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ON THE DYNAMICS OF THE MAURITANIAN SMALL-PELAGIC FISHERY, NORTH-WEST AFRICA

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Off Mauritania, North-West Africa, a pelagic fishery has operated for more than 30 years, with a recent average annual catch of about 400 000 tons. Catches are influenced by region and by seasonal hydrographic conditions. Yields of carangids (*Trachurus trachurus*, *T. trecae* and *Decapterus rhonchus*) are significantly higher ($p < 0.05$) in the southern part of the fishing zone than in the north, whereas the reverse is observed for *Sardina pilchardus*. Carangids are caught mostly during the transitional seasons (June–July and November–December), whereas clupeoids (*S. pilchardus*, *Sardinella aurita* and *Sardinella maderensis*) are mostly taken during the cold (January–May) and warm (August–October) seasons. Market destination for the different fisheries is a key factor in determining differences in species yields in the Mauritanian upwelling region. Most fleets follow concentrations of carangids, even though other species may be more abundant elsewhere. Caution should be applied in treating *cpue* as an index of abundance.

On account of various hydroclimatic factors (Ould Dedah 1995), the upwelling waters of Mauritania support a large variety and biomass of fish (Letaconnoux and Went 1970, Hempel 1982, Wolff *et al.* 1993). Small, pelagic fish have long been targeted by international fleets. In the 1980s, annual catches averaged about 400 000 tons (Chavance and Girardin 1991). Three families contributed most of the catch: Carangidae, comprising Atlantic horse mackerel *Trachurus trachurus*, Cunene horse mackerel *Trachurus trecae* and false scad *Decapterus rhonchus*; Clupeidae, consisting of European pilchard *Sardina pilchardus*, round and Madeiran sardinella *Sardinella aurita* and *S. maderensis* respectively; and Scombridae consisting of a single species, chub mackerel *Scomber japonicus*. Recently, substantial catches of Trichiuridae have also been made, in particular largehead hairtail *Trichiurus lepturus*. The biology of and fisheries for these species have been reviewed by several authors (Garcia 1982, Josse and Garcia 1986, Josse 1989, Chavance and Girardin 1991, Marchal 1991a, Ould Dedah 1995).

This paper provides an overview of the pelagic fisheries, traces their development and investigates variability in the species composition of the catch. The study investigates the spatial and short-term temporal variations in catch per unit effort (*cpue*) of species by analysing commercial catch data for small, pelagic fish off Mauritania during the period 1987–1993.

BACKGROUND OF THE FISHERIES

In Mauritanian waters, small, pelagic fish have been targeted by large international fleets from Bulgaria, Cuba, France, Germany, Ghana, Iraq, Poland, Rumania, Spain and the former Soviet Union, which will be referred to herein as the ex-USSR. Rumania has exploited pelagic fish off Mauritania since the 1970s, using purse-seiners and trawlers of different sizes. However, after 1978, only a single size category of vessel was used, namely the "Super Atlantic" (RTMS). The ex-USSR fishery operated intermittently from the 1950s. After 1985, ex-USSR vessels were present every year and they accounted for at least 60% of the total effort in the pelagic fishery. Rumanian vessels were responsible for virtually all of the remaining pelagic fishing effort until 1991, when they stopped fishing in Mauritanian waters. The other fleets either fished consistently in the region for only a few years (Germany) or episodically (e.g. Bulgaria, Ghana). The fleets operated in the Mauritanian Exclusive Economic Zone (EEZ) under agreements between the Mauritanian government and the countries from which they emanated. These joint ventures are managed by Mauritanian companies. The Mauritanian government and the local companies receive a portion of the profits. For example, some of the foreign fleets are required to have a crew consisting of about 35%

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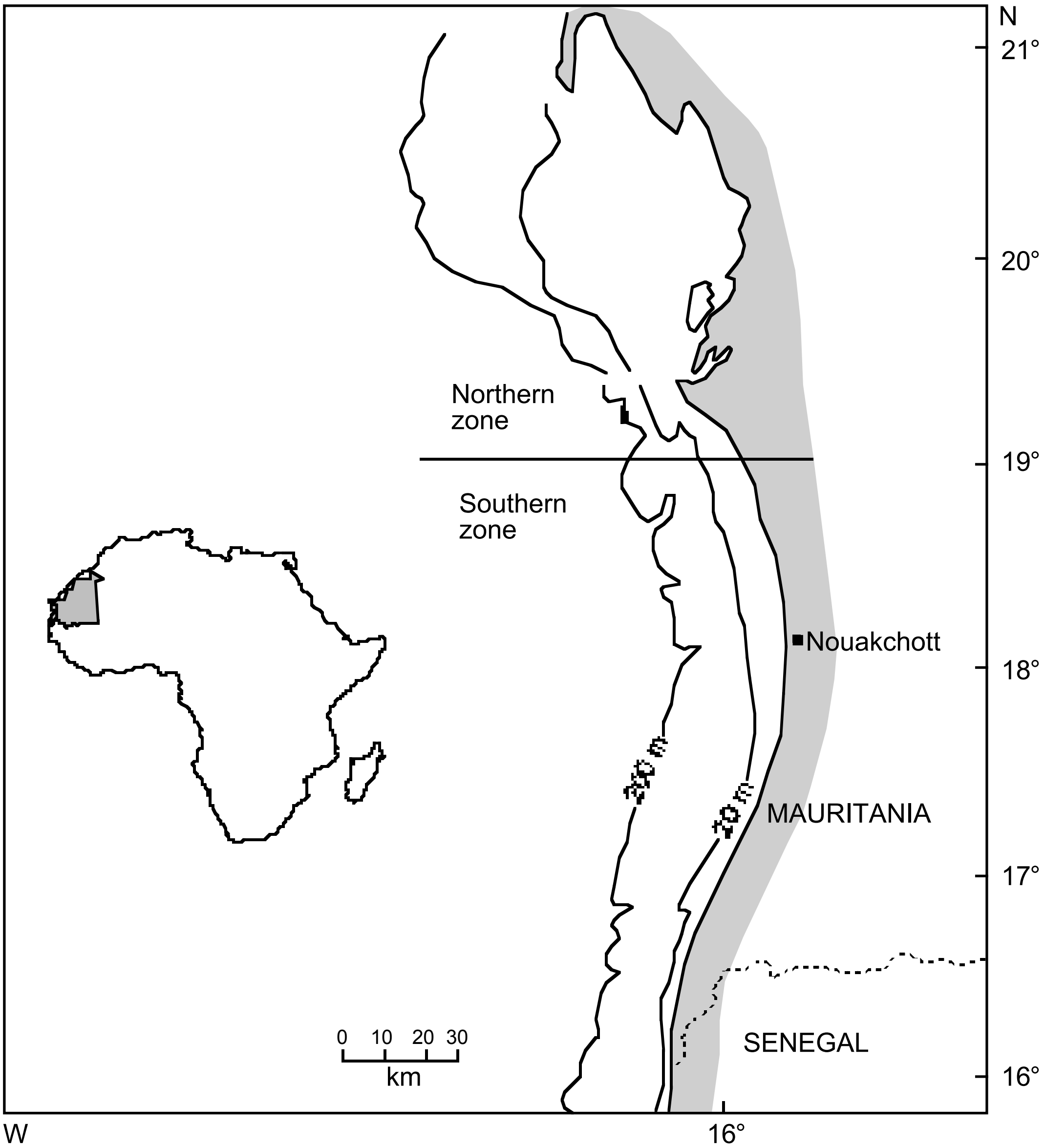

Fig 1: The study area, indicating the northern and southern fishing zones

Mauritanians, and they generally turn over about 30% of total gross profits to Mauritanian interests (Ould Soueilem 1992). Products, including frozen fish, and fish processed at sea for fish meal and oil, are not landed in Mauritania, but rather they are carried by cargo ships to Eastern Europe and sub-Saharan Africa. This study focuses primarily on the Rumanian and ex-USSR fleets during the period 1987–1993, when they dominated the fishery. These fleets consisted of highly mobile, midwater trawlers of four types (Table I).

Table I: Characteristics of the different types of fishing vessels operating in the Mauritanian EEZ in 1989 (after Chavance 1991)

Vessel type	Name	Width (m)	Length (m)	Nation	Displacement (tons)	Crew	Horse-power
1	"Super Altantik" (RMTS)	15.2	102	Rumania	3 163	88	3 880
2	"Super Atlantik" (RMTS)	15.2	102	ex-USSR	3 019	87–92	3 880
3	"Atlantik" (RTMA)	14	82	ex-USSR	2 177	80–96	2 320
4	"Medium Trawlers" (BMRT)	14	85	ex-USSR	2 400	77–93	2 000

MATERIAL AND METHODS

Data description

Commercial fisheries statistics from 1987 to 1993 were compiled from information provided by ships operating in the EEZ, made available by the Centre National de Recherches Océanographiques et des Pêches (CNROP), Nouadhibou, Mauritania. Supplementary data for 1989 were obtained from the CNROP archives (Chavance 1990). Reported catches were expressed in tons by country, fishing vessel type, month, year and species or species group. Fishing effort was expressed in days. Because some ships, particularly from the ex-USSR, reported combined catches, the following species or species groups were used: Carangid (*Trachurus trachurus*, *T. trecae* and *Decapterus rhonchus* combined); *Sardina pilchardus;* Sardinella (*Sardinella aurita* and *S. maderensis* combined); *Scomber japonicus*; and *Trichiurus lepturus*. Other species were grouped as "others", including pelagic fish such as anchovy *Engraulis encrasicolus* and demersal species such as hake *Merluccius* spp. Monthly data were grouped into four hydrographic seasons, according to Dubrovin *et al.* (1991): cold (January–May), cold-to-warm transition (June–July), warm (August–October) and warm-to-cold transition (November–December). The continental shelf was divided into two fishing zones: north and south of 19°N (Fig. 1).

Statistical analyses

A general linear modelling (GLM) procedure (SAS Institute Inc.1989) was used to perform univariate (ANOVA) and multivariate (MANOVA) data analyses. The MANOVA used *cpue* of the different species or species groups as dependent variables and fishing vessel type (Type), fishing zone (Zone) and hydrographic season of the year (Season) as independent variables. Multivariate analyses (Johnson and Wichern 1992) were deemed appropriate because (1) interdependence probably exists between the response variables (i.e. *cpue* of different species or species groups); (2) they test for simultaneous effects of independent variables on the response variables; and (3) they offer overall control of experimentwise error rate (Type I error). Also, contrast tests for specific *a priori* comparisons were used. *Post hoc* comparisons were carried out using Tukey's studentized multiple comparison test at the 5% significance level. The treatment YEAR was considered as a block, i.e. any

Table II: Annual fishing effort and catch (tons) by taxa, 1987–1993

Effort (days)		Catch (tons)						
Year	Effort	Carangidae	*Sardinella* spp.	*S. pilchardus*	*T. lepturus*	*S. japonicus*	Other	Total
1987	9 661	204 750	56 613	30 654	60 644	24 301	49 845	414 385
1988	9 074	187 828	59 600	39 628	64 208	30 545	36 712	411 798
1989	7 659	165 617	57 061	47 016	55 194	17 149	33 904	375 168
1990	8 357	89 956	107 408	32 902	57 458	20 077	66 328	365 829
1991	7 901	112 259	57 582	51 735	77 785	8 223	8 477	324 713
1992	7 789	131 552	47 554	29 380	76 374	16 723	8 579	327 027
1993	7 092	125 157	45 371	46 792	88 636	16 186	6 292	334 922
Mean	8 219	145 303	61 599	39 730	68 614	19 029	30 020	364 835
Percentage of total catch		40	17	11	19	5	8	100

Table III: Results of multivariate analysis of variance of differences in *cpue* (tons·day^{-1}) for the joint or multispecies model by year, vessel type, fishing zone and hydrographic season

Source	*Wilks' Lambda*	*F*	*Numdf*	*Dendf*	*p*
Year	0.17	8.73	36	635	**0.0001**
Type	0.10	27.73	18	408	**0.0001**
Zone	0.54	20.50	6	144	**0.0001**
Zone × Type	0.74	2.51	18	408	**0.0006**
Season	0.25	14.47	18	408	**0.0001**
Type × Season	0.72	0.98	54	739	0.5092
Zone × Season	0.62	4.11	18	408	**0.0001**
Zone × Type × Season	0.82	0.54	54	739	0.9974

Bold values denote significance at $p \leq 0.05$
Numdf = numerator degrees of freedom
Dendf = denominator degrees of freedom

year-to-year variations were removed. However, possible linear trends associated with the block were tested using contrasts (Freund and Wilson 1993). The *cpue* distribution was lognormal. Therefore, all means presented were geometric means. Descriptive statistics were generated and various plots of catch, effort and *cpue* were produced to investigate seasonal and spatial patterns as well as differences between fishing vessel. The magnitude of possible interactions was assessed. If interactions are not statistically significant, then the treatment effects (i.e. Zone, Type and Season) are independent and directly influence the response variable. When interactions do exist, determining the nature of the interaction is important, because there is an inconsistent effect of treatments on the dependent variables.

RESULTS

General considerations of effort and catch

From 1987 to 1993, total effort dropped from 9 661 to 7 092 fishing days (Table II). Most of the decrease in effort resulted from the Rumanian fleet (vessel Type 1) not fishing in the EEZ after 1991. The majority of the remaining total effort was attributable to ex-USSR vessels of Type 2. Vessels of Type 4 had the least effort and those of types 1 and 3 had intermediate contributions. Although the fleet's total effort was almost constant from month to month, its spatial deployment exhibited large seasonal variations (Fig. 2). This indicates a high degree of fleet mobility over the continental shelf. At the beginning of the year, during the cold-water season, vessels tended to move toward the southern zone where, by May, >80% of the effort was centered. During the transition from cold to warm water (June–July), the fleets moved toward the northern zone, where 85% of the total effort was concentrated by August (the warm-water season). Southward movement of the fleet gradually started again during the transition from warm to cold water (November–December). On average, annual deployment of effort was similar across the northern and southern fishing zones.

Total catch decreased from 426 000 tons in 1987 to 328 000 tons in 1993 (Table II). It is noteworthy that 1990 was the only year when the *Sardinella* catch (107 400 tons) exceeded the carangid catch (89 950 tons, Table II). The overall catch was dominated by Carangidae (40%) and Clupeidae, *Sardina pilchardus* and *Sardinella* spp., (28%). Trichiuridae and Scombridae accounted for 19 and 5% of the catch respectively.

Multispecies analysis

As stated earlier, univariate analyses permit tests for differences among vessel types, hydrographic seasons and fishing zones for each species or species grouping. However, results from univariate analyses do not guarantee an overall error protection, because the catch of one species or species group influences the catch of the others. Also, some results might be spuriously significant, because serial univariate analyses inflate the overall experimentwise error rate. In order to validate the univariate analyses, these variations require investigation at the joint or combined taxa level.

First, it should be noted that year (treated within the multivariate analysis as a blocking factor) had a significant effect (Table III), as also was the case in all univariate (individual taxa) analyses except for *Trichiurus lepturus* (Table IV). Moreover, total *cpue* tended to show statistically significant linear and quadratic trends over the years (Table V). All taxa jointly exhibited overall vessel type, fishing zone and

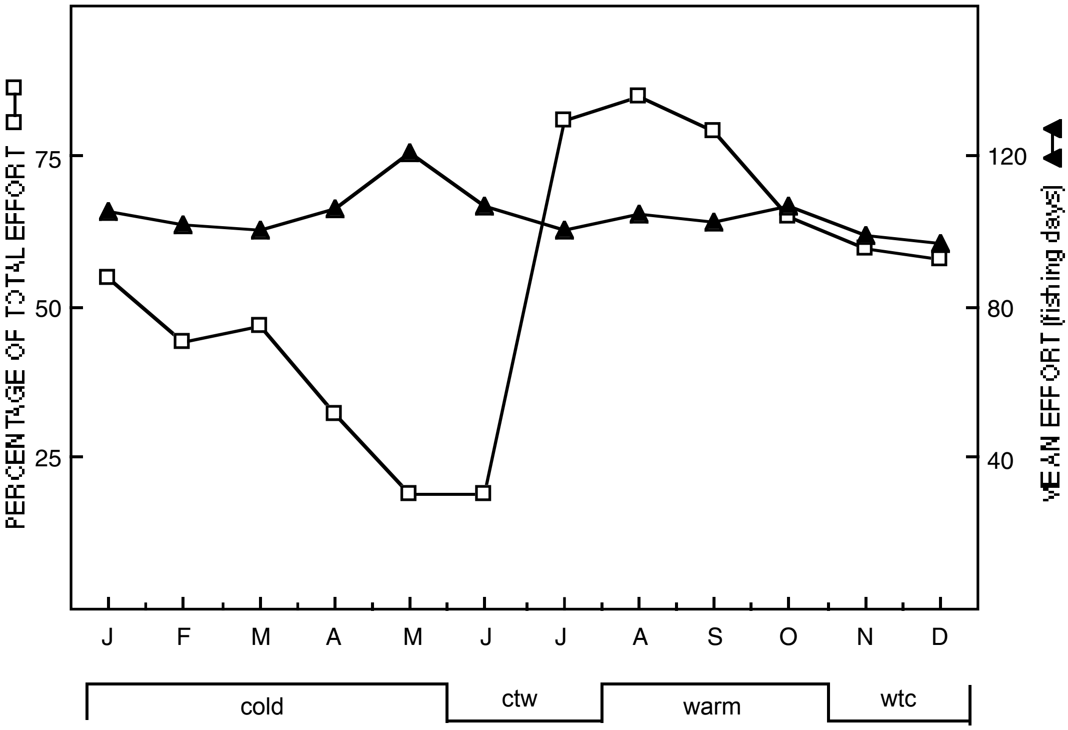

Fig. 2: Mean monthly effort (fishing days) and percentage of effort spent in the northern fishing zone for all vessels combined (1987–1993). Also shown are the hydrographic seasons: cold, cold-to-warm (ctw), warm and warm-to-cold (wtc)

hydrographic season effects as well as fishing zone × vessel type and fishing zone × hydrographic season interactions (Table III). Most of the variability in the response variable (total fishery *cpue*) can be explained by differences in vessel type ($p < 0.0001$), fishing zone ($p < 0.0006$) and hydrographic season ($p < 0.0001$). Results from Rumanian fishing vessels also differed considerably from the ex-USSR vessels, and yields in the warm-water season were significantly different from those taken during the cold-water season (Table V).

In the following sections, the various species groupings that exhibit the spatial and temporal variability that is suggested by the multivariate analysis of total fishery *cpue* are discussed.

Table IV: Results of univariate analysis of variance (*p*-values only) for differences in *cpue* (tons·day^{-1}) for each species or species grouping due to year, vessel type, fishing zone and hydrographic season

Source	*df*	Carangidae	*Sardinella* spp.	*S. pilchardus*	*T. lepturus*	*S. japonicus*	Other
Year	6	**0.0001**	**0.0001**	**0.0349**	0.1523	**0.0007**	**0.0001**
Type	3	**0.0001**	**0.0171**	**0.0001**	**0.0001**	**0.0004**	**0.0001**
Zone	1	**0.0001**	0.2026	**0.0001**	0.9465	0.3669	**0.0199**
Zone × Type	3	0.0631	0.6195	**0.0136**	0.0960	0.2774	**0.0341**
Season	3	**0.0001**	**0.0001**	**0.0001**	**0.0410**	**0.0001**	0.1379
Type × Season	9	0.3874	0.8206	0.2323	0.9449	**0.0155**	0.5978
Zone × Season	3	**0.0001**	**0.0379**	**0.0001**	0.2409	**0.0014**	0.5115
Zone × Type × Season	9	0.7500	0.9869	0.7482	0.8480	0.8001	0.9599

Bold values denote significance at $p \leq 0.05$

Table V: Test criteria and *F* statistics for multivariate analysis of variance for the hypothesis of no overall linear or quadratic effect, no differences between cold and warm hydrographic seasons, and no differences between fishing vessel types 1 and 2

Contrast	*Wilks' Lambda*	*F*	*Numdf*	*Dendf*	*p*
Linear year	0.369	41.10	6	144	0.0001
Quadratic year	0.845	4.41	6	144	0.0004
Vessel Type 1 v. 2	0.201	95.26	6	144	0.0001
Cold v. warm season	0.542	20.24	6	144	0.0001

Numdf = numerator degrees of freedom;
Dendf = denominator degrees of freedom

Species or species group analyses

CARANGIDAE

Carangid *cpue* revealed significant spatial and temporal variability. All treatment main effects (i.e. vessel type, fishing zone and hydrographic season) were significant, as was the zone × season interaction (Table IV). Carangid yields were higher in the southern fishing zone (18.4 tons·day^{-1}) than in the northern zone (9.8 tons·day^{-1}, Table VI). Also, *cpue* was significantly greater for the two transitional seasons (cold-warm = 17.7 tons·day^{-1} and warm-cold = 16.1 tons·day^{-1}) than the warm (12.5 tons·day^{-1}) and cold (9.3 tons·day^{-1}, Table VII) seasons. The *cpue* for ex-USSR vessel Type 2 (22.0 tons·day^{-1}) was significantly greater, and that for vessel Type 3 (8.8 tons·day^{-1}) significantly lower, than *cpue* for Types 1 and 4, which had similar yields (Table VIII). Carangid yield in the northern zone during the cold-water season (4.8 tons·day^{-1}) was lower than for any other zone/season combination (10.9–22.8 tons·day^{-1}, Table VI).

CLUPEIDAE

Sardinella spp.(S. aurita and S. maderensis combined) — Cpue was significantly influenced by vessel type, hydrographic season and the fishing zone × hydrographic season interaction (Table IV). Based on sum of squares, the seasonal effect accounted for the most variability, with significantly higher *cpue* of *Sardinella* spp. taken during the warm-water season (August–October, Table VII). A plot of the season × zone interaction (not shown) indicated that *cpue* of *Sardinella* spp. was higher in the northern zone from January to July (cold and cold-warm transition seasons), but lower during the remainder of the year. *Cpue* in the southern zone was highest during the warm season (10.5 tons·day^{-1}) and in the northern zone during the cold-warm transition (June–July) and warm seasons (10.2 and 9.7 tons·day^{-1} respectively, Table VI). *Post hoc* comparisons of vessel types indicated that ex-USSR Type 3 vessels had significantly higher yields of *Sardinella* spp. (6.5 tons·day^{-1}) than Type 4 vessels (4.3 tons·day^{-1}, Table VIII).

S. pilchardus — Cpue was significantly related to fishing zone, hydrographic season and the interactions of zone × season ($p < 0.0001$, Table IV) and zone × type ($p < 0.05$). In general, *cpue* was always greater in the northern zone in the cold season, and for the Rumanian vessels (Tables VI–VIII). For example, the

Table VI: Geometric mean values of *cpue* for each species or species group by fishing zone and hydrographic season (as defined in text) for all vessel types combined

Season	Geometric mean *cpue* (tons·day^{-1})					
	Carangidae	*Sardinella* spp.	*Sardina*	*Trichiurus*	*Scomber*	Other
Northern zone						
Cold	4.8	4.9	11.9	5.0	0.7	3.0
Cold-to-warm	13.6	10.2	0.4	5.7	3.9	3.0
Warm	10.9	9.7	0.6	5.6	1.7	3.1
Warm-to-cold	12.2	2.9	5.2	4.9	2.2	3.4
Mean*	9.8	6.3	2.9	5.3	1.9	3.1
Southern zone						
Cold	17.0	4.0	1.4	5.9	1.9	2.0
Cold-to-warm	22.8	4.6	0.1	6.5	3.2	1.8
Warm	14.2	10.5	0.2	4.6	1.3	2.3
Warm-to-cold	21.0	3.6	0.7	4.7	1.9	3.2
Mean*	18.4	5.2	0.5	5.4	2.0	2.3

*Geometric mean for all seasons combined highest *cpue* of *S. pilchardus* was from the northern zone during the cold season (11.9 tons·day^{-1}), whereas negligible yields were recorded in the southern zone during the transitional cold-warm and warm seasons (0.1–0.2 tons·day^{-1}, Table VI). Vessel Type 1 (Rumanian) appeared to catch more *S. pilchardus* than their ex-USSR counterparts, particularly in the northern zone.

T. lepturus — *Cpue* was significant for vessel type and hydrographic season only (Table IV). Although the total *cpue* was similar between fishing zones (Table VI), vessel Types 1 and 3 had higher *cpue*s for *T. lepturus* in the southern than in the northern zone; the reverse was true for vessel Types 2 and 4. The ex-USSR vessel Type 2 had a significantly higher *cpue* (12.3 tons·day^{-1}) than any of other vessel types; Rumanian vessels harvested the least at 0.4 tons·day^{-1} (Table VIII). The seasonal variation appeared to be weak, because *post hoc* comparisons did not show any significant seasonal *cpue* differences (Table VII). On average the highest *cpue* was observed during the cold-warm transition period (Table VII).

S. japonicus — *Cpue* varied mostly with vessel type and hydrographic season. Type × season and zone × season interactions were also significant (Table IV). The *cpue*s were significantly higher during the transitional cold-warm season (3.5 tons·day^{-1}) than during the rest of the year (Table VII). The northern zone had the highest yield except during the cold-season (Table VI). The Rumanian vessels had the highest yield (2.9 tons·day^{-1}), whereas Type 2 and 4 vessels had the lowest average *cpue* (1.8 and 1.5 tons·day^{-1} respectively, Table VIII).

Other species — *Cpue* for other species was significantly different for vessel types, fishing zones and the combined effect of type and zone. Type 1 vessels had the lowest *cpue* at 1.5 tons·day^{-1} (Table VIII). Yields for ex-USSR vessels were always higher in the northern than in the southern zone.

DISCUSSION

Multivariate analyses of species yields within the Mauritanian fishery for small, pelagic species show clear effects of year, vessel type, fishing zone and hydrographic season on fish yields. These are different for each species or group of species, being influenced by whether or not it is a primary fishery target of the various international fleets.

There are several strong indications that all types of fishing vessels tend primarily to target carangids. First, the combined catch is largely dominated by that group (40%). Second, throughout the year this species group consistently yields at least 22 tons·day^{-1}. Third, fleets tend to follow the migration of carangids. Highest yields of carangids are taken during the two transitional hydrographic seasons, corresponding to the migration of *Trachurus trachurus* and *T. trecae* over the Mauritanian continental shelf (Chavance *et al.* 1991a, Josse 1989). *T. trachurus* are taken over the shelf during the cold-water season, when they move southwards and reproduce along the coast (Garcia 1982). During the transition from cold to warm water, they reverse this migration, returning to the north and exiting Mauritanian waters by July (Garcia 1982, Chavance et *al.* 1991a). *T. trecae* are present throughout the year over the continental shelf. Their migration is closely related to the displacement of the front at the Inter-Tropical Convergence Zone (ITCZ, Chavance *et al.* 1991b). During the cold-water season, *T. trecae* are abundant in the southern region of the shelf. They start migrating northwards with the arrival of warm water from the south and occupy the whole shelf region during the warm-water season (Chavance *et al.* 1991a). The migration pattern of *D. rhonchus* is similar to that of *T. trecae*. The species is present off Mauritania throughout the year, being most abundant in the southern region of the shelf. They seem to migrate along the African coast in response to movement of the ITCZ (Garcia 1982, Chavance *et al.* 1991b). Carangid yields are lower in the north than in the

Table VII: Geometric mean values of *cpue* for each species or species group by hydrographic season for all vessel types and fishing zones combined. Also presented are Tukey's studentized multiple comparison tests by taxa. Treatments with nonoverlapping letters within the parentheses are significantly different at $p \leq 0.05$

Season	Geometric mean *cpue* (tons·day^{-1})					
	Carangidae	*Sardinella* spp.	*Sardina*	*Trichiurus*	*Scomber*	Other
Cold	9.3 (B)	4.4 (B)	4.5 (A)	5.4 (A)	1.3 (B)	2.4 (A)
Cold-to-warm	17.7 (A)	7.0 (B)	0.2 (C)	6.1 (A)	3.5 (A)	2.4 (A)
Warm	12.5 (B)	10.1 (A)	0.4 (C)	5.1 (A)	1.5 (B)	2.7 (A)
Warm-to-cold	16.1 (A)	3.2 (B)	2.3 (B)	4.8 (A)	2.0 (B)	3.3 (A)

Table VIII: Geometric mean values of *cpue* for each species or species group by vessel type for all hydrographic seasons and fishing zones combined. Also presented are Tukey's studentized multiple comparison tests by taxa. Treatments with nonoverlapping letters within the parentheses are significantly different at $p \leq 0.05$

Vessel type	Geometric mean *cpue* (tons·day^{-1})					
	Carangidae	*Sardinella* spp.	*Sardina*	*Trichiurus*	*Scomber*	Other
1	13.7 (B)	6.3 (AB)	2.8 (A)	0.4 (C)	2.9 (A)	1.5 (B)
2	22.0 (A)	5.9 (AB)	1.0 (B)	12.3 (A)	1.8 (B)	2.9 (A)
3	8.8 (C)	6.5 (A)	1.5 (B)	6.5 (B)	2.1 (AB)	2.8 (A)
4	11.9 (B)	4.3 (B)	1.2 (B)	5.0 (B)	1.5 (B)	3.5 (A)

south, and are reduced during the cold-water season. Acoustic surveys conducted over the Mauritanian continental shelf indicate that carangids dominate the pelagic biomass in the southern zone, especially during the cold-water season (Josse and Chavance 1988a, b). During the cold-water season, carangid catch consists mostly of *T. trachurus,* in both the northern and southern fishing zones. During the cold season, *D. rhonchus* is absent in the northern zone and *T. trecae* is predominant only in the southern zone (Chavance *et al.* 1991a). However, during the remainder of the year, *T. trecae* is the dominant species in both zones.

Clupeids constitute the second primary target for the pelagic fleets, accounting for an average of 28% of the total combined catch. Fishing vessels concentrate on *Sardinella* spp. throughout the year, but their maximum yield is taken during the warm season. The higher yield of *Sardinella* spp. taken during the warmer seasons is probably attributable to the fisheries targeting spawning aggregations. Round sardinella *S. aurita* spawn between July and August and a major part of spawning by Madeiran sardinella *S. maderensis* occurs between May and September (Boèly *et al.* 1982, Chavance 1991, Marchal 1991b). It is difficult to distinguish the catch of one *Sardinella* species from the other. Therefore, there is uncertainty in catch statistics that have been reported from elsewhere (F.A.O. 1994, 1995). Both species are present year-round, although acoustic surveys show that round sardinella disappear from the northern part of the shelf in May (Josse and Chavance 1988a). Therefore, it is likely that the catch during the transition from cold to warm water is mostly Madeiran sardinella.

The seasonal pattern for *Sardina pilchardus* is the reverse of that for *Sardinella* spp., with high yield taken during the cold-water season (January–May) and moderate catches during the transition from warm to cold water (November–December). *S. pilchardus* migrate onto the Mauritanian continental shelf in September–October and disappear around June (Chavance *et al.* 1991a). The species appears to prefer the cold water that intrudes onto the continental shelf during the cold-water season, and consequently yields are much higher in the northern zone. Availability may be higher than the catches suggest, given that acoustic surveys indicate that *S. pilchardus* represents up to 45% of the pelagic fish biomass in the northern part of the shelf during the cold season (Josse and Chavance 1988a, b).

The remaining groups targeted include *T. lepturus*, *S. japonicus* and the other unidentified species. Yields of these groups exhibit large seasonal and spatial variations, which are primarily determined by the availability of the more sought-after carangids and clupeids and the type of fishing vessel, rather than by their availability.

Key differences were also noticed between yields for Rumanian and ex-USSR vessels of *T. lepturus* and Clupeidae (*Sardina pilchardus* and *Sardinella* spp. combined). The average yield of *T. lepturus* for Rumanian vessels was only 0.4 tons·day^{-1}, whereas for ex-USSR vessels levels of 12.3 tons·day^{-1} were obtained. Although the proportion of *Sardinella* spp. in the total catch was almost identical for the four vessel types, Rumanian ships had a much higher yield of *S. pilchardus*, especially in the northern zone (up to 12 tons·day^{-1}). These differences can be attributable in part to market destination and on-board processing of the product. Ex-USSR vessels tend to export to Sub-Saharan countries such as Nigeria or Ghana, which have a clear preference for horse mackerels that are usually consumed smoked. Other species in the ex-USSR catch are usually processed into fishmeal. The Rumanian fleet exports either frozen or canned products to Eastern Europe, and to a lesser extent Egypt. Within the ex-USSR fleet (vessel Types 2–4), it appears that catch differences are mostly attributable to differences in the physical characteristics of the vessels. On average, Type 2 vessels have the highest yield, whereas Type 3 have generally higher yields than Type 4, except for carangids. This may be because Type 3 vessels tend to remain more in the northern part of the shelf; on average 66% of their total effort is spent in the northern fishing zone. As such, they seem to catch more clupeids and fewer carangids (Table VIII).

In summary, the small pelagic fishery off Mauritania has complex interactions between fleet movement and the seasonal variability of the species or species groups. The majority of the fleets tend to follow maximum carangid concentrations during all four seasons, whereas the other species' abundances may be maximum elsewhere. For example, during the cold-water season, *S. pilchardus* yield is high, especially in the north, yet the majority of the fleet stays in the south to harvest carangids. Therefore, extreme care needs to be exercised if *cpue* is to be used as an abundance index, because the fleets' fishing strategies and subsequent landings do not reflect the actual seasonal abundance of some of the species within the composite catch. To alleviate some of these problems, it is recommended that the annual *cpue* be constructed based on such methods as weighted least squares or combined ratio estimates.

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