

SWATH-MAPPING AND RELATED DEEP-SEA TRAWLING IN THE SOUTHEASTERN PART OF THE ECONOMIC ZONE OF NEW CALEDONIA

by

René GRANDPERRIN (1), Jean-Marie AUZENDE (2), Christian HENIN (1),
Yves LAFOY (3), Bertrand RICHER de FORGES (1), Bernard SÉRET (4),
Sabrina VAN de BEUQUE (5) & Sabrina VIRLY (6)

ABSTRACT. - Within the framework of the programme "ZoNéCo" of evaluation of the marine resources of the economic zone of New Caledonia, a series of operations were completed in the south-eastern part of the economic zone. The first was a bathymetrical and geophysical survey of the major part of the Norfolk Ridge and the southern end of the Loyalty Ridge. The data obtained on this survey provided a base for the preparation and completion of the deep-sea trawling survey "HALIPRO 2", the main objective of which was to search for commercial quantities of deep-sea fish, primarily orange roughy (*Hoplostethus atlanticus*). During this survey, 106 hauls were made between 230 and 1,860 m depth. A total catch of 263 fish species was made belonging to 192 genera and 101 families. In particular, 37 species of sharks and rays were collected of which 40% are new to science. The results confirm the extreme specific richness of the deep-sea ichthyofauna and the presence of species of commercial interest such as the alfonsino, *Beryx splendens*. However, orange roughy, was not located.

RÉSUMÉ. - Cartographie et chalutages profonds dans la partie sud-orientale de la zone économique de Nouvelle-Calédonie.

Dans le cadre du programme "ZoNéCo" d'évaluation des ressources marines de la zone économique de Nouvelle-Calédonie, une série d'opérations a été réalisée dans la partie sud-est de cette zone. Dans un premier temps, un relevé bathymétrique et géophysique a couvert la presque totalité de la Ride de Norfolk et de l'extrémité méridionale de la Ride des Loyauté. Les données acquises ont ensuite servi de base à la programmation et à la réalisation de la campagne de chalutage exploratoire "HALIPRO 2" menée sur des fonds de 230 à 1 860 m de profondeur et dont le principal objectif était d'identifier des ressources exploitables en poissons de profondeur, et notamment l'empereur (*Hoplostethus atlanticus*). Durant cette campagne, 106 traits de chalut ont permis la capture de 263 espèces de poissons appartenant à 192 genres et 101 familles. En particulier 37 espèces de requins et de raies ont été collectées dont 40% étaient inconnues. Les résultats de cette campagne confirment la grande richesse spécifique de l'ichtyofaune profonde et la présence d'espèces d'intérêt commercial, notamment de *Beryx splendens*. En revanche, aucun empereur n'a été capturé.

(1) ORSTOM, BP A5, Nouméa, NOUVELLE-CALÉDONIE. [grandper@noumea.orstom.nc]

(2) IFREMER, DRO/GM/Brest, FRANCE, now at: IFREMER c/o ORSTOM, BP A5, Nouméa, NOUVELLE-CALÉDONIE.

(3) Services des Mines et de l'Énergie, BP 465, Nouméa, NOUVELLE-CALÉDONIE.

(4) Muséum national d'histoire naturelle, Laboratoire d'Ichtyologie générale et appliquée, Antenne ORSTOM, 43 rue Cuvier, 75231 Paris Cedex 05, FRANCE.

(5) Université de Bretagne Occidentale (UBO), 29200 Brest, FRANCE, now at: ORSTOM, BP A5, Nouméa, NOUVELLE-CALÉDONIE.

(6) SMAI, BP 8231, Nouméa Sud, NOUVELLE-CALÉDONIE.

Key-words. - Deep-sea fishes, *Beryx splendens*, ISEW, New Caledonia, Swath-mapping, Deep-sea trawling, Inventory.

In order to evaluate the living and non-living marine resources of the economic zone (EZ) of New Caledonia, a programme named "ZoNéCo" was initiated in 1991. "ZoNéCo" comprises several partners: the French State, the "Service Hydrographique et Océanographique de la Marine" (SHOM), "Météo-France", the Territory of New Caledonia, the three Provinces ("Iles Loyauté", "Nord" and "Sud"), and the locally established research institutions (IFREMER, ORSTOM, "Université Française du Pacifique"). This programme involves many scientific disciplines: bathymetry and imagery of the seafloor, gravimetry, magnetism, seismology, satellite altimetry, physical oceanography and fishery sciences. The first priority of "ZoNéCo" was to establish a precise bathymetric map of the New Caledonian EZ. Initially all available conventional bathymetric data were compiled and a map of the entire EZ (Missègue *et al.*, 1992) was produced (Fig. 1). This map was used to select areas to be covered in more detail by swath-mapping surveys. Between 1993 and 1996, four swath-mapping cruises were carried out onboard the French research vessel "L'Atalante" equipped with the multibeam echosounder EM 12 DUAL. One of the major results of these surveys was the discovery of a number of ridges and seamounts previously unknown as well as the acquisition of more precise bathymetry of named structures. These data were used to select the features that could potentially be favorable to the existence of deep sea living resources. As a result of this work, several exploratory fishing surveys were carried out onboard the ORSTOM research vessel "Alis". In 1994 and 1995 two of these surveys were devoted to deep bottom-longline fishing between 300 and 800 m north of the main island of New Caledonia and on the Loyalty Ridge (Grandperrin *et al.*, 1995a, 1995b). In 1994, a bottom-trawling survey investigated the deep resources along the east coast and in the south of New Caledonia between 200 and 1,200 m (Grandperrin *et al.*, 1995c).

As far as the southeastern part of the EZ is concerned, several seamounts were studied by scientific exploratory cruises between 1980 and 1987 (Barro, 1981; Richer de Forges and Grandperrin, 1987) and then exploited by longlining from 1988 to 1991 (Laboute, 1989; Grandperrin *et al.*, 1990; Grandperrin and Lehodey, 1993; Lehodey, 1994) targeting the deep demersal alfoncino, *Beryx splendens*. The objective of this paper is to illustrate the input of swath-mapping on the strategy of the first deep-sea trawling survey ("HALIPRO 2") carried out in 1996 in the southeastern part of the EZ in the frame of the "ZoNéCo" programme. As a result of this work, commercial fishing is expected to take place in this area in the forthcoming years.

Topography of the southeastern part of New Caledonia

The southeastern part of New Caledonia EZ was swath-mapped in 1993 during the "ZoNéCo 1" survey onboard "L'Atalante" (Pautot *et al.*, 1993; Dupont *et al.*, 1995). Fifty-six EM 12 DUAL bathymetric profiles allowed a quite complete coverage of the area. A central zone represented by a 2,400 m-deep basin separating the Norfolk Ridge to the west from the Loyalty Ridge to the east was excluded of the survey.

The Norfolk Ridge, underlined by the isobath 2,000 m, is trending N 160°E and is characterized by a succession of ridges and seamounts. In detail the structure of the Norfolk Ridge comprised a west and east region. The western region is characterized by 2,000 m-deep ridges supporting shallow seamounts culminating at less than 600 m-

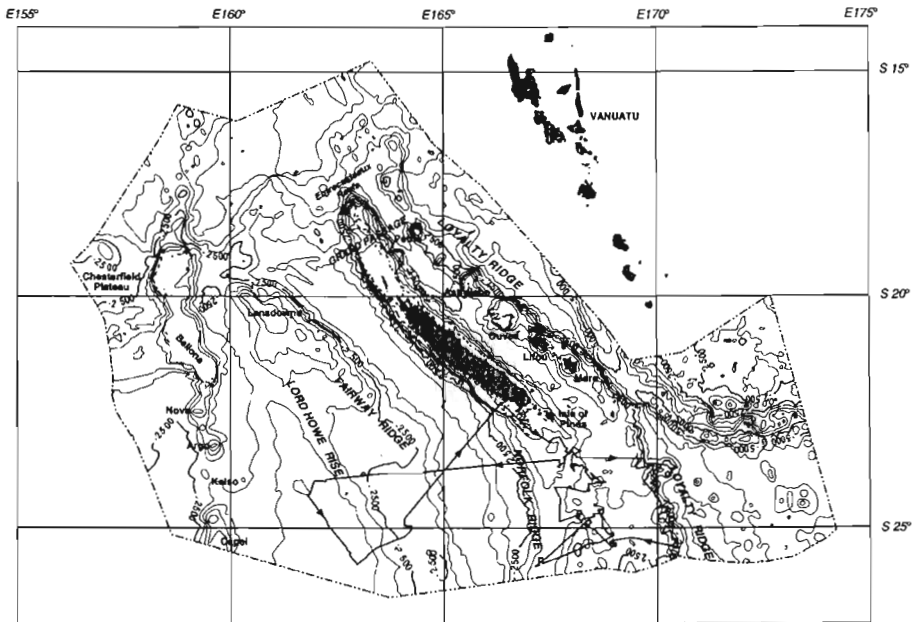


Fig. 1. - Bathymetric map of the EZ of New Caledonia (after Missègue *et al.*, 1992) and tracks of the deep-sea trawling survey "HALIPRO 2" (from Grandperrin *et al.*, 1997b).

depth. These seamounts are elongated along a NS or N 160°E direction and show small narrow tops of about 5 km long bounded by steep slopes (30%). The eastern region is deeper and comprises three large mounds 30 to 40 km-wide, aligned in a N 160°E trend.

Although the central basin east of the Norfolk Ridge was not surveyed during the cruise "ZoNéCo 1", the conventional bathymetric data give a general idea of its topography. It is 2,500 m-deep in its southern part and then the depth rises toward the northwest up to 23°S where a less than 2,000 m-deep saddle separates the central basin from the Loyalty Basin.

East of the central basin, the Loyalty Ridge is globally deeper than the Norfolk Ridge and its base is underlined by the 2,200 m isobath. The Loyalty Ridge is like the Norfolk Ridge roughly trending N 160°E, but the seamounts and ridges present on the main ridge show a complicated pattern, probably related to recent volcanic and tectonic events. Schematically they are aligned along a zig-zag model with the succession of NS and N 150°E directions. The secondary ridges are about 60 km-long and 40 km-wide and are flanked by steep slopes. They have large tabular summits culminating at less than 1,000 m depth. On the eastern side of the area transverse N 160°E trending ridges are evident. They are related to a transverse faulting characterizing the whole area.

The morphology and the nature of the structures observed on the swath-mapping and imagery maps offer particularly interesting features as far as marine habitats are concerned. Before swath-mapping, the surface exploited by the fishery from 1988 to 1991 on both the Norfolk and the Loyalty Ridges at depths ranging from 500 to 800 m was about 280 km². The survey "ZoNéCo 1" increased this surface up to 1,230 km². The depths between 800 to 1,500 m occupy about 15,000 km².

A SURVEY FOR DEEP-SEA RESOURCES: HALIPRO 2

The deep-sea trawling survey "HALIPRO 2" (Grandperrin *et al.*, 1997a, 1997b) was carried out in 1996 onboard the "*Tangaroa*", a New Zealand research vessel owned by the National Institute of Water and Atmospheric Research Ltd. (NIWA) and chartered by the programme "ZoNéCo". The survey aim was the identification of deep-sea fishery resources mainly on the Norfolk Ridge and the southern end of the Loyalty Ridge. This zone, the area of which is 73,000 km², was previously mapped during the seabed mapping survey "ZoNéCo 1" (Pautot *et al.*, 1993). An area to the west of the Lord Howe Rise was also surveyed (Fig. 1).

The survey

The trawl was similar to the one used by the New Zealand commercial deep-sea trawlers (headline length 38 m, headline height 7 m, codend meshsize 100 mm) with an additional codend liner/cover meshsize 40 mm. Seventeen scientists were on board, representing the three Provinces of New Caledonia, IFREMER, ORSTOM, and research institutions from New Zealand, Great Britain and the United States. In addition to fishing operations, the marine environment was studied by obtaining 18 CTD temperature and salinity profiles down to 1,500 m.

A total of 3,755 nautical miles were covered and 106 hauls were made at depths ranging from 230 to 1,860 m of the survey area. Most of the tows were completed on flanks and tops of seamounts (Fig. 2). The charts produced during the swath-mapping survey "ZoNéCo 1" were entered into the navigation system of the "*Tangaroa*" and they proved remarkably useful, providing such details that they were used by the fishing officers and scientists to work out the best trawl track. During a large part of the survey they could have been used as navigation charts.

The non-living environment

During "HALIPRO 2", temperature and salinity profiles did not fluctuate between stations. The corresponding TS diagrams show that the Intermediate Antarctic Waters as defined by Reid (1965, 1973), i.e., with temperature between 2°C and 10°C and salinity between 33.8 and 34.5, do not reach the EZ of New Caledonia (Grandperrin *et al.*, 1997b). Temperature and salinity sections also show a geostrophic circulation from east to west in the north of the zone and from west to east in the south.

Bottom types varied according to the area. Sediment was collected on many occasions and large pieces of rock were often found in the trawl. Seamounts from the northern part of the southern end of the Loyalty Ridge have a hard substratum with little sediment. Further south, sandy sediment appears more frequent. Although the seamounts of the Norfolk Ridge show mostly hard substratum outcrops, they are easier to trawl than the ones of the Loyalty Ridge for their summits and flanks are predominantly covered with mud and sand. As a whole, the area surveyed by "HALIPRO 2" was rather difficult to investigate by bottom-trawling due to the multiplicity of hard and rough bottoms on seamounts, particularly on sharp peaks and pinnacles.

The catch

"HALIPRO 2" confirmed the high fish species diversity already suspected from previous results (Barro, 1981; Richer de Forges and Grandperrin, 1987; Grandperrin *et al.*, 1990; Grandperrin and Lehodey, 1993; Lehodey, 1994; Séret *et al.*, 1997). A total of 263 fish species belonging to 192 genera and 101 families were caught (Table I). Of signifi-

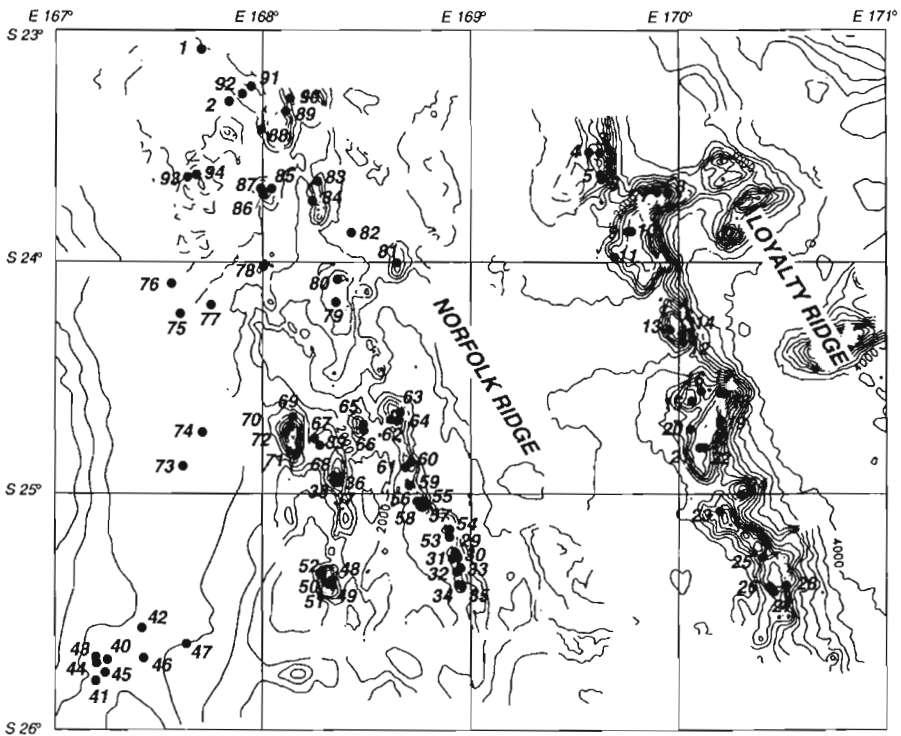


Fig. 2. - Swath-bathymetric map of the south-eastern part of the EZ of New Caledonia and locations of deep-sea trawling stations completed on the Norfolk Ridge and the southern part of the Loyalty Ridge during the deep-sea trawling survey "HALIPRO 2". For practical reasons, the trawled seamounts had to be named during the survey so that their name could be entered into the R/V "Tangaroa" internal computer network. These names have not been submitted to the agreement of the Intergovernmental Oceanographic Commission. Stations numbers are given in Grandperrin *et al.* (1997b). Interval between isobaths: 200 m.

cance, 37 different species of shark and ray were collected of which 40% are new to science (Table II). The best represented families were the Macrouridae with 24 species, the Squalidae with 19 species and the Alepocephalidae with 16 species. These families are found between 500 and 1,500 m in the world ocean. Many samples were collected for further analysis (population genetics, phylogeny, ageing, tissue analysis and parasite identifications).

A total of 15 commercial species representing close to 88% of the total fish catch were caught: *Beryx splendens*, *B. decadactylus*, *Pseudopentaceros richardsoni*, *Pentaceros decacanthus*, *Pristipomoides auricilla*, *P. flavipinnis*, *Cookeolus japonicus*, *Etelis coruscans*, *Wattsia mossambica*, *Hyperoglyphe antarctica*, *Seriola dumerili*, *S. lalandi* and the sharks *Squalus megalops*, *S. mitsukurii* and *Squalus* sp. *Beryx splendens* comprised 94% of the commercial fish. Its presence was confirmed between 500 and 800 m over the summits of the seamounts where this species was previously exploited. Hauls made deeper over slopes and flat bottoms produced no catch of orange roughy in spite of the fact that this species is abundant further south where it is the target of a flourishing New Zealand fishing industry.

Many invertebrates were caught such as echinoderms (ophiuroids and crinoids), molluscs (a few squids and octopus) and crustaceans. Many benthic organisms (sponges, gorgonians and corals) were often found meshed in the net. Among the crustaceans, some species of prawns which are commercially exploited in other countries were found in the catches (*Aristeomorpha foliacea*, *Aristeus virilis*, *Heterocarpus* spp., ...).

Table I. - Families (101) and numbers of genera (192) and species (263) of fishes caught during the deep-sea trawling survey "HALIPRO 2" off New Caledonia.

	Nb genera	Nb species		Nb genera	Nb species		Nb genera	Nb species
Chondrichthyes			Chlorophthalmidae	4	7	Zeniontidae	1	1
Chlamydoselachidae	1	1	Scopelarchidae	1	1	Macrurocyttidae	1	1
Hexanchidae	1	1	Notosudidae	2	2	Grammicolepididae	2	2
Squalidae	8	16	Synodontidae	1	2	Fistulariidae	1	1
Odontaspidae	1	1	Giganturidae	1	1	Macrorhamphosidae	1	1
Scyliorhinidae	2	8	Paralepididae	3	3	Scorpaenidae	2	3
Proscyllidae	1	1	Anopteridae	1	1	Triglidae	1	1
Rajidae	2	3	Evermannellidae	1	1	Psychrolutidae	1	1
Urolophidae	2	2	Omosudidae	1	1	Liparidae	1	1
Hexatrygonidae	1	1	Alepisauridae	1	3	Caproidae	1	2
Chimaeridae	2	2	Myctophidae	4	5	Priacanthidae	1	1
Rhinochimaeridae	1	1	Neoscopelidae	1	2	Serranidae	1	1
Teleostei			Moridae	3	3	Apogonidae	1	1
Congridae	1	1	Melanonidae	1	1	Acropomatidae	2	3
Ophichthyidae	1	1	Macrouridae	13	24	Lutjanidae	2	4
Synphobranchidae	2	2	Ophidiidae	4	7	Lethrinidae	1	1
Nettastomidae	1	1	Lophiidae	1	1	Pentacerotidae	3	4
Serrivomeridae	1	1	Chaunacidae	2	3	Bramidae	3	3
Nemichthyidae	2	3	Ogcocephalidae	2	2	Emmelichthyidae	2	2
Halosauridae	3	5	Himantolophidae	1	1	Carangidae	2	3
Gonorynchidae	1	1	Linophrynidae	2	2	Bathyclupeidae	1	1
Argentiniidae	1	1	Melanocetidae	1	1	Chiasmodontidae	3	5
Eurypharyngidae	1	1	Gigantactinidae	1	1	Uranoscopidae	1	1
Bathylagidae	1	1	Veliferidae	1	1	Percophidae	1	2
Alepocephalidae	9	16	Trachipteridae	1	1	Scombrobrabrachidae	1	1
Stomiidae	3	4	Berycidae	3	5	Gempylidae	8	9
Chauliodontidae	1	1	Ostracoberycidae	1	1	Trichiuridae	2	2
Astronesthidae	2	3	Trachichthyidae	1	2	Centrolophidae	2	2
Idiacanthidae	1	2	Anomalopidae	1	1	Ariommidae	1	1
Malacosteidae	2	2	Diretmidae	1	1	Monacanthidae	1	2
Melanostomiidae	5	6	Holocentridae	1	1	Triodontidae	1	1
Phonichthyidae	2	2	Stephanoberycidae	1	1	Tetraodontidae	1	1
Gonostomidae	2	4	Polymixiidae	1	1	Triacanthotidae	4	4
Sternoptychidae	3	4	Barbourisiidae	1	1			
Aulopidae	1	1	Zeidae	3	3			
						Total	192	263

Table II. - Chondrichthyan fishes caught during the deep-sea trawling survey "HALIPRO 2" off New Caledonia (L & S refers to Last and Stevens, 1994).

Chlamydoselachidae
<i>Chlamydoselachus anguineus</i> Garman, 1884
Hexanchidae
<i>Heptranchias perlo</i> (Bonnaterre, 1788)
Squalidae
<i>Centrophorus harrissoni</i> McCulloch, 1915 (Séret & Last, in prep.)
<i>Centrophorus</i> sp. n. "white fins" (Séret & Last, in prep.)
<i>Centroscymnus owstoni</i> Garman, 1906
<i>Centroscymnus "plunketi"</i> (Waite, 1909)
<i>Dalatias licha</i> Rafinesque, 1810
<i>Deania quadrispinosa</i> (McCulloch, 1915)
<i>Etmopterus lucifer</i> Jordan & Snyder, 1902
<i>Etmopterus</i> sp. cf. sp. "C" of L & S (1994) (Séret & Last, in prep.)
<i>Etmopterus</i> sp. cf. sp. "D" of L & S (1994) (Séret & Last, in prep.)
<i>Etmopterus</i> sp. cf. sp. "F" of L & S (1994) (Séret & Last, in prep.)
<i>Etmopterus</i> sp. ("pseudo-squaliolus") (Séret & Last, in prep.)
<i>Isistius brasiliensis</i> (Quoy & Gaimard, 1824)
<i>Squaliolus laticaudus</i> Smith & Radcliffe, 1912
<i>Squalus megalops</i> (Macleay, 1881)
<i>Squalus mitsukurii</i> Jordan & Snyder, 1903
<i>Squalus</i> sp. n. (Séret & Last, in prep.)
Odontaspidae
<i>Odontaspis ferox</i> (Risso, 1810)
Scyliorhinidae
<i>Apristurus</i> sp. 1 (long-snout) (Nakaya & Séret, in prep.)
<i>Apristurus</i> sp. 2 (white type) (Nakaya & Séret, in prep.)
<i>Apristurus macrorhynchus</i> (Tanaka, 1909)
<i>Apristurus platyrhynchus</i> (Tanaka, 1909)
<i>Apristurus sinensis</i> Chu & Hu, 1981
<i>Apristurus</i> sp. cf. <i>microps</i> Gilchrist, 1922 (Nakaya & Séret, in prep.)
<i>Parmaturus</i> sp. 1 (Séret & Last, in prep.)
<i>Parmaturus</i> sp. 2 ? (Séret & Last, in prep.)
Proscyllidae
<i>Gollum attenuatus</i> (Garrick, 1954)
Rajidae
<i>Raja</i> (subgenus C) sp. n. (blue) (Séret & Last, in prep.)
<i>Pavoraja</i> sp. 1 (dark) (Séret & Last, in prep.)
<i>Pavoraja</i> sp. 2 (pale) (Séret & Last, in prep.)
Urolophidae
<i>Plesiobatis daviesi</i> (Wallace, 1967)
<i>Urolophus</i> sp. n. (Séret & Last, in prep.)
Hexatrygonidae
<i>Hexatrygon</i> sp. n. (long snout) (Séret & Last, in prep.)
Chimaeridae
<i>Chimaera phantasma</i> Jordan & Snyder, 1900
<i>Hydrolagus</i> sp. (Whitley, 1939) (Dagit & Séret, in prep.)
Rhinochimaeridae
<i>Rhinochimaera pacifica</i> (Mitsukuri, 1895)

DISCUSSION - CONCLUSION

The emergence of multibeam echosounders has greatly improved seafloor mapping. These tools allow a more efficient coverage of large areas of ocean than the conventional sounders. They also provide images of the bottom which could be interpreted in terms of seabed texture. These kinds of data, which help to describe the topography and bottom type, provide a necessary step prior to any exploratory surveys and subsequent commercial fishing trips. Knowledge of these parameters saves time during the survey and increases the safety of deep-sea trawling operations. The topography of the southeastern part of the EZ of New Caledonia is now well known. The area is characterized by large shallow ridges which should constitute good spots for deep-sea longlining and trawling operations. However, swath-mapping has revealed the existence of sharp peaks and pinnacles which make trawling difficult.

The survey "HALIPRO 2" confirmed the high richness of the fish fauna and the presence of an exploitable resource mainly represented by the alfonsino. Unfortunately, the expected orange roughy was not caught. The absence of this fish could be related to the stratigraphy of the water column where the Intermediate Antarctic Waters do not occur. In contrast, the Intermediate Antarctic Waters are present around New Zealand where they characterise the habitat of the orange roughy.

During the "ZoNéCo 1" survey of R/V "L'Atalante" in June and July 1993, an Acoustic Doppler Current profiler (ADCP) revealed a large counter-clockwise gyre centered between the two ridges of Norfolk and the Loyalty Islands and recorded as deep as 700 m (Henin, 1994). The existence of the geostrophic currents flowing in opposite directions revealed during "HALIPRO 2" might confirm the existence of the gyre. Such a strong eddy might play a major role in the dissemination of larvae and juveniles of some marine species of commercial interest such as *Beryx splendens* (Lehodey, 1994; Lehodey *et al.*, 1997) and would evidence the existence of a single stock over the area. This information is of major importance for the management of a future fishery. Genetic studies presently carried on muscle samples of alfonsino collected during "HALIPRO 2" will confirm or not this hypothesis.

Acknowledgements. - The authors wish to thank the programme "ZoNéCo" of evaluation of the marine resources of the economic zone of New Caledonia for its financial and logistical support. Special thanks are due to Dominique Dagit, Tomio Iwamoto, Peter Last, Nigel Merrett, Kazuhiro Nakaya and Clive Roberts for their fruitful collaboration in identifying and studying some groups of fishes.

REFERENCES

- BARRO M., 1981. - Rapport de mission à bord du chalutier japonais "Kaimon Maru" (26 nov.-10 déc. 1980). 21 p. Nouméa: ORSTOM.
- DUPONT J., LAFOY Y., PAUTOT G., LE SUAVE R., CLUZEL D., MISSEGUE F., GRANDPERRIN R., HENIN C., VOISSET M., DURAND SAINT OMER L., GAUTHERON L., BUTSCHER J., MOLLARD L., MAURIAMAI RAKOIA et le Groupe ZoNéCo à bord de "L'Atalante", 1995. - Étude morphostructurale de la zone sud des rides Nouvelle-Calédonie et Loyauté (Zone Economique Exclusive de Nouvelle-Calédonie, Pacifique Sud-Ouest). *C. R. Acad. Sci. Paris*, 320, 11a: 211-218.

- GRANDPERRIN R., LABOUTE P., PIANET R. & L. WANTIEZ, 1990. - Campagne "AZTEQUE" de chalutage de fond au sud-est de la Nouvelle-Calédonie (N.O. "Alis", du 12 au 16 février 1990). Nouméa: ORSTOM. *Rapp. Missions, Sci. Mer, Biol. mar.*, 7: 21 p.
- GRANDPERRIN R., BARGIBANT G. & J.-L. MENOUE, 1995a. - Campagne HALICAL 1 de pêche à la palangre de fond dans le Nord et sur la ride des Loyauté, en Nouvelle-Calédonie. N.O. "Alis", 21 novembre - 1er décembre et 12-23 décembre 1994. *Conv. Sci. Mer, Biol. mar.*, 12: 67 p. Nouméa: ORSTOM.
- GRANDPERRIN R., MENOUE J.-L., BARGIBANT G., HOFFSCHIR C. & T. LE VAILLANT, 1995b. - Campagne HALICAL 2 de pêche à la palangre de fond dans le Nord et sur la Ride des Loyauté, en Nouvelle-Calédonie, N.O. "Alis", 17-27 janvier et 1-10 février 1995. Convention ORSTOM/Programme ZoNéCo (Evaluation des ressources marines de la zone économique de Nouvelle-Calédonie). *Conv. Sci. Mer, Biol. mar.*, 13: 48 p. Nouméa: ORSTOM.
- GRANDPERRIN R., BUJAN S., MENOUE J.-L., RICHER de FORGES B. & J. RIVATON, 1995c. - Campagne HALIPRO 1 de chalutages exploratoires dans l'Est et dans le Sud de la Nouvelle-Calédonie (N.O. "Alis", 18-25 mars-1er avril 1994). *Conv. Sci. Mer, Biol. mar.*, 14: 61 p. Nouméa: ORSTOM.
- GRANDPERRIN R., RICHER DE FORGES B., AUZENDE J.-M., BOUNIOT E., DURAND SAINT-OMER L., HABAUT C., HENIN C., LABOUTE P., LAFOY Y., RIVATON J., THOMAS J., VAN DE BEUQUE S. & S. VIRLY, 1997a. - Ressources marines de Nouvelle-Calédonie: le programme ZoNéCo (Marine resources of New Caledonia: the ZoNéCo programme). 100 p. Nouméa: Programme ZoNéCo d'évaluation des ressources marines de la zone économique de Nouvelle-Calédonie (edit.).
- GRANDPERRIN R., FARMAN R., LORANCE P., JOMESEY T., HAMEL P., LABOUTE P., LABROSSE P., RICHER DE FORGES B., SÉRET B. & S. VIRLY, 1997b. - Campagne HALIPRO 2 de chalutages exploratoires profonds dans le sud de la zone économique de Nouvelle-Calédonie (R.V. "Tangaroa", 4-28 novembre 1996). 150 p. Nouméa: Programme ZoNéCo d'évaluation des ressources marines de la zone économique de Nouvelle-Calédonie (edit.).
- GRANDPERRIN R. & P. LEHODEY, 1993. - Étude de la pêcherie de poissons profonds dans la zone économique de Nouvelle-Calédonie. Rapport final. *Conv. Sci. Mer, Biol. mar.*, 6: 321 p. Nouméa: ORSTOM.
- HENIN C., 1994. - Rapport des données physiques de la campagne ZoNéCo I à bord du N.O. "L'Atalante" du 26 juin au 15 juillet 1993. *Rapp. Missions, Sci. Mer, Océanogr. Phys.*, 11: 62 p. Nouméa: ORSTOM.
- LABOUTE P., 1989. - Mission d'observations halieutiques sur le palangrier japonais "Fukuju Maru" du 21 novembre au 12 décembre 1988. *Rapp. Missions, Sci. Mer, Biol. mar.*, 2: 15 p. Nouméa: ORSTOM.
- LAST P.R. & J.D. STEVENS, 1994. - Sharks and Rays of Australia. 513 p. Australia: CSIRO, Division of Fisheries.
- LEHODEY P., 1994. - Les monts sous-marins de Nouvelle-Calédonie et leurs ressources halieutiques. Thèse de Doctorat, 402 p. *Travaux et Documents microfichés*, 122. Paris: ORSTOM.
- LEHODEY P., GRANDPERRIN R. & P. MARCHAL, 1997. - Reproductive biology and ecology of a deep-demersal fish, alfoncino *Beryx splendens*, over the seamounts off New Caledonia. *Mar. Biol.*, 128: 17-27.
- MISSEGUE F., DUPONT J. & J. DANIEL, 1992. - Carte bathymétrique de synthèse de la zone économique de la Nouvelle-Calédonie. Projet ZOE 500. *Conv. Sci. Terre, Géol. Géophys.*, 5: 43 p. (unpubl.). Nouméa: ORSTOM.
- PAUTOT G., DUPONT J., LAFOY Y., LE SUAVE R., AUGUSTIN J.-M., BUTSCHER J., CLUZEL D., DURAND SAINT-OMER L., GAUTHERON L., GRANDPERRIN R., HENIN C., LE DREZEN E., LE FUR Y., MAURIAMAI R., MISSEGUE F., MOLLARD L. & M. VOISSET, 1993. - Campagne ZoNéCo I, rapport de fin de campagne. 173 p. Brest, France: IFREMER.
- REID J.L., 1965. - Intermediate waters of the Pacific Ocean. *Johns Hopkins Oceanogr. Stud.*, 2: 85 p.
- REID J.L., 1973. - The shallow salinity minima of the Pacific Ocean. *Deep-Sea Res.*, 20: 51-68.

- RICHER DE FORGES B. & R. GRANDPERRIN, 1987. - La campagne CHALCAL II sur les guyots de la ride de Norfolk (N.O. "Coriolis" 26 octobre-1er novembre 1986). *Rapp. sci. tech.*, 42: 41 p. Nouméa: ORSTOM.
- SÉRET B., GRANDPERRIN R. & J. RIVATON, 1997. - Poissons de profondeur et ressources halieutiques de la zone économique de Nouvelle-Calédonie. *Cybium*, 21(1) suppl.: 99-106.