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FISHEYE: A NEW DATABASE ON THE BIOLOGY AND ECOLOGY OF LAGOON AND REEF FISHES OF THE SOUTH PACIFIC. EXAMPLE OF ITS USE ON THE ECOLOGY OF COMMERCIAL HERBIVOROUS FISHES

by

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ABSTRACT. - FISHEYE is a database on lagoon and reef fishes of the South Pacific. This data base yields information on the biology of species (reproduction, diet, length-weight relationships, etc.) and ecology of fish communities (species richness, density, biomass, trophic structure, etc.). To date only half of the available data is in the data base. These data are mainly from New Caledonia. In a near future data from French Polynesia, Tonga, Flores will be added and in a more distant future data from Fiji and Samoa should be available. Information is extracted from FISHEYE by requests based on three keys: zone, species and type of analysis (biology or ecology). Some possible uses of FISHEYE are illustrated by the case study of commercially important herbivorous fishes. Species richness, density and biomass of three families, Acanthuridae, Scaridae and Siganidae are compared for three regions (SW lagoon, Ouvea atoll and North lagoon) of New Caledonia and three subregions of the North lagoon. Three biotopes are considered, barrier, intermediate and fringing reefs. Between and within region differences are found mainly for the density and biomass of these fish. The North lagoon displays the highest biomasses for all three families and the highest density for Acanthuridae. In general, there is a decline from the barrier reef towards the fringing reefs, except for Siganidae which show the opposite trend. A more detailed study was performed on five major species belonging to these families: *Acanthurus blochii*, *Naso unicornis*, *Scarus microrhinos*, *S. ghobban* et *Siganus argenteus*. Finally, the importance of these herbivores within the trophic structure of reef fish were analyzed with FISHEYE. These results confirm the increase of densities and biomasses of reef fishes according to oceanic influence. The between and within regional differences could be related to geographical factors (terrigeneous and oceanic influences) and fishing pressure.

RÉSUMÉ. - FISHEYE: une nouvelle base de données sur la biologie et l'écologie des poissons récifaux et lagonaires du Pacifique Sud. Exemple de son utilisation en écologie des poissons herbivores commerciaux.

FISHEYE est une base de données sur les poissons lagonaires et récifaux du Pacifique Sud. Elle fournit des informations sur la biologie des espèces (reproduction, alimentation, relations taille-poids, etc.) et l'écologie des communautés (richesse spécifique, densité, biomasse, structure trophique, etc.). Plus de la moitié des données actuellement disponibles sont intégrées dans la base. Elles concernent principalement la Nouvelle-Calédonie. Dans un futur proche, viendront s'ajouter les données de Polynésie Française, de Tonga, des Îles Flores, et dans un futur plus lointain, celles de Fidji et des Samoa américaines. Les informations sont extraites de FISHEYE par des requêtes basées sur trois clés: zone, espèce, type de traitement (biologie ou écologie). Certaines possibilités d'utilisation de FISHEYE sont illustrées par l'étude d'un cas: celui des poissons herbivores commerciaux. La richesse spécifique, la densité et la biomasse de trois familles, les Acanthuridae, les Scaridae et les Siganidae sont comparées dans trois régions (lagon sud-ouest, lagon nord et atoll d'Ouvéa) et sous-régions de la Nouvelle-Calédonie ainsi que sur les trois principaux biotopes récifaux que sont les récifs barrières, intermédiai-

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res et frangeants. Les différences inter- et intra-régionales concernent principalement les densités et les biomasses. Le lagon nord montre les plus fortes valeurs de biomasse pour les trois familles et la densité la plus élevée pour les Acanthuridae. Globalement, les différences entre biotopes montrent, pour les trois paramètres étudiés, un gradient décroissant du récif barrière vers le récif frangeant pour les Acanthuridae et les Scaridae. La tendance inverse est observée pour les Siganidae. Une analyse plus détaillée est présentée pour les espèces principales appartenant à ces trois familles: *Acanthurus blochii, Naso unicornis, Scarus microrhinos, S. ghobban* et *Siganus argenteus*. Enfin, la place des herbivores dans les structures trophiques de l'ensemble des communautés de poissons récifaux a pu aussi être analysée grâce à FISHEYE. Ces résultats confirment ceux qui ont été obtenus dans d'autres régions du Pacifique Sud, notamment ceux qui sont relatifs à l'augmentation des densités et des biomasses en fonction de l'influence océanique. Les variations inter-régionales observées peuvent être reliées à des situations géographiques (influences terrigènes et océaniques) et à des pressions de pêche différentes.

Key-words. - Lagoon fish, Reef fish, ISEW, South Pacific, Database, Biology, Ecology.

From 1995 to 1998, ORSTOM assessed the resources of demersal lagoon and reef fishes of commercial interest, at the request of New Caledonia's Northern Province. This resulted in large data sets on the biology and ecology of these fish (Labrosse *et al.*, 1996, 1997a; Letourneur *et al.*, 1997b). Such knowledge will be of interest to a wide range of audience but especially those concerned with the development and management of the lagoon's biological resources, such as fisheries and environmental agencies, professional fishermen and even anyone looking for information on the subject.

So far, the results of this kind of studies have been always presented in a « traditional » format, namely in the form of technical reports. Although such reports contain valuable information, they are often ignored or read by few people. Other problems are the limited distribution of these reports and the great difficulty in using these data sets for comparisons with other studies in an interactive way.

It was thought that the best way to answer the problems of this type of data set was a computerised client / server application, accessible through the Internet. FISHEYE was therefore developed as a solution, a locally based, user friendly and easily upgradable database where the information could be rapidly and easily available to its end-users.

The similarities between the sampling methods we used for the North Province survey and those used by other ORSTOM studies carried out over the last 14 years (Kulbicki, 1997a) suggested the possibility of integrating into FISHEYE large data sets covering other areas such as the south-west lagoon of New Caledonia (Kulbicki *et al.*, 1987, 1991, 1996), the atoll of Ouvea (Kulbicki *et al.*, 1994), the Chesterfield Islands (Kulbicki *et al.*, 1990), French Polynesia (Harmelin *et al.*, 1997), Tonga (Matoto *et al.*, 1996), Flores in Indonesia (Kulbicki, 1996), etc. These data cover various methods, the most used being underwater visual census (UVC), trawling, gill netting and rotenone poisoning. Future research by ORSTOM in new areas (e.g., Fiji) will be integrated into this data-base as data becomes available. We are also hoping to awake the interest of other scientists in the Pacific and have their data sets included in FISHEYE as is the case of data from the American Samoa by Green (1996).

In this paper, some of the potential uses of FISHEYE are illustrated by a case study. The distribution patterns of three families of fish, Acanthuridae, Scaridae and Siganidae, which are mainly herbivores, will be investigated. These fish are of major economical and ecological importance in New Caledonia as well as in a number of Indo-Pacific countries and therefore the example illustrate both scientific and management implications. Similar informations could be drawn for many other species or families (FISHEYE holds information on more than 500 species at present). The aim of the present article is not to explore all the possibilities offered by this data-base, but rather to demonstrate the practical usefulness of the FISHEYE concept. Some of the planned future developments of FISHEYE will also be briefly outlined in the discussion.

PRESENTATION OF FISHEYE

Basic facts on FISHEYE

At the moment FISHEYE has information on a number of fish parameters. The summary presented in table I gives an idea of the present and future potential use of this data base. This indicates that less than half of the information collected is accessible at the moment. Altogether there is data on over a thousand species, but the quality and quantity of the information is variable from one species to another.

Access to FISHEYE

FISHEYE is available in two versions, one in French the other in English. They can be consulted on the following URL (universal resource locator):

English version: http://noumea.orstom.nc/BASE/FISHEYE/presentation_en.html

French version: http://noumea.orstom.nc/BASE/FISHEYE/presentation_html

Structure of FISHEYE

FISHEYE can be described as a dynamic data base. This means that it performs calculations at the time of the user's request, using the most recently entered data. In order to retrieve information from FISHEYE, the user has to perform a request, each request being based on three major interactive choices or selections (Fig. 1): Geographical area, species and type of computation. Usually, geographical area and species are chosen first. This may involve several areas simultaneously and one or several species or families. In a second step the user chooses the type of information needed among a set of processing schemes which encompasses three fields: biology, ecology and population or community structures. The details of the various computations used are available in an interactive mode in the data base. In many instances, the data processing options include the possibility of analysing the information as a function of given parameters, such as fish size, depth or season.

Geographical choice

At the moment, only data from New Caledonia are in the data base, but we have in store data from Tonga, French Polynesia, American Samoa, Chesterfield Islands and Flores (Indonesia). Within a country, i.e., New Caledonia, the user may choose to select one or several areas (there are 5 areas available at the moment for New Caledonia) and within each area one or several zones, which are further divided into subzones.

Species choice

Species are listed alphabetically and by family. The user may select either species or families, knowing that a selection may include an unlimited number of species or families. At the moment, over 500 species belonging to 86 families are available.

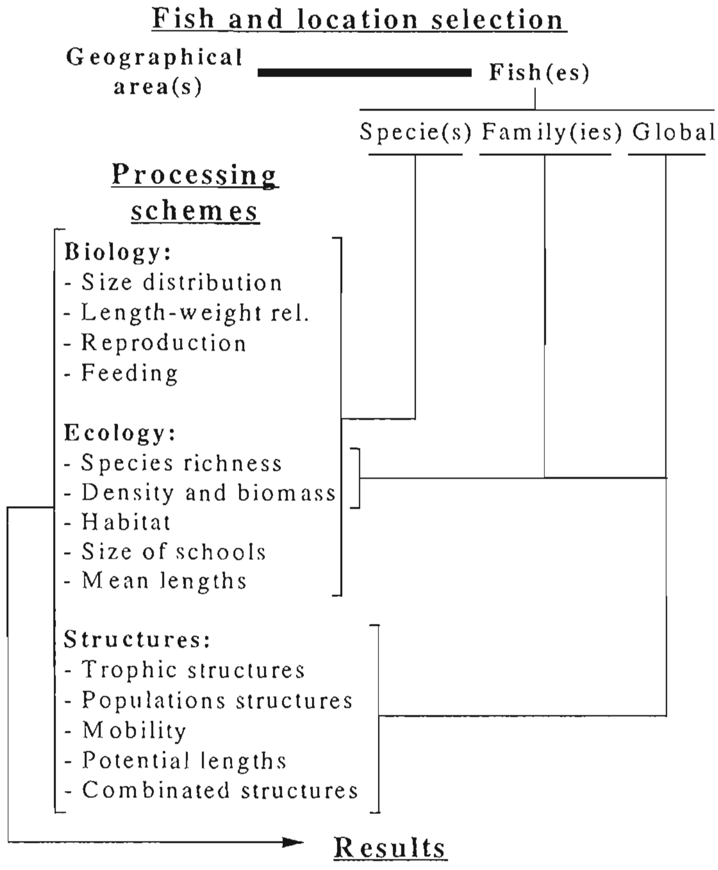

Fig. 1. - Path for a request in FISHEYE. The user chooses a geographical area, then the species and finally the processing scheme.

Table I. - Major types of informations available on FISHEYE (UVC = underwater visual censuses).

	Number of records		Number of species concerned	
	In 1997	In store	In 1997	In store
Sampling				
UVC	170 000	180 000	500	700
Experimental fishing	10 000	15 000	200	900
Biology				
Size	150 000	120 000	500	900
Reproduction	5 000	10 000	120	250
Diet	8 000	25 000	200	370
Ecology				
School size	150 000	120 000	500	900
Habitat	150 000	120 000	500	900
Distribution	180 000	150 000	500	900

Computation choices

Fourteen different modes of data processing are available, divided into 3 categories:

- The biology of species: size distribution, length-weight relationships, reproduction and diet.
- The ecology of species and/or families: species richness, biomass, density, habitat, school size, average specimen size.
- The structures of communities for all species: trophic, demographic, mobility, size potential, and combinations among them.

Size distribution

Data on the size of fish has been obtained from estimates by divers using UVC as well as fish measured from experimental fishing. Based on this data, it is possible to obtain size distribution for any combination of area or biotope for each species.

Length-weight relationships

These are used for estimating the weight as a function of size for the species and area selected. It is based on lenght-weight relationships that have been calculated existing data in FISHEYE. They are of the form: $W = a \times L^b$. Parameters a and b are estimated through the least square regression using the following logarithmic transformation: $\ln(W) = \ln(a) + b \times \ln(L)$.

Reproduction

The sex and level of sexual development of fish caught are determined by macroscopic examination of the gonads. The data can then be retrieved as a function of size, season and depth of capture for any given species.

Diet

Average composition of food intake for each species is determined by examination of the stomach contents of fish caught during experimental fishing. The results are expressed as percent volume and can be retrieved as a function of size, sex, season or depth for any combination of species and area.

Density and biomass

Density and biomass are obtained from two sources; underwater visual censuses (UVC) and trawling. For UVC these parameters are calculated using the method of line-transect (Buckland *et al.*, 1993). For trawls, densities and biomasses are estimated from the area swept by the trawl, a catchability coefficient of 1 being used.

Habitat

During underwater visual censuses, the characteristics of the substrate and the cover by living organisms (algae, hard and soft coral, etc.) are recorded. From these data it is therefore possible to estimate the average composition of the substrate and its living cover for a given species, for the area chosen.

School size

This information is obtained from UVC data, by dividing the total number of fish observed by the number of occurrences for a given species. This parameter is therefore a crude estimate of school size, and can be obtained per biotope, depth or fish size.

Average sizes

The average size of fish is given for UVC data for different depth strata.

Species richness

This indicates the number of species within one family or fish assemblage. It is expressed as the mean number of species per station within the area chosen. This parameter is given separately for each biotope and for the different sampling methods (UVC and experimental fishing).

Trophic structure

Most species have a varied diet, including several kinds of food: nekton (piscivores), macro-invertebrates (> 20 mm), micro-invertebrates, zooplankton, other planktonic organisms, macro-algae, micro-algae, detritus, corals. The contribution of each species to any of the trophic groups can be evaluated. It is a function of the percentage of this type of food in its total food intake. For example, a 100 g fish whose diet includes 20% nekton contributes 20 g to the biomass of the piscivores. The other 80 g are distributed proportionately to the respective percentages of the other components of its diet. This structure is available only in multispecies selection.

Potential size

Fish are classified in relation to the average size of the adult specimen known from available literature. For example, if the average adult size of *Lethrinus atkinsoni* (yellow tailed emperor) is 32 cm, and even though some individuals may measure only 5 cm while some others reach 45 cm, the species is classified as being in the 30-50 cm category. It is available only in multispecies selections.

Demographic structure

Each species is classified according to its biological characteristics, such as lifespan, age at sexual maturity, etc., into 6 different categories. Despite the imprecisions due to the limited knowledge for certain species, the proportion of each category within a fish assemblage can be useful for understanding its potential evolution when faced with particular events (fishing activities, pollution, cyclone, etc.).

Mobility

The different species of lagoon and reef fishes display various degrees of mobility. A fish assemblage observed while diving may be broken down according to the degree of mobility of the different species encountered (territorial, sedentary, mobile small radius, mobile large radius).

Combined structures

This function presents cross-tables from trophic structures, demographic structures and mobility. In a near future, school size and average size will also be integrated in this function.

CASE STUDY: COMMERCIAL HERBIVOROUS FISHES

In order to illustrate some of the potentials of FISHEYE, we have choosed to analyse the distribution and major ecological traits of three families of commercially important fish, Acanthuridae, Scaridae and Siganidae, which are mainly herbivorous. Three regions the North lagoon, South West lagoon and Uvea atoll and three subregions of the North lagoon were selected. For each region and subregion the species richness, average density and biomass per family and for some major species were obtained. For these selected species size distribution and school size were also retrieved from FISHEYE. Within the Northern Province the spatial distribution of species richness for the major biotopes is examined as well as the contribution of herbivores to the trophic structure.

For the three families considered, species richness (species/station), density (fish/m^2) and biomass (g/m^2) are given for the three regions and the three subregions (Table II). Acanthuridae and Scaridae had the same species richness (5.3 to 5.7 species/transect) and density (0.11 fish/m^2) whilst Siganidae had lower species diversity (1.47 species/transect) and lower densities (0.024). Scaridae had biomasses twice larger than Acanthuridae and 20 times larger than Siganidae. Regional differences were found in terms of density and biomass. However, within region differences were of the same magnitude than regional differences. Ouvea was characterized by low levels of Siganidae, low densities of Scaridae and high densities of Acanthuridae; the SW lagoon had the lowest densities and biomasses of Acanthuridae and the lowest biomass of Scaridae; the North lagoon had the highest densities of Scaridae and Siganidae and the highest biomass of Acanthuridae and Scaridae. Within the North lagoon, the north part had the highest biomass for all three families, but the highest densities only for Acanthuridae, thus suggesting large fish in that area.

Table II. - Species richness (RS = species/transect), density (D = fish/m^2) and biomass (B = g/m^2) for three regions: Ouvea, SW Lagoon and North Lagoon and three subregions of the North Lagoon: East, North and West.

	Ouvea	SW lagoon	North lagoon	North lagoon subregions			Average
				East	North	West	
Species richness							
Acanthuridae	5.76	5.28	4.87	4.50	6.02	4.08	5.30
Scaridae	5.20	5.49	6.34	5.89	7.51	5.63	5.68
Siganidae	0.90	1.95	1.54	1.76	1.79	1.08	1.47
Density							
Acanthuridae	0.146	0.059	0.0124	0.087	0.184	0.101	0.110
Scaridae	0.071	0.108	0.0154	0.124	0.151	0.187	0.111
Siganidae	0.010	0.028	0.0033	0.050	0.033	0.016	0.024
Biomass							
Acanthuridae	21.09	6.51	30.87	10.49	62.92	19.19	19.49
Scaridae	44.35	21.54	72.54	44.54	113.30	59.78	46.14
Siganidae	0.89	4.10	2.65	2.55	3.10	2.29	2.54

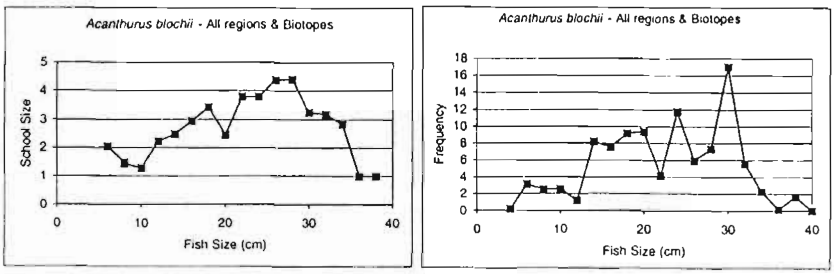

Fig. 2. - School size and size distribution of *Acanthurus blochii*, for the three selected regions and all biotopes combined.

Differences between biotopes for species richness are illustrated in table III. There is a decrease in species richness from the barrier reef towards the fringing reefs for Acanthuridae and Scaridae whilst the opposite trend is observed for Siganidae. Scaridae are however an exception, their species richness increasing from the barrier reef towards the fringing reef in the northern part of the North lagoon. The same trends were found for densities and biomasses which are not illustrated here.

The five major species of these three families can be analyzed separately (Table IV). Ouvea supported the largest densities and biomasses of *Acanthurus blochii*, the SW lagoon had the highest values for *Siganus argenteus* and the North lagoon had the highest densities and biomasses for the three other species. Variarions within the north region were important (Table IV) but they confirmed observations between regions, in particular the higher densities and biomasses of *Naso unicornis*, *Scarus ghobban* and *S. microrhinos* in the North lagoon.

FISHEYE will give information on a number of biological and ecological traits. Two examples of these traits, fish size and school size for the five major commercial herbivorous species of New Caledonia are illustrated hereafter.

Size distribution and school size for all regions and biotopes are given for *Acanthurus blochii* (Fig. 2). The frequency of this species tended to increase from fish sizes of 13 cm till 30 cm, then numbers declined rapidly. Similarly the largest schools of *A. blochii* were found for fish sizes between 23 and 28 cm then school size declined with fish size. It is possible to investigate the variations in size distribution or school size of a species between biotopes and regions. This is illustrated also for *A. blochii* (Fig. 3). One notices that the size of this species increased from the fringing reefs towards the barrier reefs for all regions and that there were modes in the size distributions which were common to all regions. The increase in school size with fish size for this species was essentially due to the large schools found in Ouvea (Fig. 3).

Differences between species may also be of interest. This is illustrated for variations in school size and size distribution for the other four major herbivorous species on the barrier reefs of the three regions investigated. Without going into a detailed analysis of these results (Fig. 4), one notices that size distributions for these four species were very close between the SW lagoon and the North lagoon, but differ from those of Ouvea. For instance, larger *Scarus ghobban*, smaller *Siganus argenteus*, and no large *Naso unicornis* were observed in Ouvea. The analysis of school size indicates that the largest schools were formed by *S. argenteus*. For this species, peaks in school size correspond to peaks in size distribution, thus suggesting that the peaks of size distribution could corre-

Table III. - Species richness (number of species/station) of Acanthuridae, Scaridae and Siganidae for three different reef biotopes, three regions and three subregions.

	Ouvea	SW lagoon	North lagoon	Nortb lagoon subregions		
				East	North	West
Acanthuridae						
Barrier	9.40	5.94	5.75	5.67	6.70	4.87
Intermediate		5.49	4.53	4.31	5.69	3.60
Fringing	2.12	4.40	4.32	3.51	5.66	3.78
Scaridae						
Barrier	9.15	6.44	7.16	7.18	6.63	7.66
Intermediate		5.98	6.40	6.32	7.88	4.99
Fringing	1.25	4.06	5.48	4.18	8.02	4.23
Siganidae						
Barrier	1.42	1.13	0.97	1.04	1.08	0.80
Intermediate		2.40	1.89	2.36	2.25	1.07
Fringing	0.38	2.33	1.76	1.88	2.03	1.38

Table IV. - Biomass (B = g/m^2), density (D = fish/m^2) and number of fish observed (N) for three regions: Ouvea, SW Lagoon and North Lagoon and three subregions of the North Lagoon: East, North and West.

	Ouvea	SW lagoon	North lagoon	North lagoon subregions			All regions
				East	North	West	
Acanthurus blochii							
Biomass	8.51	1.40	3.77	0.67	7.00	3.63	4.56
Density	0.012	0.005	0.008	0.003	0.015	0.007	0.008
Number	1513	2436	2304	390	1217	697	6253
Naso unicornis							
Biomass	1.25	1.73	8.71	3.66	17.08	5.38	3.90
Density	0.002	0.003	0.008	0.005	0.013	0.005	0.004
Number	261	1247	3194	1247	1296	651	4702
Scarus microrhinos							
Biomass	5.60	1.308	10.94	5.77	17.84	9.20	5.95
Density	0.0025	0.0014	0.0062	0.0048	0.0089	0.0048	0.003
Number	302	605	2373	940	761	672	3280
Scarus ghobban							
Biomass	1.60	1.32	5.21	2.31	5.98	7.35	2.71
Density	0.001	0.003	0.013	0.008	0.009	0.021	0.006
Number	141	1248	3825	1201	702	1922	5214
Siganus argenteus							
Biomass	0.84	2.68	1.25	0.61	2.60	0.54	1.59
Density	0.0075	0.0126	0.0040	0.0018	0.0068	0.0033	0.008
Number	893	5787	1363	451	487	425	8043

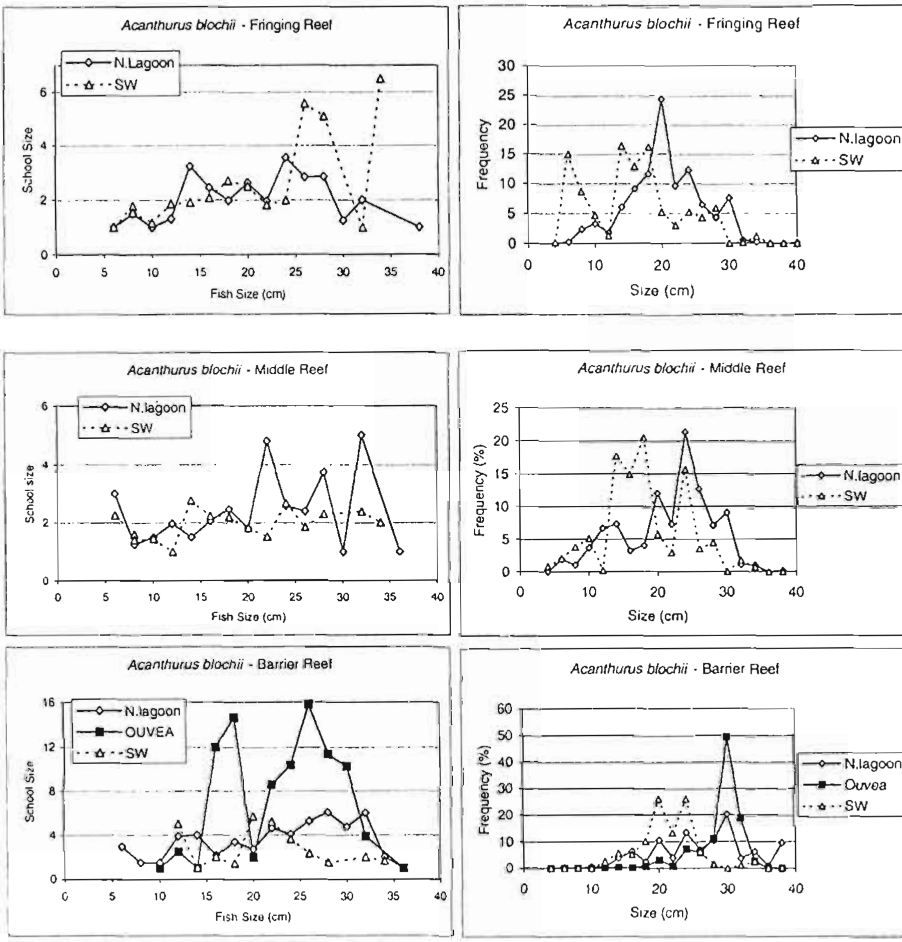

Fig. 3. - School size and size distribution of *Acanthurus blochii* for each region and each biotope.

Table V. - Trophic structure of two regions. All numbers are percentages per columm. (RS = species richness, D = density, B = biomass).

	Species richness		Density		Biomass	
	Ouvea	SW Ouvea	Ouvea	SW Ouvea	Ouvea	SW Ouvea
Piscivores	19.30	20.13	4.30	3.61	23.48	11.50
Macrocarnivores	30.67	30.76	15.82	5.64	21.27	21.93
Microcarnivores	12.24	12.5	10.85	16.03	2.81	4.42
Zooplanktivores	16.25	16.23	48.08	58.38	9.02	14.66
Other planktivores	0.34	1.08	0.33	3.94	0.11	0.49
Macroherbivores	2.67	2.27	1.27	0.69	11.97	4.71
Microherbivores	12.84	11.90	12.44	6.62	26.86	26.09
Coral feeders	4.22	3.66	3.85	2.89	2.75	14.48
Detritus feeders	1.51	1.47	3.06	2.20	1.72	1.72

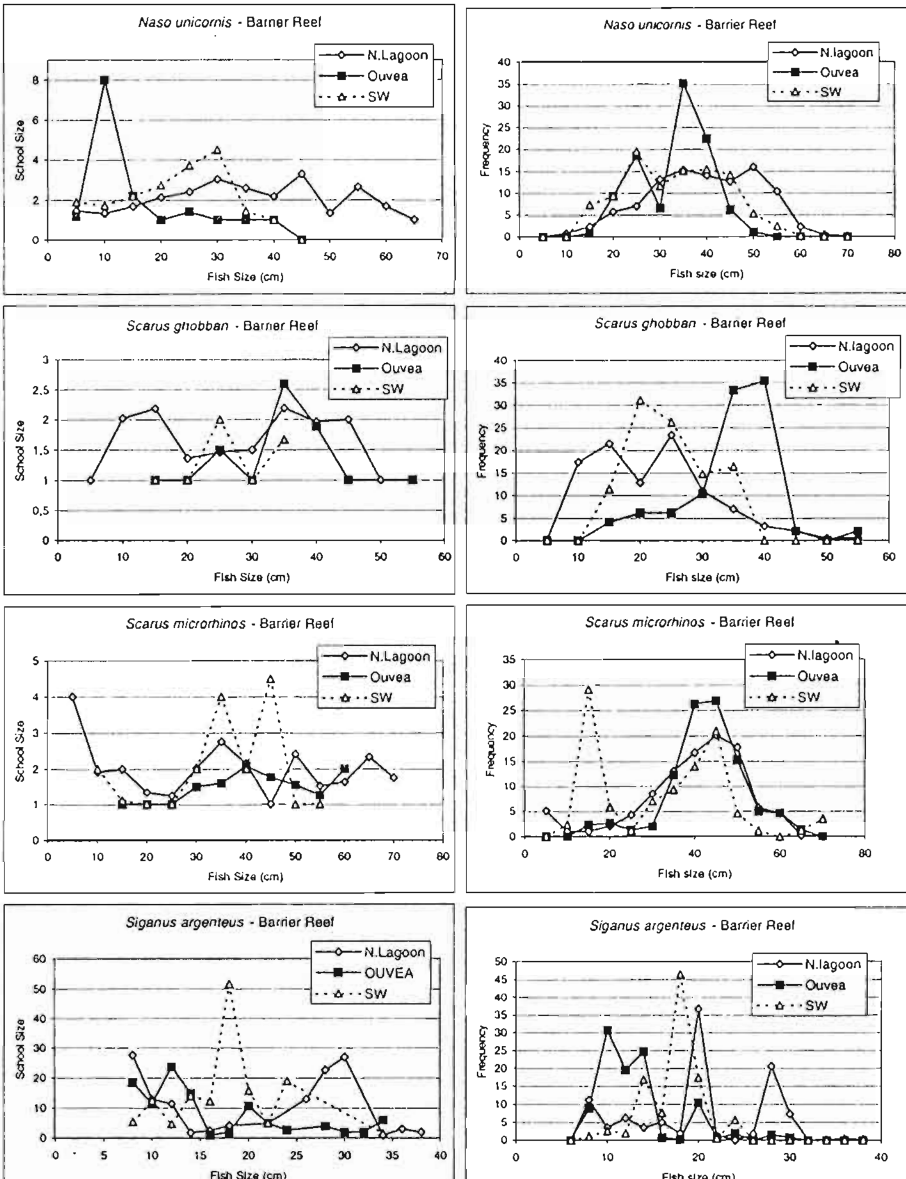

Fig. 4. - School size and size distribution of *Naso unicornis*, *Scarus ghobban*, *S. microrhinos* and *Siganus argenteus* on the Barrier reef of each region.

spond to cohorts. For the remaining three species, school size was small and its variations with fish size did not reflect any particular trends.

Finally, it may be interesting to investigate the importance of herbivores in the trophic structures of reef fish communities. These structures are given for two regions

(Table V) where total counts were available (other regions had only UVCs for commercial species). Species richness of any trophic group hardly changed between the two regions. However, there were important changes between regions for density and biomass of the various trophic groups. Looking at herbivores, both micro- and macro-herbivores made larger contributions to density and biomass in Ouvea than in the SW lagoon. This was compensated by larger contributions of microcarnivores and plankton feeders in the SW lagoon.

DISCUSSION

FISHEYE

The development of Internet and the use of data bases through this system is a source of many questions as indicated by an increasing number of workshops and seminars on this matter. Some of the issues are examined here in relation to FISHEYE. Data from a base should be proofed in some way. In the case of FISHEYE no data is preprocessed therefore errors will come mainly at the input of the data into the system. To avoid this problem data are entered twice from two different input sources and the two data sets are overlaid in order to find errors. Of more concern is the precision of the data in the base. For instance, all the length estimates from underwater visual censuses are subjected to an error linked to the observer. In addition, these length estimates are clustered in size classes of increasing size as fish size increases as recommended by Bell *et al.* (1985). Some results may therefore be difficult to interpret. In the present article, the size distributions show a number of modes which may simply be attributed to the lumping by observers of fish sizes into fixed categories. Another problem with data interpretation is that the experimental design is not accessible to the user. In other words, the number of stations in a given biotope is preset and the user can not select a sub-set of these stations in order to build a suitable experimental design to answer his question(s). Thus in the present example, the number of stations for each biotope was not equal and the variations through time could not be taken into account (all the sampling did not take place the same season or the same year). With work covering a large geographical zone and long periods, there may be nomenclature errors (Bailly *et al.*, 1995). To avoid this, the list of scientific names was run through the specialised spell-checking and synonyms programme developed by Froese (1997).

At the moment the data in FISHEYE is also stored in paper files and much of it is not yet in official technical or scientific reports. To write such reports would probably take years because the amount of data in FISHEYE is important. Electronic storage of data is not considered as permanent and citation of such sources in scientific work is still a problem. In order to minimize this problem we are considering the creation of a yearly version of FISHEYE on CDROM disks. Another important issue is the protection against abusive use of the data. The intent of this data base is to make available data which otherwise would not be easily accessible. By letting these data available to anyone there is a risk that some of it may be used in distorted ways or used without prior consent of the data collectors. However, we feel that the benefits to the scientific community far outweight these risks. In addition it is not possible for the user to gain directly access to the raw data. Therefore, if someone is interested in solving a particular question and needs access to more detailed data he has to contact the collectors of these data. Another protective mechanism is the absence of a measure of data variability in the outputs. This is a double edge decision, because in many cases a measure of error is necessary to test an hypothesis. We feel that the investigator who needs this type of information will contact us and consequently we should then be in a position to know how the data is used.

One of the major advantage of FISHEYE over a bibliographical approach is that the combination of outputs has no limits. The cost to the user and the time required for retrieving the information are also an attractive part of this approach. In the example illustrated in this article only a low number of the possible outputs of FISHEYE were investigated. In particular, all the information available on the biology of the species (reproduction, diet) were not used, and much of the ecological information were not investigated in detail (habitat type, distribution with depth, etc.).

FISHEYE is still in its initial stages of development. Among the major improvements planed are the possibility to study time series and "horizontal" questioning. At the moment the user has to define the fish species or group of species for which he wishes to retrieve information. This can be viewed as "vertical" access to the data. The user may also wish to retrieve information only according to a variable which is not directly linked to the choice of a species or group of species. For instance, he may want to know all the species found to feed on crustaceans or those which reproduce in the deeper parts of the lagoons during the winter months. This would be "horizontal" access to the data. Another improvement will be the possibility to get some information on the variability of the data.

We plan also to develop other tools within FISHEYE, for instance the possibility to have some information on the productivity of lagoon fish communities. This would allow direct input in softwares such as ECOPATH or ECOSIM. In the future, individual files for each fish species will be built, with a part of fixed information and a part of user interactive information.

Less than half of all the data available at the moment is accessible. The entire data set should be available by mid 1999 and from then on other data sets will be eventually included.

FISHEYE is at the moment available only on one web site, Nouméa. The problem is that this site is only accessible at present through paths with slow data outputs. This may be a problem when using FISHEYE from a remote area. Two solutions are underway. First the data flow from the site of Nouméa will be improved. Second, a mirror site is planed in Paris. This should increase the ease of access to the information considerably. There are more applications of FISHEYE. In this article a direct scientific use of FISHEYE was illustrated. Similar uses and applications for managers, fishermen and education exist.

Herbivores from New Caledonian Reefs

The work presented here can be compared to very similar studies by Russ (1984a, 1984b) or by Letourneur *et al.* (1997a). In some cases (for instance the details on the size distribution or school size), the present results go beyond the type of results presented by these authors. FISHEYE allows to investigate many more traits which could be useful in this kind of research such as the variations of mean size with depth, the variations in habitat type, or the variations of some biological traits such as size at maturity with biotope or depth.

The observed cross shelf distribution of the three families is similar to the findings of Russ on the Great Barrier Reef (1984a, 1984b). These results also confirm observations made in Tonga (Matoto *et al.*, 1997), the Chesterfield (Kulbicki *et al.*, 1989) and

French Polynesia (Galzin, 1985) that Acanthuridae and Scaridae tend to increase with oceanic influence.

Many of the inter-regional variations (for fish size, school size, density or biomass) observed for a given family can be linked to two factors, geography and fishing pressure. Indeed, the SW lagoon lies in waters cooler than the two other regions and is exposed to far more intense fishing activities. Ouvea, where fishing pressure is low, is an atoll and oceanic influence there is strong. The three subregions of the North lagoon are subjected to different terrestrial inputs; the Northern part receives little and the Eastern part a lot. There are also differences in fishing pressure among these three subregions, the Western part gets the highest and the Northern the lowest pressure. Thus, the lowest densities and biomasses of Scaridae and Acanthuridae found in the SW lagoon are probably the result of higher fishing pressure. This is reflected by the smaller size of the fish in that region. The effect of fishing pressure is well illustrated by the differences in density and biomass for all major species within the North lagoon. This is a confirmation of the study by Labrosse *et al.* (1997b).

The variations in trophic structure between the SW lagoon and Ouvea atoll confirm the findings of Kulbicki (1997a) who compared the trophic structure of the barrier reef fish communities of these two locations. The reason why herbivores are less important in the SW lagoon are not known, but resource availability could be a factor. Indeed, Ouvea atoll is essentially autotrophic (Clavier *et al.*, 1992; Kulbicki, 1995), whereas the SW lagoon is heterotrophic (Clavier *et al.*, 1994). In other words, the primary production in Ouvea exceeds the consumption, whereas in the SW lagoon the primary production is supported by external inputs, essentially terrigenous ones. As a consequence algal production per unit of consummer is higher in Ouvea than in the SW lagoon thus allowing a larger percentage of such consummers.

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REFERENCES

BAILLY N. & J.-C. HUREAU, 1995. - Bases de données en biologie: quelques problèmes liés à la nomenclature et aux références bibliographiques. *Cybium*, 19(4): 325-332.

BELL J.D., CRAIK G.J.S., POLLARD D.A. & B.C. RUSSEL, 1985. - Estimating length frequency distributions of large reef fish underwater. *Coral Reefs*, 4: 41-44.

BUCKLAND S.T., ANDERSON D.R., BURNHAM K.P. & J.L. LAAKE, 1993. - Distance Sampling. Estimating Abundance of biological Populations. 446 p. London: Chapman & Hall.

BURNHAM K.P., ANDERSON D.R. & J.L. LAAKE, 1980. - Estimation of density from line transect sampling of biological populations. *Wildlife Monogr.*, 72: 1-202.

CLAVIER J., BOUCHER G. & C. GARRIGUE, 1994. - Benthic respiratory and photosynthetic quotients in a tropical lagoon. *C.R. Acad. Sci. Paris, Sci. Vie*, 317: 937-942.

CLAVIER J., GARRIGUE C., BARGIBANT G., DI MATTEO A., HAMEL P., KULBICKI M. & R. URBAIN, 1992. - Étude quantitative du benthos dans le lagon d'Ouvéa. Liste taxonomique, densités et biomasses du macrobenthos, ATP, pigments photosynthétiques et matière organique dans le sédiment. *Rap. Sci. Tech., Sci. Mer, ORSTOM Nouméa*, 64: 1-71.

FROESE R., 1997. - An algorithm for identifying misspellings and synonyms in lists of scientific names of fishes. *Cybium*, 21(3): 265-280.

GALZIN R., 1985. - Écologie des poissons récifaux de Polynésie Française. Thèse Doctorat d'État, 195 p. Univ. de Montpellier 2.

GREEN A., 1996. - Status of the Coral Reefs of the Samoa Archipelago. 125 p. Samoa's Department of Marine & Wildlife Resources Technical Report.

HARMELIN-VIVIEN M., KULBICKI M., GALZIN R. & G. MOU THAM, 1997. - Reef fish communities structure within atoll lagoons in French Polynesia (Tuamotu Archipelago). *In:* Abstracts of the 5th Indo-Pacific Fish Conference, Nouméa (New Caledonia), 1997: 41.

KULBICKI M., 1995. - The marine resources of Ouvea Atoll (New Caledonia), a summary of the work performed by ORSTOM from 1991 to 1994. Integrated Coastal Fisheries Management Project, Technical Report n°12: 613-652. Nouméa: South Pacific Commission.

KULBICKI M., MOU-THAM G., BARGIBANT G., MENOU J.-L. & P. TIRARD, 1987. - Résultats préliminaires des pêches expérimentales à la palangre dans le lagon sud-ouest de la Nouvelle-Calédonie. *Rap. Sci. Tech., Biol. Mar., ORSTOM Nouméa*, 49: 1-104.

KULBICKI M., DOHERTY P., RANDALL J.E., BARGIBANT G., MENOU J.-L., MOU-THAM G. & P. TIRARD, 1990. - La campagne « Corail 1 » du N.O. Coriolis aux Îles Chesterfield (du 15 août au 4 septembre 1988): données préliminaires sur les peuplements ichtyologiques. *Rap. Sci. Tech., Biol. Mar., ORSTOM Nouméa*, 57: 1-88.

KULBICKI M., MOU-THAM G., RANDALL J.E. & J. RIVATON, 1991. - Suivi mensuel des peuplements ichtyologiques des récifs coralliens dans le lagon SW de Nouvelle-Calédonie. *Rap. Sci. Tech., Biol. Mar., ORSTOM Nouméa*: 1-61.

KULBICKI M., MOU-THAM G., THOLLOT P. & L. WANTIEZ, 1993. - Lenght-weight relationships of fish from the lagoon of New Caledonia. *Naga, The Iclarm Quaterly*, 16(2-3): 26-30.

KULBICKI M., BARGIBANT G., MENOU J.-L., MOU-THAM G., THOLLOT P., WANTIEZ L. & J. WILLIAMS, 1994. - Évaluation des ressources en poissons du lagon d'Ouvéa. 3ème partie: les poissons. 448 p. Rap. Conv., Sci. Mer, Biol. Mar. Nouméa: ORSTOM.

KULBICKI M., 1996. - First observations of the reef communities of fringing reefs in the region of Maumere (Flores - Indonesia). *Atoll Res. Bull.*, 437: 1-20.

KULBICKI M., GALZIN R., LETOURNEUR Y., MOU-THAM G., THOLLOT P., WANTIEZ L., SARRAMEGNA S. & C. CHAUVET, 1996. - Les peuplements de poissons de la réserve marine du récif Aboré (Nouvelle-Calédonie): composition spécifique, structures trophique et démographique avant l'ouverture à la pêche. *Doc. Sci. Tech., ORSTOM Nouméa*, 11: 1-210.

KULBICKI M., 1997a. - Bilan de 10 ans de recherche (1985-1995) par l'Orstom sur la diversité, la densité, la biomasse et la structure trophique des communautés des poissons lagonaires et récifaux en Nouvelle-Calédonie. *Cybium*, 21(1) suppl.: 47-79.

KULBICKI M., 1997b. - How acquired behavior of commercial reef fish influence results obtained from visual censuses. *J. Exp. Mar. Biol. Ecol.*, 222: 11-30.

LABROSSE P., LETOURNEUR Y., AUDRAN N., BOBLIN P. & M. KULBICKI, 1996. - Évaluation des ressources en poissons démersaux commerciaux des lagons de la Province Nord de la Nouvelle-Calédonie. Résultats des campagnes d'échantillonnages de la zone nord. 118 p. Rap. Conv., Sci. Mer, Biol. Mar. Nouméa: ORSTOM.

LABROSSE P., LETOURNEUR Y., AUDRAN N., BOBLIN P., MALESTROIT P., PADDON J.R. & M. KULBICKI, 1997a. - Évaluation des ressources en poissons démersaux commerciaux des lagons de la Province Nord de la Nouvelle-Calédonie. Résultats des campagnes d'échantillonnages de la zone ouest. 110 p. Rap. Conv., Sci. Mer, Biol. Mar. Nouméa: ORSTOM.

LABROSSE P., LETOURNEUR Y., PADDON J. & M. KULBICKI, 1997b. - Incidences de la pression de pêche sur les stocks de poissons démersaux commerciaux du lagon ouest de la Province Nord. 15 p. Rap. Conv., Sci. Mer, Biol. Mar. Nouméa: ORSTOM.

LETOURNEUR Y., KULBICKI M. & P. LABROSSE, 1997a. - Spatial structure of commercial reef fish communities along a terrestrial gradient in the Northern Lagoon of New Caledonia. *Environ. Biol. Fish.*, 51: 141-159.

LETOURNEUR Y., LABROSSE P., AUDRAN N., BOBLIN P., PADDON J.R. & M. KULBICKI, 1997b. - Évaluation des ressources en poissons démersaux commerciaux des lagons de la Province Nord de la Nouvelle-Calédonie. Résultats des campagnes d'échantillonnages de la zone est. 130 p. Rap. Conv., Sci. Mer, Biol. Mar. Nouméa: ORSTOM.

MATOTO S., LEDUA E., MOU-THAM G., KULBICKI M. & P. DALZELL, 1996. - The aquarium-fish fishery in Tongatapu, Tonga. Status and recommendations for management. 23 p. Integrated Coastal Fisheries Management Project, Country Assignment Report. Nouméa: South Pacific Commission.

RUSS G., 1984a. - Distribution and abundance of herbivorous grazing fishes in the central Great Barrier Reef. 1 - Levels of variability across the entire continental shelf. *Mar. Ecol. Prog. Ser.*, 20: 23-34.

RUSS G., 1984b. - Distribution and abundance of herbivorous grazing fishes in the central Great Barrier Reef. Patterns of zonation of mid-shelf and outershelf reefs. *Mar. Ecol. Prog. Ser.*, 20: 35-44.