	0	0
Cynoscion phoxocephalus	0	0	0	0	0	0	0	0	0,003
Dasyatis longus	0,0078	0	0,0049	0,0312	0	0	0	0	0,0156
Diapterus peruvianus	0	0	0	0	0	0	0	0	0,005
Diplectrum eurypiectrum	0	0	0	0	0	0,0026	0,0009	0	0
Diplectrum macropoma	0	0	0	0	0	0	0	0,004	0
Epinephelus niphobles	0	0	0,0035	0	0	0	0	0	0
Eucinostomus gracilis	0	0	0	0,0091	0	0	0	0	0
Gerres cinereus	0	0	0	0,0096	0	0	0	0	0
Gymnothorax equatorialis	0	0	0	0	0	0,0028	0	0,0049	0
Hemanthias peruanus	0	0	0	0	0,0022	0,001	0	0	0
Hemanthias signifer	0	0	0	0	0,0011	0	0,0018	0	0
Hoplopagrus guntheri	0	0	0	0,0038	0	0	0	0	0
Lophiodes caulinaris	0	0,0014	0	0	0,0003	0,0019	0,0006	0,0005	0
Lutjanus argentiventris	0	0	0	0,0033	0	0	0	0	0

Lutjanus guttatus	0.0103	0	0	0.007708	0	0	0	0	0
Lutjanus peru	0	0	0	0,0045	0	0	0	0	0
Mustelus lunulatus	0	0	0,023603	0	0	0,001	0	0	0
Narcine brasiliensis	0,0122	0	0,0006	0,017	0	0	0	0	0
Neopisthopterus tropicus	0	0	0	0	0	0	0	0	0,0471
Paralichthys woolmani	0	0	0	0,0005	0	0,002	0	0	0
Paralonchurus dumerilii	0	0	0	0	0	0	0	0	0,0229
Peprilus snyderi	0	0	0,0016	0	0,0298	0	0,0002	0,0275	0
Peristedion barbiger	0	0,0024	0	0	0,0002	0,0001	0,0003	0	0
Polydactylus approximans	0	0	0	0	0	0	0	0	0,0032
Pomadasys branickii	0,0066	0	0	0	0	0	0	0	0
Pontinus sierra	0	0,0002	0	0	0,0003	0	0,0036	0	0
Porichthys margaritatus	0	0	0	0	0,0007	0	0	0,0056	0
Prionotus albirostris	0	0	0	0	0	0,0036	0	0	0
Prionotus horrens	0	0	0	0,0087	0	0	0	0	0,0036
Prionotus sp.	0	0	0	0	0	0	0	0,0114	0
Raja velezi	0	0,0048	0,0076	0	0	0,0223	0	0,0028	0
Rhinobatos leucorhyncus	0	0	0	0,0203	0	0	0	0	0
Selene brevortii	0	0	0	0,0059	0	0	0	0	0
Selene oerstedii	0	0	0	0,0311	0	0	0	0	0
Selene peruviana	0	0	0	0	0	0	0	0,0501	0,0004
Sphaeroides annulatus	0,0031	0	0	0,0119	0	0	0	0	0
Sphaeroides lobatus	0,0151	0	0	0,0133	0	0	0	0	0
Stellifer illecebrosus	0	0	0	0	0	0	0	0	0,0005
Syacium latifrons	0	0	0	0,0017	0	0	0	0,004	0
Syacium ovale	0	0	0	0,0013	0	0	0	0,0076	0
Synodus evermanni	0	0	0,0002	0,0002	0,0015	0,0034	0	0	0
Synodus scituliceps	0	0	0	0,0002	0	0	0	0,0074	0
Trichiurus nitens	0	0	0	0	0	0	0,0735	0	0
Trinectes sp.	0	0	0	0	0	0	0	0	0,0006
Umbrina bussingii	0	0,000	0	0	0	0,0008	0,0028	0	0
Urotrygon nana	0	0	0	0	0	0	0	0	0,007
Zapteryx exasperata	0	0	0,0006	0,0072	0	0,0017	0	0	0

all cases the MDS-plots match the cluster dendrograms well as seen by the coincidence of the group numbers between the clusters and MDS- plots. The following general pattern emerges:

(1) Groups are formed by stations of a certain depth range and/ or geographical location. Thus in the December beam trawl cluster and MDS plot for example, the stations of the interior and central part of GN (group I), those of the outer lateral part of GN (group V) and the shallow stations of GD and ST (group VIII) are grouped together. A similar pattern is repeated in the other cluster.

(2) The deepest station 54 (228 m) at the outer slope of GN is separated from other stations in December, both in the otter trawl and beam trawl catches.

(3) Flatfish species (generally small sized) are the main components in the beam trawl catches and important for the similarity within station groups whereas in the otter trawl catches, roundfish and rays are more important. Sharks and some pelagic fish like *Anchoa* sp., *Selene* spp. almost exclusively occur in the otter trawl catches;

(4) More species account for the similarity within groups in the otter trawl catches, reflecting a general higher species richness in the otter trawl catches. This is confirmed by the comparison of the species area curves of the beam trawl and otter trawl collections (Fig.2).

By observing the species cluster (Fig. 7a,b and 8a,b) it is seen that some species occurred only on a few, others on many stations. In the otter trawl catches the following were only found on the central and interior stations of Golfo de Nicoya (45,01,06,30) and might thus well characterize this area: *Cyclopsetta querna, Achiurus mazatlana, Prionotus* sp., *Prionotus horrens, Arius troschelli, Arius dovii, Paralonchurus dumerillii, Polydactylus approximans, Trinectes* sp., *Diapterus peruvianus, Cynoscion phoxocephalus, Anisotremus dovii, Rhinobates leucorhynchus.* Other species were common on these stations, but also occurred in other areas, like *Selene peruviana* and *Achiurus scutum* (H), *Gymnothorax equatorialis* (53), *Peprilus snyderi* (52,54,M) or *Dasyatis longus* (M,H,J, R). The following species occurred only on the deeper stations during both seasons: *Mustelus lunatus* (I,52,53,M), *Hemanthias peruanus* (52,53), *Hemanthias signifer* (52,54, 12), *Diplectrum euryplectrum* (52,53), *Umbrina bussingii* (52,53,54,M,I2). Some predominated at the deeper stations but also occurred further inshore like *Trichiurus nitens* (54,53,52,M,I, 06,30), *Pontinus sierra* (54,52,I2,I,M, 31), *Bollmania stigmantura* (53,53,I, 06, I,I2,31), *Synodus evermani* (53,52,M,3I).

In addition to the species mentioned above, there were many that occurred during one of both sampling dates only. Among those are several shoaling carangid species caught on station 31 (Bahía Ballena) during February: *Caranx vinctus, Selene brevortii, Selene oerstedii, Caranx otrynter, Caranx speciosus,* The latter was also found at this station during December, while *C. vinctus* and S. *oerstedii* (H,35,S) were also found in the Golfo Dulce area during December. *Cynoscion nannus,* a small scianid was the only species occurring exclusively in the otter trawl catches of the GD - area in both seasons (I,L,M,B,C). *Sphoeroides lobatus* (J) and *S. anulatus* (H,J,K) were restricted to the GD catches in the rainy season, as were *Caranx vinctus* (H,I,12), *Chlorophthalmus mentis* (I,12), *Neobythes stelliferoides* (12), *Himantura pacifica* (H) and *Diplectrum labarum* (K,H). *Epinephelus niphobles* only ocurred on station M during the dry season.

The following species were those most frequently captured by the ottertrawl (both seasons): *Synodus evermanni/scituliceps* (10), *Dasyatis longus* (8), *Bollmannia stigmatura* (8), *Lutjanus guttatus* (8), *Trichiurus nitens* (8), *Selene peruviana* (7) and *Raya velezi* (7).

The general pattern of species groups of the ottertrawl cluster are repeated in the beam trawl catches, although many species differ. The following were found on the stations of the central and interior parts of GN on both sampling dates (some of those were also found in the other study areas): flatfish: *Achiurus klunzingeri* (31), *Syacium latifrons* (31,C, 51, 53, F, H, N), *Cyclopsetta querna* (30,35,P), *Symphurus elongatus* (30, 35, 01, P, Q, 06, 43), *Syacium ovale* (06,35,F,50,P), *Etropus crassotus* (35), *Symphurus chabaudi* (30,35,01,45,43); round fish: *Synodus scituliceps* (35,P,D,F,E, H,06,01,50), *Sphoeroides lobatus* (30, E, Q, H, 06,01,50,P), *Porichthys greeni* (01, 45, 30, 35, G,52, 06,50,P). During December, the following additional species were caught at these sta-

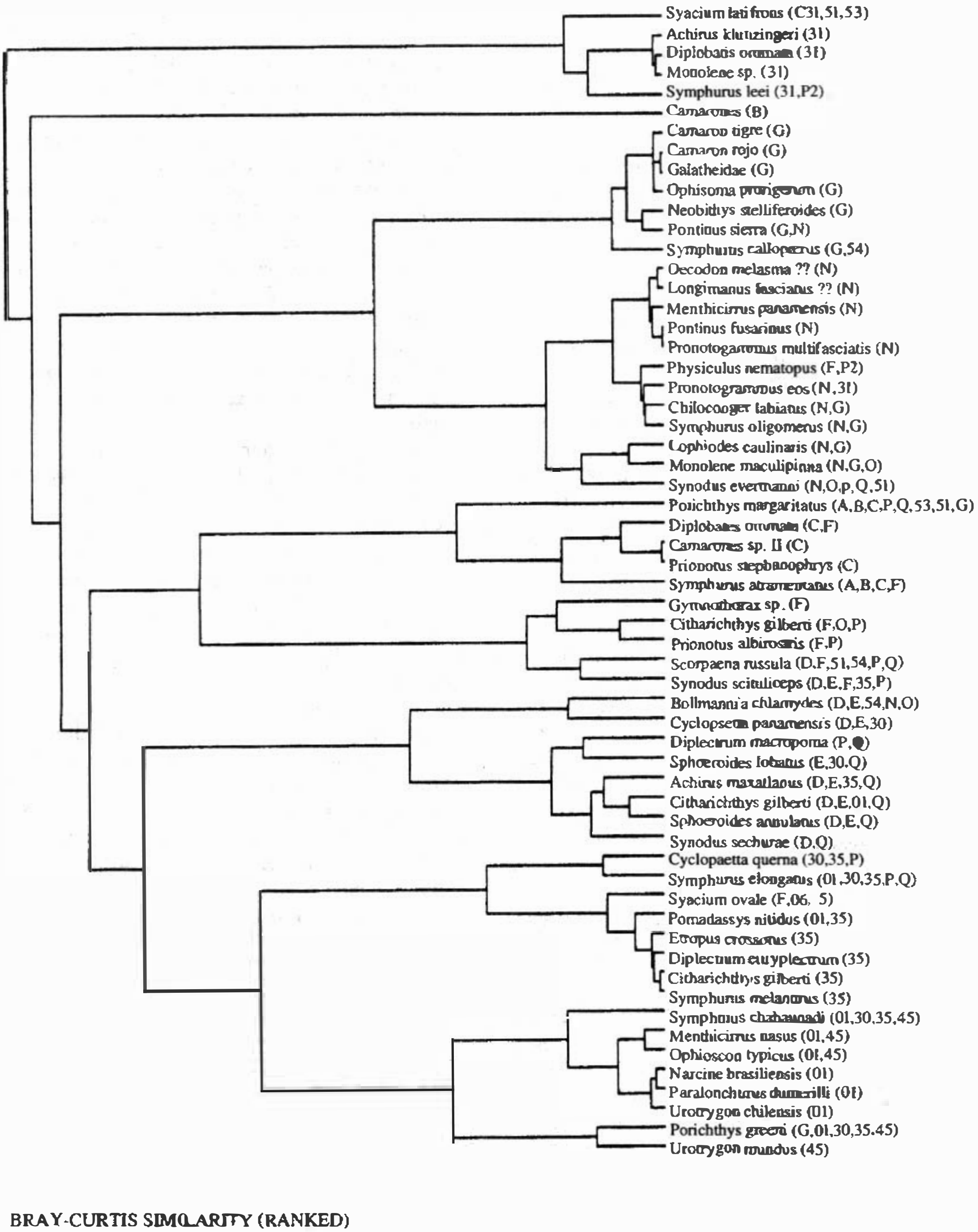
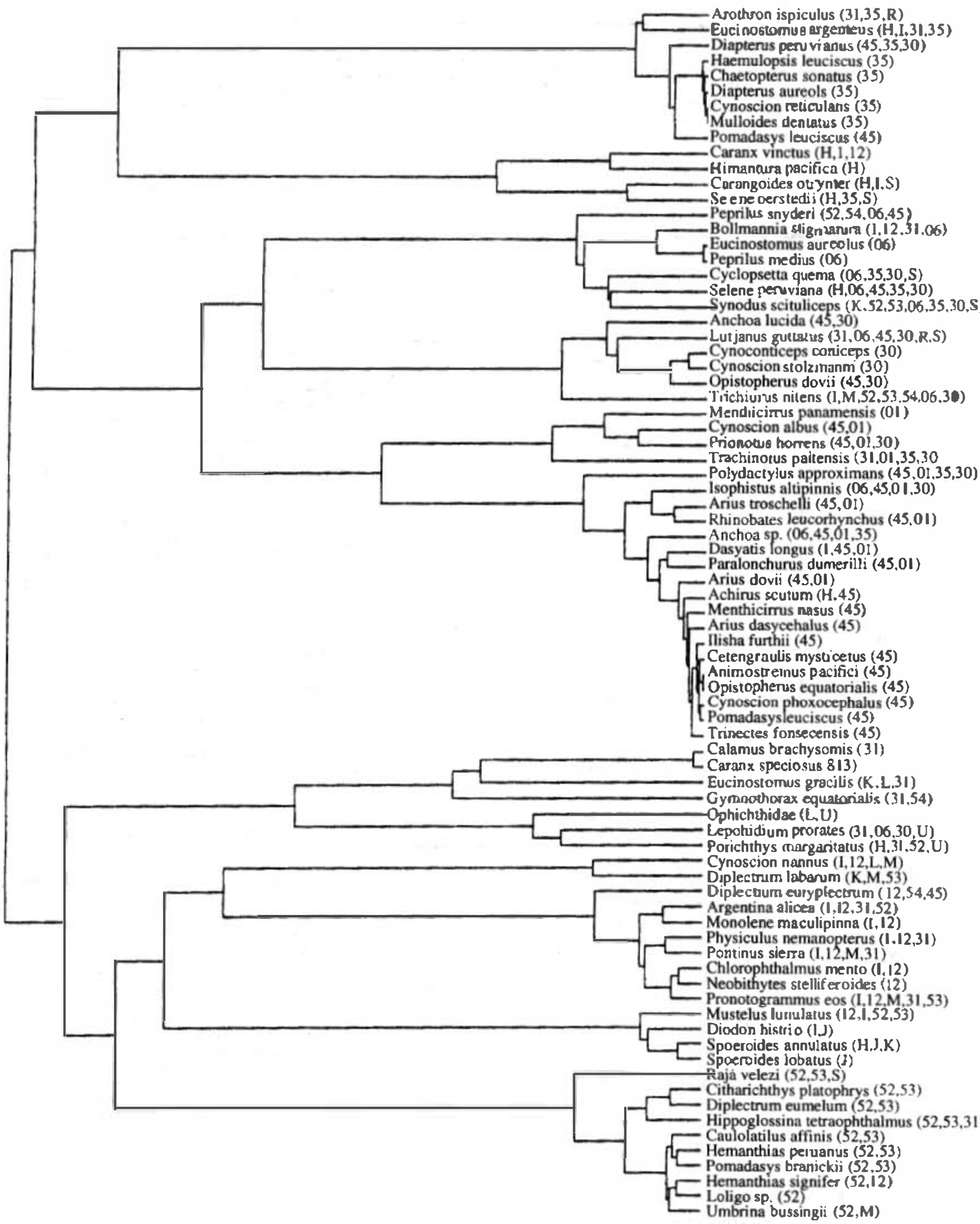


Fig. 7. Species dendrograms for the beamtrawl (this page 59 species) and ottertrawl (next page 79 species) collections during December (stations of species occurrence are given in parenthesis).



BRAY-CURTIS SIMILARITY (RANKED)

Fig. 7 (continued)

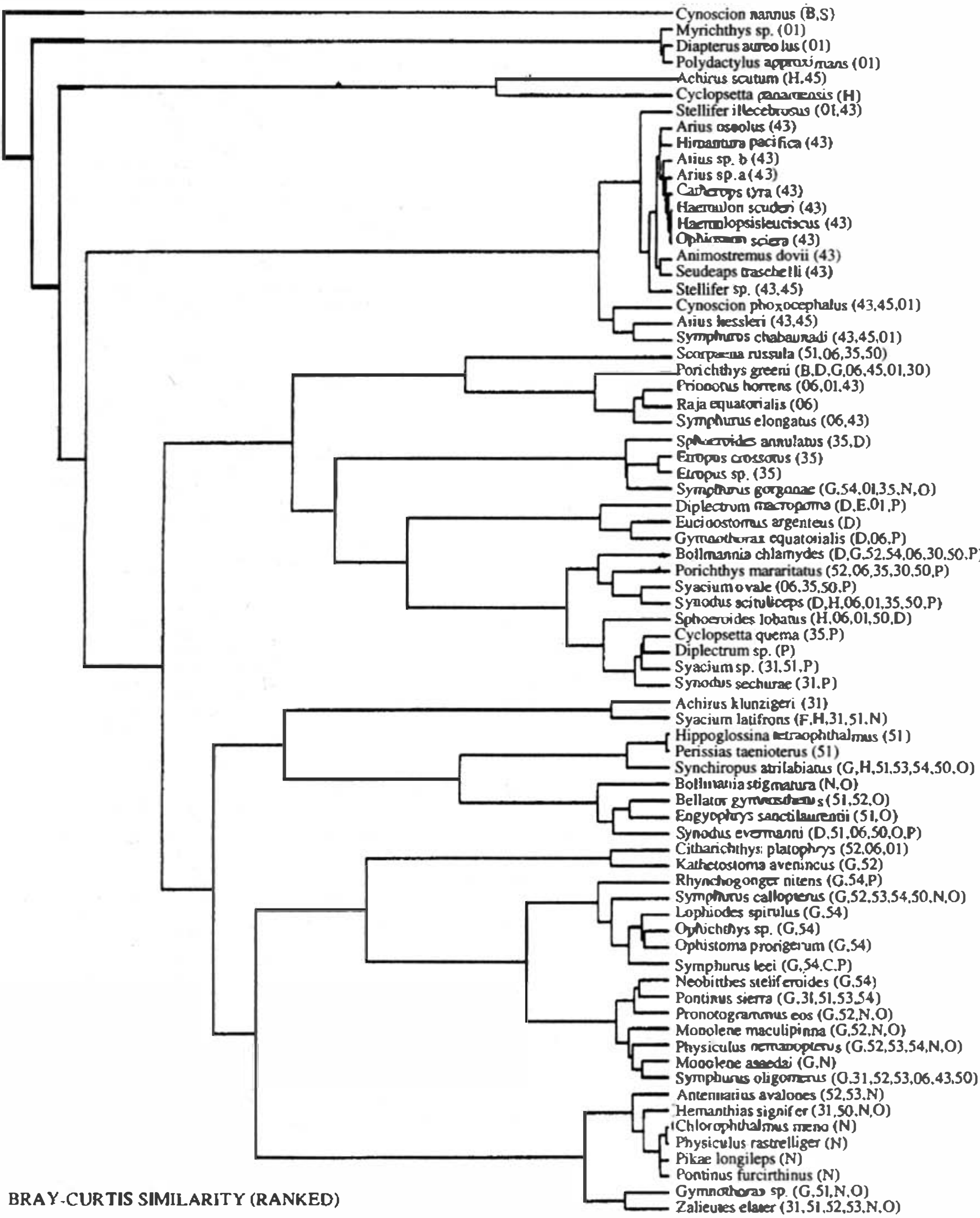
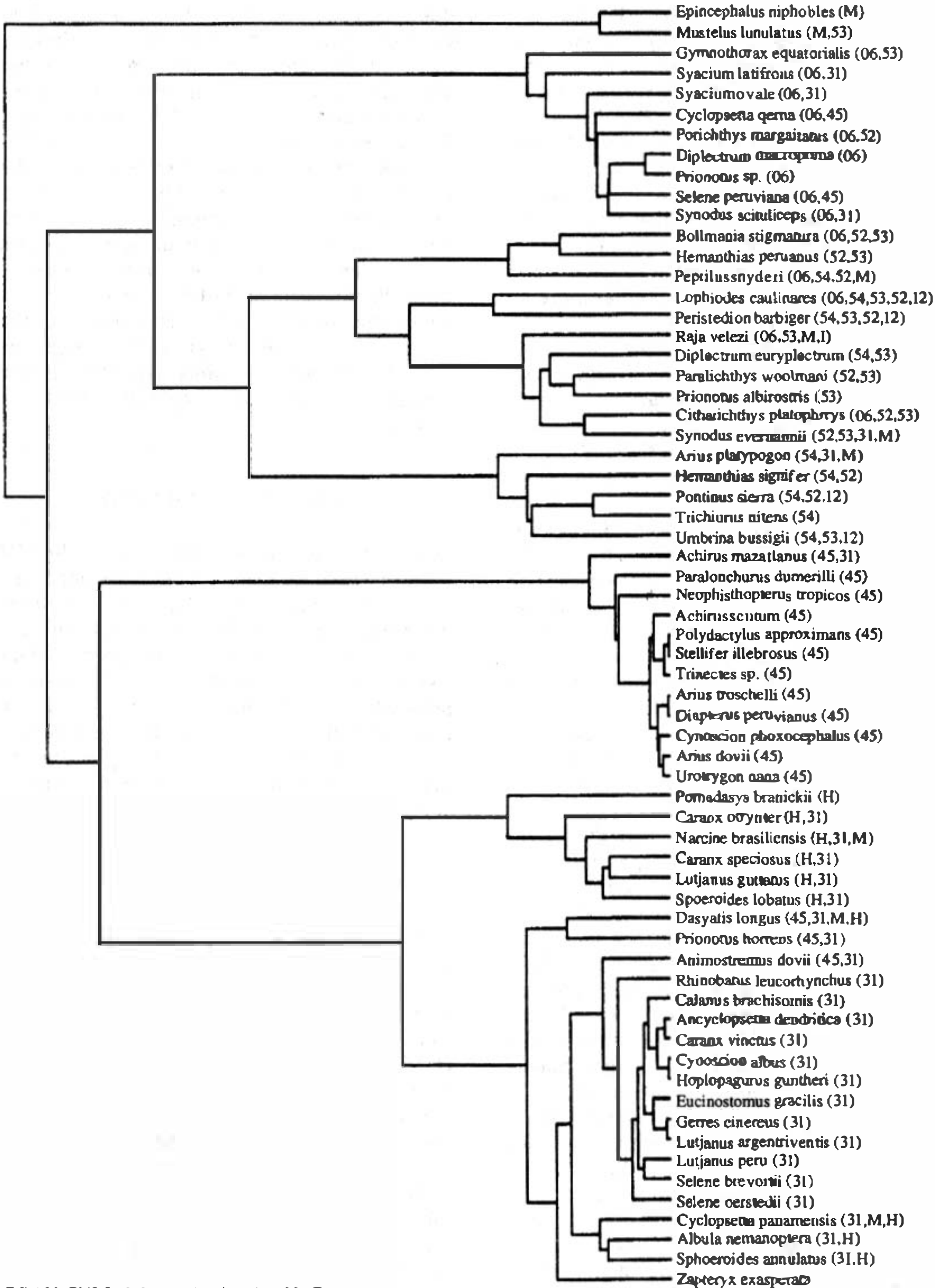


Fig. 8. Species dendrograms for the beamtrawl (this page 68 species) and ottertrawl (next page 64 species) collections during February (stations of species occurrence are given in parenthesis).



BRAY-CURTIS SIMILARITY (RANKED)

Fig. 8 (continued)

tions: *Diplobatis ommata* (31), *Monolene* sp. (31), *Symphurus lei* (31,P), *Promatogrammos eos* (31,N), *Achiurus mazatlanus* (35,E,D,Q), *Citharychthys gilberti* (01, D, E, Q), *Pomadasys nitidus* (35,01), *Diplectrum euryplectrum* (35), *Symphurus melanudus* (35), *Menticirrhus nasus*, *Ophioscion typicus* (10,45), *Narcine brasiliensis*, *Paralonchurus dumerillii*, *Urotrygon chilensis* (01) and *Urotrygon mundus* (45). The shallow water station 43 (10 m) was only sampled during February and provided three new ariid species and several further species only found here.

Few species were restricted to deep water stations in both seasons: *Ophisoma pangina* (G,54), *Neobythites stelliferoides* (G,54), *Pontinus fusarius* (N), *Pronotogrammus multifasciatis* (N,G,52,O). The genera *Porichthys*, *Symphurus*, *Synodus*, *Bollmania* and *Syacium* contributed with several species to the catches on several stations during both seasons.

An in detail comparison of our collections with those of Bartels *et al.* (1984), Leon (1973), Phillips (1983) or Rojas *et al.* (1994) is difficult as most sampling stations, time of the collections as well as sampling gears used were different. In addition, they did not give biomass per swept area estimates for direct comparison with our data. The latter three authors concentrated their sampling to the shallow upper region of GN, while the first also included the central part of the gulf, but their sampling did not exceed 60 m water depth. Consequently, many of the deeper water species found in this study, namely those mentioned in the above paragraph (and others), were absent in their collections. In addition, our large otter trawl had a higher capturability for larger sized fish which resulted in comparatively higher proportions in the catches of rays, sharks, large congrids and carangids. However, the general findings of the above authors regarding the dominant groups of the upper GN (sciaenids, sea ctafishes and flatfishes) and the lower GN (flounders, gobies, morays and congers among others) are confirmed by the present study. In addition, the subdivision of Bartels *et al.* (1983) of the GN based on abiotic factors (dissolved oxygen, temperature, salinity, depth, distance to the ocean), coincides quite well with our subdivision based on the stations similarity based on the station - species matrix. All species that were shared between the first twenty (in terms of percentage of occurrence) of the three cruises reported by Bartels *et al.* (1983), were also among the first 20 (in terms of production) in our beamtrawl and/or ottertrawl catches. These were: *Synodus scituliceps*, *Prionotus horrens*, *Porichthys* sp.,*Cyclopsetta querna*, *Syacium ovale*, *Diplectrum pacificum*, *Sphoeroides furthii*, *Symphurus* sp., *Bollmannia chlamydes*.

Although some species only occured in the December and February samples and others more frequently at one sampling date, the station groupings derived form the station species -matrix were similar in both seasons. This confirms the statement of Bartels *et al.* (1983), that the position of the "assemblage zones" (station groups in the present study) did not change significantly between seasons indicating stable estuarine configurations from a biological perspective.

ACKNOWLEDGEMENTS

I thank the captain and crew of the RV Victor Hensen for the excellent work done during the two cruise legs of this study. Without the taxonomic knowledge and tireless identification work of William Bussing, Myrna López and Raul Rojas this work would not have been possible. My thanks also to Angelika Dummermuth for her help with the elaboration of the data and preparation of the figures and to three anonymous reviewers whose constructive suggestions helped to improve the manuscript.

RESUMEN

Durante un crucero con el BC Victor Hensen en diciembre 1993 y febrero 1994 la comunidad de peces demersales fue evaluada en las áreas de Golfo de Nicoya (GN), Bahía Coronado - Sierpe-Térraba (ST) y Golfo Dulce (GD) a lo largo de transectos desde aguas someras (20 m) hasta aguas del borde de la plataforma (200 m). Se tomó 44 muestras con una draga y 29 muestras con una red de arrastre de un área total de 2 119 405 m², recolectando un total de 242 especies de peces. Aunque el número de muestras fue menor para la red de arrastre, se recolectó más especies (195 comparado con 169 de la draga). Las curvas de

especies vs. área muestreada y logarítmica-normal indican que la comunidad de peces fue muestreada y se calculó la riqueza específica teórica (SR) para el área total (306). Los promedios del número de especies y biomasa por muestra fueron muy inferiores para el GD (9.3 especies, 0.36 g/m²) al los de ST (15.4, 0.81) y GN (17.3, 0.74), indicando una comunidad de peces demersales muy empobrecida en el área de GD. Los valores mas bajos del número de especies como también de la biomasa fueron los de la parte central profunda (200 m) del GD, incrementando hacia el área de la entrada ("sill area") y hacia las estaciones someras sobre la termoclina. La biomasa promedio fue un orden de magnitud superior en la parte interior del GN comparado con las otras áreas con valores máximos de 18.1g/m². Con base en los resultados del análisis multivariado de las colecciones, se puede dividir el GN en las siguientes zonas: (1) una zona somera interior (<50 m) caracterizada por esciánidos, bagres, rayas látigo, lenguados, cabros, (2) una zona exterior (>100 m) caracterizada por moras, lapones, gobios, cintas, cabrillas, bocones y lenguados y una zona de transición de las partes centrales y laterales del golfo con una comunidad mezclada de peces con carángidos, chayotes, pargos, algunos lenguados y garrobos como elementos comunes. Muy característico para la parte profunda del GD son las especies pequeñas de *Cynoscion* y *Porichthys*, de los cuales el primero solo apareció aquí. Estas especies aparecieron en densidades muy bajas, indicando una capacidad de carga muy reducida de esta zona para biomasa de peces en cuanto al alimento y oxígeno. Muchas especies características de esta profundidad para otras áreas estuvieron ausentes aquí. Las especies que aparecieron en las estaciones someras del GD también se encontraron en las otras áreas, pero faltan muchas especies, como los bagres y muchas de las corvinas del área de GN. La comunidad de especies en el área de ST se asemeja la del GN, pero los bagres también faltan. Descriptores bióticos para las estaciones tales como biomasa, abundancia, producción y dominancia no se correlacionaron en forma significativa con factores abióticos (temperatura, oxígeno, profundidad) indicando que otros factores del hábitat, que no medidos, tales como heterogeneidad ambiental, distancia al océano abierto, corrientes y disponibilidad de alimento pueden ser de gran importancia para la estucturación de las comunidades de peces.

REFERENCES

Arreguín-Sánchez, F., E. Valero-Pacheco & E.A. Chávez. 1993. A trophic box model of the coastal fish communities of the southwestern Gulf of México, 197-205. *In* Christensen & Pauly (eds.). Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26.

Bartels, C.E., K.S. Price, M.I. López & W. A. Bussing.1983. Occurrence, distribution, abundance and diversity of fishes in the Gulf of Nicoya, Costa Rica. Rev.Biol.Trop. 31: 75-101.

Bartels, C.E., K.S. Price, M.I. López & W. A. Bussing.1984. Ecological assessment of fin fish as indicators of habitats in the Gulf of Nicoya, Costa Rica. Hydrobiologia 112: 197-207.

Browder, J.A. 1993. A pilot model of the Gulf of México Continental shelf. 279-284. *In* Christensen & Pauly (eds.). Trophic models of aquatic ecosystems. ICLARM Conf.Proc. 26.

Bussing, A.W. & M.I. López. 1993. Peces demersales y pelágicos costeros del pacífico de Centro América Meridional. Guía illustrada. Rev. Biol. Trop. (Spec. Public. I). 164 p.

Bussing, A.W. & M.I. López. 1996. Fishes collected duming the RV. Victor Hensen Costa Rica Expedition, 1993/1994. Rev. Biol. Trop. 44. Suppl. 3: 183-186.

Clarke, K.R. & R.M. Warwick.1994. Change in marine communities: an approach to statistical analysis and interpretation. Natural Environment Research council, United Kingdom. 144 p.

León, P. 1973. Ecología de la ictiofauna del Golfo de Nicoya, un estuario tropical. Rev. Biol. Trop. 21: 5-30.

Mendoza, J.J. 1993. A preliminary biomass budget for the Northeastern Venezuela Shelf Ecosystem, 285-297. *In* Christensen & Pauly (eds.). Trophic models of aquatic ecosystems. ICLARM Conf. Proc. 26.

DePaula E Silva, R., M.I. Sousa & A.M. Caramelo. 1993. The Maputo Bay Ecosystem (Mozambique), 214-223. *In* Christensen & Pauly (eds.). Trophic models of aquatic ecosystems. ICLARM Conf.Proc. 26.

Phillips, P.C. 1983. Diel and monthly variation in abundance, diversity and composition of littoral fish populations in the Gulf of Nicoya, Costa Rica. Rev. Biol. Trop. 31: 297-306.

Rojas, J.R., J.F. Pizarro & M. Castro. 1994. Diversidad y abundancia íctica en tres áreas de manglar en el Golfo de Nicoya, Costa Rica. Rev. Biol. Trop. 42: 663-672.

Warwick, R.M & K.R. Clarke. 1993. Comparing the severity of disturbance: a meta-analysis of marine macrobenthic community data. Mar. Ecol. Prog. Ser. 92: 221-231.

Wolff, M. & J.A. Vargas (eds.). 1994. RV Victor Hensen Costa Rica Expedition 1993/1994. Cruise report. ZMT Contribution 2. 109p.