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Optimization of a fishery sampling technique by analysing specific diversity.

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Abstract : To study a coastal nectobenthic fish nursery along the Pas-de-Calais in Eastern Channel, an appropriate sampling technique was developed by analysing the specific diversity and the multispecific structure of the samples obtained by trawling. In this paper I have examined the role of the trawling time to choose an average duration and the trawling direction compared to the tidal current to collect a representative fauna list of the fish community in the nursery. The optimized fishery sampling technique, based on the standard, was finalized at a speed for each trawling operation of about 1.5 knot during 15 minutes against the tidal current and parallel to the coast.

Résumé : Une technique d'échantillonnage appropriée a été mise au point, par l'analyse de la diversité spécifique et de la structure multi-spécifique des échantillons obtenus par chalutage, pour être appliquée à une étude écologique d'une nourricerie littorale de poissons nectobenthiques le long du Pas-de-Calais. Dans ce travail, j'ai examiné le rôle du temps de chalutage pour déterminer une durée moyenne, et la direction de chalutage par rapport au courant de marée pour obtenir une liste faunistique représentative des peuplements de poissons de la nourricerie. La technique d'échantillonnage, optimisée et inspirée des standards existants, a été réalisée à une vitesse de chalutage d'environ 1.5 nœud pendant 15 minutes contre le courant de marée, et parallèle à la côte.

INTRODUCTION

The purpose of this work is to develop a sampling technique which will later be adapted to an ecological survey of a coastal nectobenthic fish nursery. Indeed, a study of the by-catch in an artisanal brown shrimp (*Crangon crangon*, L.) fishery in the Canche Bay, which shows the existence of an important nursery of nectobenthic fish, demonstrates the necessity of a scientifically proven sampling strategy (Safran, 1987 a).

In most of the surveys of young fish, authors never provide any critical justification of their techniques (Riley & Corlett, 1965 ; Edwards & Steele, 1968 ; Boddeke *et al.*, (1969) 1970 ; Beillois *et al.*, 1979 ; Riley *et al.*, 1981 ; Dorel, (1980) 1983 ; Peronnet & Tetard, 1984 ; Durand & Dorel, (1981) 1984) ; nevertheless, for some commercial species, some of them analyse with precision the ease of catching, the retentivity, the selectivity and the valuerability (Cassie, 1955 ; ICNAF, 1963 ; Parrish, 1963 ; Gulland, 1975 ; Saville, 1978 ; Grosslein & Laurec, 1982). In the present work I am also concerned with the problem of the efficiency and the selectivity of the tool, but with a plurispecific aspect. In other words, for studying the influence of the technique on sample characteristics, the comparison critera is the specific diversity and the multispecific structure of the samples. In line with this view I examine the role of the trawling time in order to choose an appropriate average duration, and the trawling direction compared to the tidal current for collecting representative fauna

list of the multispecific populations of the nursery. This work is a part of a survey performed along the Pas-de-Calais in Eastern Channel, and published in Safran (1987 b).

MATERIALS AND METHODS

STUDY AREA

The study area was located in the north of the Canche estuary, along the french Opal Coast in Eastern Channel (Fig. 1). The coastal zone had a sand/sand-mud bottom with a depth varying from three to six meters according to the tidal index, and was relatively homogeneous in terms of multispecific aspects.

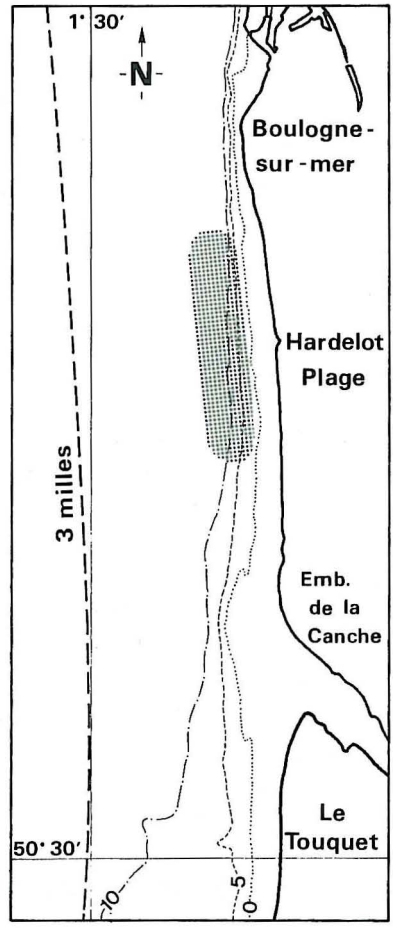

Fig. 1 : Study area : the Opal coast (Eastern Channel, Pas-de-Calais, France).

TRAWL

For this study an experimental beam-trawl was formed, according to the standards and specially adapted to the oceanographic vessel "SEPIA II"(Station Marine de Wimereux - Université des Sciences et Techniques de Lille 1/ Centre National de la Recherche Scientifique : "CNRS"). This ship has similar technical characteristics to small professional fishing boats : 12.5 meter in length and 112 HP engine power.

The characteristics of this experimental beam-trawl are shown in figure 2. The trawl length was about 8.20 meters, with a pole stretching a span of 2.80 meters and skates which were 0.40 meter in height. The pocket included two sectors, the first one was formed by a 14 millimeters mesh-side and the second one was formed by a 10 millimeters mesh-side. In front of this net was a chain-pad which was preceded by a chain used to raise the fishes (Kuipers, 1975).

SAMPLING METHOD

To choose an appropriate average duration and to allow ourselves a maximum of experimental captures during about twelve hours of "sea working time", once or twice a month, a series of trawling operation were implemented : two trawling operations during five minutes, two during 10 minutes, one during 15 minutes, one during 20, 25, 30, 35, 40 and 45 minutes. These operations were done at a speed of about 1.5 knot (1.5 mile per hour), against the tidal current and parallel to the coast, on March 10 of 1986. This technique was based on the standard professional techniques, and indeed some fishermen use this way of trawling to collect brown shrimp and by-catch (Safran, 1985).

To select the trawling direction, a second series of experimental trawling operations was done varying the trawling direction, according to the tidal current. For each trawling duration : of 5, 15, 25, 35 and 45 minutes. two operations were done ; the first was against the tidal current and the second with the tidal current, on April 7 1986.

DATA ANALYSIS

The trawling composition was variable, so complementary multivariate statistical methods were used in order to show common points and differences between the samples. Specific Diversity was obtained by the Shannon Index (Shannon & Weaver, 1963), while Evenness was obtained by the Pielou Index (Pielou, 1975). A good description of the specific diversity of a sample is given by a representation of the distribution of individuals among species, so Rank-Frequency Diagrams, or RFD, are used to model this distribution (Frontier, 1985). For one sample, the shape of the curve is generally irregular, smoothed curves are obtained by accumulating the samples following Safran (1987 a). In this paper, average RFD were got by accumulating the number of individuals by rank, independent of the species in the ranks which fluctuated from one sample to another sample.

To compare the different trawling operation on the basis of the relative composition

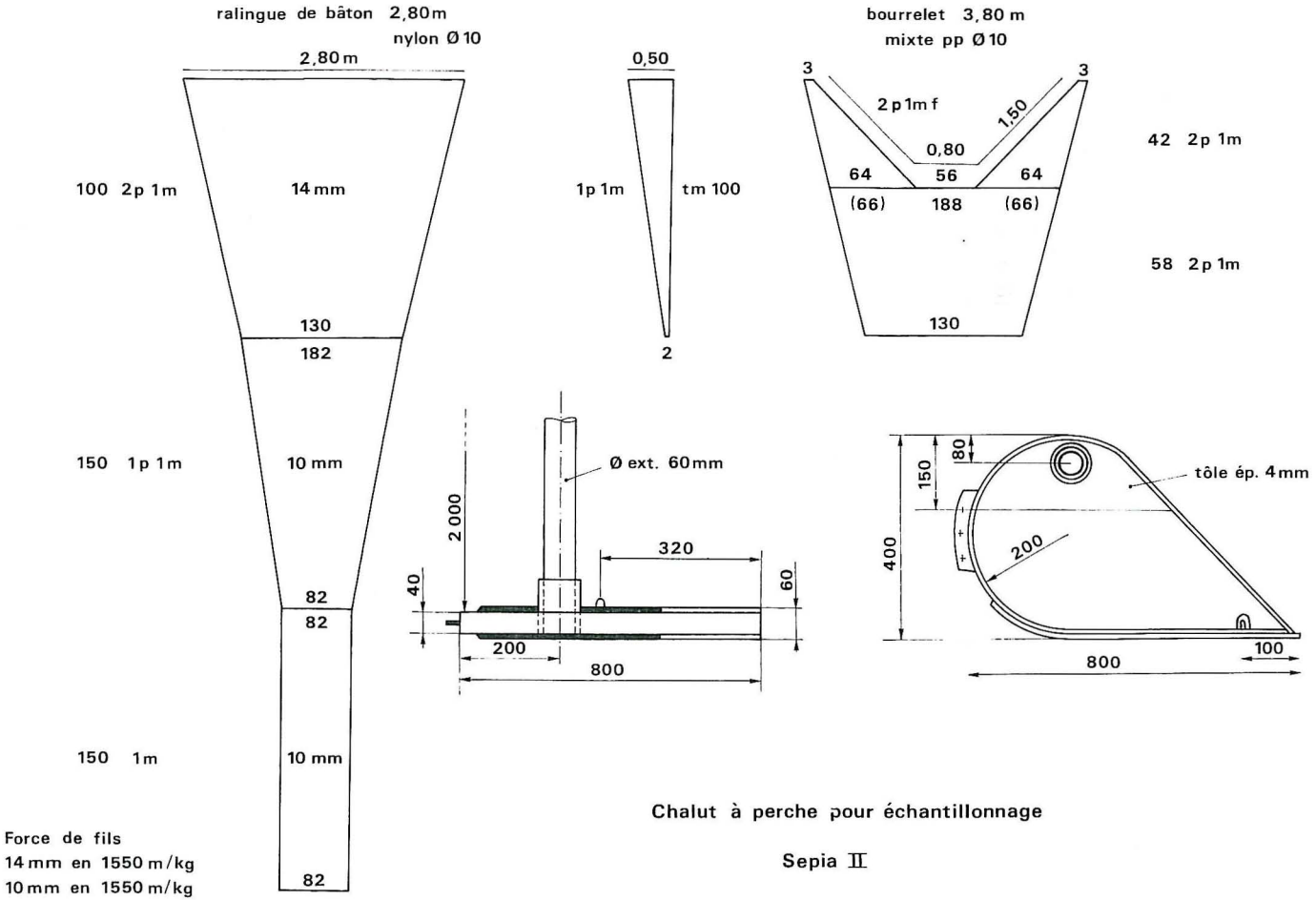

Fig. 2 : Experimental beam-trawl : technical card (IFREMER, Boulogne-sur-Mer, XII 84, ech. 1/50, ref. F 312).

species, Factorial Analysis of Correspondence (Legendre & Legendre, 1984) was used. A sample-point in the factorial space represented the relative composition of species, near points showing that the mutual proportions in species were not very different. Numerical Classification by Cluster Analysis was obtained by the Quantitative Similarity Index of Gower based on the abundance of species (Gower, 1971), and by the Qualitative Similarity Index of Ochiai based on the presence-absence of the species (Ochiai, 1957). The dendrogram was obtained by the Flexible Clustering Method of Lance-Williams (Lance & Williams, 1967).

RESULTS

SELECTION OF THE TRAWLING DURATION.

The different Data Analyses applied on the data board of contingence (11 experimental trawlings and 27 collected species of fish juvenile) showed two groups of samples. The

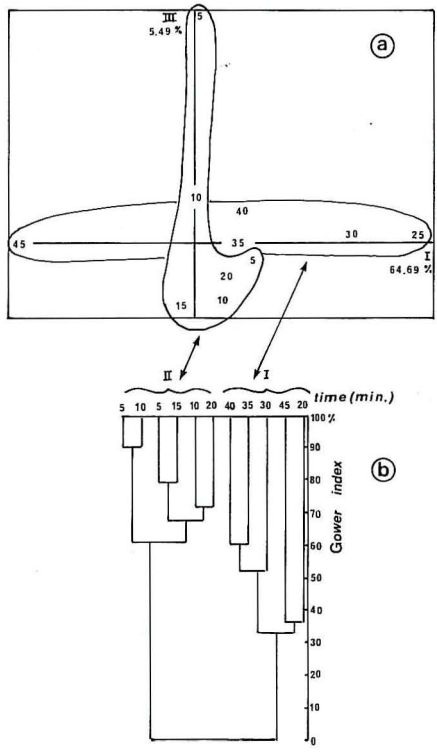

Fig. 3 : Selection of the trawling duration : Factorial Analysis of Correspondence (a) - projections in the plane of axes I and III of "time" vectors, and (b) dendrogram obtained by Gower similarity index.

Factorial Analysis of Correspondence showed that 64.69 % of the total inertia were absorbed by the first axis, which was defined by a group of samples with a trawling duration of 25 to 45 minutes (Fig. 3a). This group contrasted with a group of samples with a trawling duration of less than 25 minutes, shown on the third axis (5.45 % of the inertia). The quantitative similarity obtained by the Gower Index showed the same ordination (Fig. 3b) : trawling operations with a duration of 25 minutes or more (I) and trawling operations with a duration of less than 25 minutes (II).

SELECTION OF THE TRAWLING DIRECTION.

The Data Analysis showed a difference between two replicative samples of the same duration done against the tidal current and with the tidal current. The Numerical Classification of samples, represented by the dendrogram obtained by the Qualitative

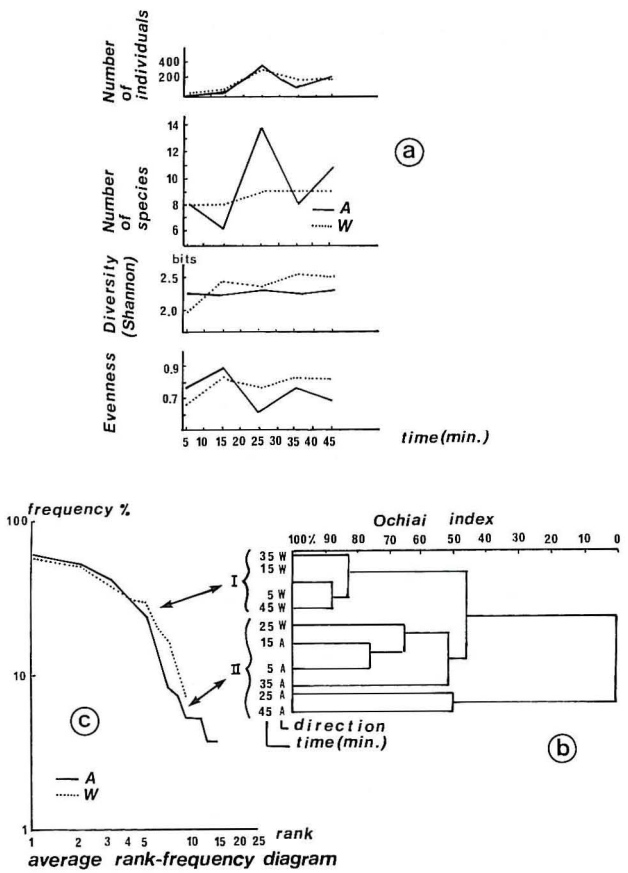

Fig. 4 : Selection of the trawling direction : fluctuations of number of individuals, specific richness, specific diversity (Shannon index) and Evenness (Pielou index) according to the trawling duration (a) ; dendrogram obtained by Ochiai similarity index (b) ; and average rank-frequency diagrams (c) for the trawling operations against the tidal current (A) and with the tidal current (W)..

Similarity Index of Ochiai (Fig. 4b), showed a group (I) of trawling directions with the tidal current and another group (II) composed of trawling directions against the tidal current. The specific diversity obtained by the Shannon Index (Fig. 4a) and the plurispecific structure, illustrated by the smoothed average rank-frequency diagram (Fig. 4c), showed that the multispecific population sampled with the tidal current seemed more diversified and more regular than the samples caught against the tidal current. Nevertheless, the frequency of the species was lower, while in the community sampled against the tidal current the specific richness increased (Fig. 4a), seven new species appeared and a better stability of the specific diversity was found . The average RFD of the samples obtained against the tidal current (Fig. 4c) was more vertical and its evenness was lower.

DISCUSSION

The results obtained in this survey suggested that for a trawling duration of more than 20 minutes, which represented a prospected zone larger than 3000 m^2, the study area lost its fauna homogeneity. A sample bias could be introduced by a mixture and/or a change of community, or by an encounter with a monospecific shoal. More, it was difficult to draw conclusion based on the weak values obtained for 5 minutes of trawl. In conclusion, the selection of an appropriate average duration was performed in the second group which was represented by trawling time less than 25 minutes, and more than 5 minutes. 15 minutes were chosen, and that was in agreement with the standard trawling duration which is usually used for young fish survey.

The technique of trawling against the tidal current, which showed a specific richness higher, a specific diversity more stable and quite homogeneous and an evenness lower, seemed to be more appropriate than the technique of trawling with the tidal current. The first technique gave to get a better image of the fish community in this area. A more complete fauna list of the multispecific populations, which will be studied within the framework of an ecological survey of a nectobenthic fish nursery, was obtained by this fishery technique ; more- over, this way of trawling was in agreement with the professional technique which was the fisherman's great empirical knowledge of the sea.

In conclusion, the fishery sampling technique, which will later be used to study the nursery along the Pas-de-Calais, based on the standard and optimized by analysing the specific diversity, was finalized at a speed for each trawling operation of about 1.5 knot during 15 minutes against the tidal current, and parallel to the coast.

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REFERENCES

BEILLOIS, P., Y. DESAUNAY, D. DOREL & M. LEMOINE, 1979. Étude des nurseries littorales de la baie du Mont Saint-Michel et du Contentin. CIEM/G : 30 (Cté des poissons de fond), 6 p.

BODDEKE, R., N. DANN, K.H. POSTUMA, J.F. DE VEEN & J.J. ZIJLSTRA, (1969) 1970. A census of juvenile demersal fish in the Dutch Waddensea, the Zeeland nursery ground, the Duth coastal area and the open sea areas off the coasts of the Netherlands, Germany and the southern part of Denmark (YFS) *CIEM ann. biol.*, n° 26 : 269-275.

CASSIE, R.M., 1955. The escapement of small fish from trawl nets and its application to the management of the New Zealand Snapper Fisheries. *New Zealand marine Dept., Fish. Bull.*, n° 11 : 99 p.

DOREL, D., (1980) 1983. Étude des nurseries de deux secteurs côtiers de la Manche en 1980. *CIEM ann. biol.*, n° 37 : 292-297.

DURAND, J.L. & D. DOREL, (1981) 1984. Évaluation de l'abondance du pré-recrutement pour quelques nurseries littorales françaises. *CIEM ann. biol.*, n° 38 : 179-180.

EDWARDS, R. & J.H. STEELE, 1968. The ecology of 0-group Plaice and Common Dab at Loch Ewe. I : Population and Food. *J. Exp. Mar. Biol. Ecol.*, Vol. 2. : 215-238.

FRONTIER, S., 1985. Diversity and Structure in aquatic ecosystems. *Oceanogr. Mar. Ann. Rev.*, 23 : 253-312.

GOWER, J.C., 1971. A general coefficient of similarity and some of its properties. *Biometrics*, 27 : 857-871.

GROSSLEIN, M. D. & A. LAUREC, 1982. Bottom trawl surveys design, operation and analysis. INT/79/019, *CACAF/ECAF. Series 81/22*, 25 p.

GULLAND, J.A., 1975. Manual of methods for fisheries resource survey and appraisal. Part 5. Objectives and Basic methods. *FAO Fish. Tech. Pap.*, 145, 29 p.

ICNAF, 1963. *The selectivity of fishing gear.* Special publication n° 5, 225 p.

KUIPERS, B., 1975. On the efficiency of a two-meter beam trawl for juvenile Plaice (*Pleuronectes platessa*, L.). *Neth. J. of Sea Research*, 9 (1) : 69-85.

LANCE, G.N. & W.T. WILLIAMS, 1967. A general theory of classificatory sorting strategies. I. Hierarchical systems. *Computer J.*, 9 : 373-380.

LEGENDRE, L. & P. LEGENDRE, 1984. *Écologie Numérique*. I : *Le traitement multiple des données écologiques*. Masson écologie n° 12, Paris, 260 p. II : *La structure des données écologiques*. Masson écologie N° 13, Paris 335 p.

OCHIAI, A., 1957. Zoogeographic studies on the soleoid fishes found in Japan and its neighbouring regions. *Bull. Jap. Soc. Sci. Fish.*, 22 : 526-530.

PARRISH, B.B., 1963. Some remarks on selection processes in fishing operations. In, The *Selectivity of Fishing gear*, ICNAF, Special publication n° 5 : 166-170.

PERONNET, I. & A. TETARD, 1984. Évolution pluriannuelle des nourriceries de poissons plats dans le secteur de la baie de Somme. CIEM/G : 22 (Cté des poissons démersaux), 10 p.

PIELOU, E.C. 1975. *Ecological diversity*. Wiley, NY, VIII, 165 p.

RILEY, J.D. & J. CORLETT, 1965. The numbers of 0-group Plaice in Port Erin Bay, 1964-66. *Rep. Mar. Biol. Sta. Port Erin*, 78 : 51-56.

RILEY, J.D., D.J. SYMONDS & L. WOOLNER, 1981. On the factors influencing distribution of 0-group Demersal fish in coastal waters. *Rapp. P. v. Reun. Cons. Int. Explor. Mer*, 178 : 223-228.

SAFRAN, P., 1985. Stratégie d'échantillonnage de la pêche accessoire dans la pêcherie artisanale de crevettes grises. Application à la baie de Canche (Pas-de-Calais). Rapport d'étude, contrat 512 UST Lille/IFREMER 84-3255, 22 p.

SAFRAN, P., 1987a. Étude d'une nurserie littorale à partir des pêches accessoires d'une pêcherie artisanale de crevettes grises (*Crangon crangon*, L.). *Oceanol. Acta*, Vol. 10, 2 : 239-248.

SAFRAN, P., 1987b. Étude écologique d'une nourricerie littorale de poissons nectobenthiques le long du Pas-de-Calais par méthodes statistiques multivariables. Thèse Doct. Biol., UST Lille, 104 p.

SAVILLE, A., 1978. Méthodes de prospection pour l'évaluation des ressources halieutiques. *FAO, Doc. Tech. Pêches*, n° 171, 81 p.

SHANNON, E.C. & W. WEAVER, 1963. *The mathematical theory of communication*. University of Illinois Press. Urbana, 117 p.