b) computation of ϕ' ($= \log_{10}K + 2\log_{10}L_\infty$) from previous estimates of growth parameters in other populations of the same species (two cases), or related species (one case);
c) estimation of K from the ϕ' and L_∞ values; and
d) construction of length-converted catch curves, from which total mortality (Z) and ancillary statistics are estimated.

This methodology, building on Pauly (1980, 1987), is fully documented in Venema et al. (1988), and was implemented using a beta version of the FiSAT software package (Pauly and Sparre 1991).

This led to the results summarized in Table 2 from which the following can be seen:

- estimated mean sizes at first capture are rather large, ranging from 32 cm in *C. sonnerati* to 42 cm in *E. chlorostigma*;
- the mean of the three estimates of fishing mortality in Table 1 ($F = 0.26$ year^{-1}) is rather low compared with the mean of the estimates of natural mortality ($M = 0.35$ year^{-1})

These results suggest, albeit very tentatively, that the stocks from which the samples in Table 1 originated were lightly fished.

Table 2. Summary of statistics estimated from the length-frequency data in Table 1.

Statistic (Unit)	*Cephalopholis sonnerati*	*Epinephelus areolatus*	*Epinephelus chlorostigma*
TL_∞(cm)	50.2	49.4	69.1
ϕ'	2.315[a]	2.644[b]	2.191[b]
K (year^{-1})	0.082	0.18	0.17
Z (year^{-1})	0.21	1.19	0.44
M (year^{-1})[c]	0.25	0.43	0.38
F (year^{-1})	(-0.04)[d]	0.76	0.06

[a] Mean ϕ' for related grouper species.
[b] From growth parameters for the same species in Kuwait (Mathews and Samuel 1987).
[c] Based on an annual mean habitat (bottom water) temperature of 20°C (from Bouhlel 1988).
[d] Not a possible value, but indicating low F, and thus used to compute mean of three species.

Acknowledgements

Messrs. A.H. Bilil, M.M. Dacud and H.A. Houmed collected the bulk of the data in Table 1, and their input is gratefully acknowledged. Also, I thank Dr. W. Künzel (GTZ) for making possible the study stage during which the (French language) draft of this contribution was written; Dr. D. Pauly at ICLARM for sharing his knowledge in a language I understand better than English, and for translating and editing the draft of this paper. Finally, I thank Mr. Felimon Gayanilo, Jr., for patiently teaching me how to operate computer software, particularly the FiSAT package.

References

Bouhlel, M. 1988. Poissons de Djibouti. Resources and Development Associates and US Agency for International Development, Djibouti. 416 p.

Kedidi, S.M. and M. Bouhlel. 1985. Stock assessment for the blood snapper *Lutjanus sanguineus* from the Djiboutian waters (Red Sea - Gulf of Aden). Project for the Development of Fisheries in the Red Sea Areas of the Gulf of Aden, Cairo. FAO/UNDP RAB/83/023/11, 20 p.

Mathews, C.P. and M. Samuel. 1987. Growth, mortality and assessment of groupers in Kuwait. Kuwait Bull. Mar. Sci. (9):173-191.

Pauly, D. 1980. Une selection de méthodes simples pour l'estimation des stocks de poissons tropicaux. FAO Circulaire sur les Pêches (729), 63 p.

Pauly, D. 1987. A review of the ELEFAN system for analysis of length-frequency data in fish and aquatic invertebrates, p. 7-34. *In* D. Pauly and G.R. Morgan (eds.) Length-based methods in fisheries research. ICLARM Conf. Proc. 13, 468 p.

Pauly, D. and P. Sparre. 1991. A note on the development of a new software package, the FAO-ICLARM stock assessment tools (FiSAT). Fishbyte 9(1):47-49.

Venema, S., J. Møller-Christensen and D. Pauly, Editors. 1988. Contributions to tropical fisheries biology. FAO Fish. Rep. 389, 519 p. Rome, Italy.

A. DARAR *is with the Project on "Les Resources Halieutiques et les Quantités Pêchable des Eaux Djiboutiennes", executed jointly by the Direction de l'Elevage et des Pêches, Republique de Djibouti, and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), GmbH.*

Comparative Growth Performance of Jack Mackerels of the Genus *Trachurus*, with Emphasis on *T. symmetricus murphyi* in Chile

LUIS S. CUBILLOS
HUGO F. ARANCIBIA

Abstract

This contribution presents von Bertalanffy growth parameter estimates for species/stocks of jack mackerels of the genus *Trachurus* from around the world, and compares these with growth parameters for *T. symmetricus murphyi* caught off central-southern Chile (33°S-39°S). It is found that *Trachurus* stocks inhabiting upwelling areas such as the Humboldt and Benguela current systems grow better than their ecological equivalents in temperate waters, such as the North Sea. The von Bertalanffy growth parameters estimated for Chilean horse mackerel are: $FL_\infty = 65.2$ cm ($TL_\infty = 71.6$ cm) and $K = 0.138$ year^{-1}.

Introduction

Growth parameter estimates for different stocks of a given species can be usefully compared via the ϕ' growth performance index of Pauly and Munro (1984), based on Pauly (1979), and computed from the von Bertalanffy parameters L_∞ and K (see also Venema et al. 1988). Thus, when growth data are not available for a specific stock, a mean value of ϕ' can be estimated from other stocks of the same species, and ϕ' used in conjunction with an estimate of L_∞ to indirectly obtain an estimate of the K parameter.

Furthermore, "it is likely that the value of [ϕ'] represents and quantifies the energetics of a given habitat or niche because [ϕ'] is directly related to growth performance and hence metabolism and food consumption" (Munro and Pauly 1983).

Considering the worldwide distribution and considerable ecological and economic importance of the genus *Trachurus*, the objectives of this contribution are: (1) to present a summary of the von Bertalanffy and growth performance indices of different *Trachurus* stocks from around the world; and (2) to estimate the growth parameters for horse mackerel caught off central-southern Chile (33°S-39°S), for which previous estimates exist which are mutually incompatible (Kaiser 1973; Aguayo et al. 1981). [Also note that the taxonomic status of this species is far from clear (Parrish 1989)].

Materials and Methods

Length-at-age data, or L_∞ and K estimates for *Trachurus* stocks from around the world were obtained from the literature, then grouped by species and regions. When growth parameters had not been estimated, this was done by fitting the available length-at-age data pairs with the von Bertalanffy growth function using the nonlinear routine incorporated in the FISHPARM package (Saila et al. 1988).

Subsequently, the growth performance of the different stocks was compared using the ϕ' index of Pauly and Munro (1984), i.e.,

$$\phi' = \text{Log}_{10}K + 2\text{Log}_{10}L_\infty \qquad ...1)$$

To estimate the growth parameter of horse mackerel caught off central-southern Chile, annual length-frequency data (fork length, FL), raised to the total annual catches from the fishery, for the period 1982 to 1991, were used to obtain an average length-frequency sample roughly representative of the steady-state population. Subsequently, an estimate of the asymptotic length was obtained by using the Wetherall (1986) method as modified by Pauly (1986) and incorporated in the Compleat ELEFAN software package of Gayanilo et al. (1988). The estimate of FL_∞ obtained in this fashion was converted to TL_∞ using the relationship:

$$TL_{(cm)} = 0.5 + 1.091\ FL_{(cm)}\ (n = 125;\ r^2 = 0.95) \qquad ...2)$$

Then, TL_∞ was used in conjunction with the average value of ϕ' for *T. symmetricus murphyi* to estimate K.

Results and Discussion

The growth parameters and the ϕ' values computed for various stocks of *Trachurus* are listed in Table 1.

An ANOVA test of the ϕ' values of *T. trachurus*, *T. trachurus capensis* and *T. symmetricus murphyi* shows that there are significant differences in the mean ϕ' of those species ($P < 0.01$). This suggests that *T. symmetricus murphyi* grows better, as a whole, than the other *Trachurus* stocks. *T. capensis* also has high values of ϕ', suggesting that horse mackerel stocks inhabiting upwelling areas, where they may have an enormous predatory impact (Muck and Sanchez (1987), grow better than their ecological equivalents in other areas. This would validate Munro and Pauly's interpretation of ϕ'.

The average catch composition of *T. symmetricus murphyi* from central-southern Chile is shown on Fig. 1, left panel. From this, the modified Wetherall plot (Fig. 1, right panel) yielded an estimate of FL_∞ 65.2 cm (TL_∞ 71.6 cm), compatible with the maximum size of 60 cm FL observed, off New Zealand, by Russian researchers (A. Grechina, pers. comm.).

The asymptotic length and the mean value of $\phi' = 2.85$ for this species led to an estimate of $K = 0.138\ \text{year}^{-1}$.

We believe that our estimates of L_∞ and K adequately describe the growth of the fraction of the population of *T. symmetricus murphyi* caught along the central-southern area of Chile.

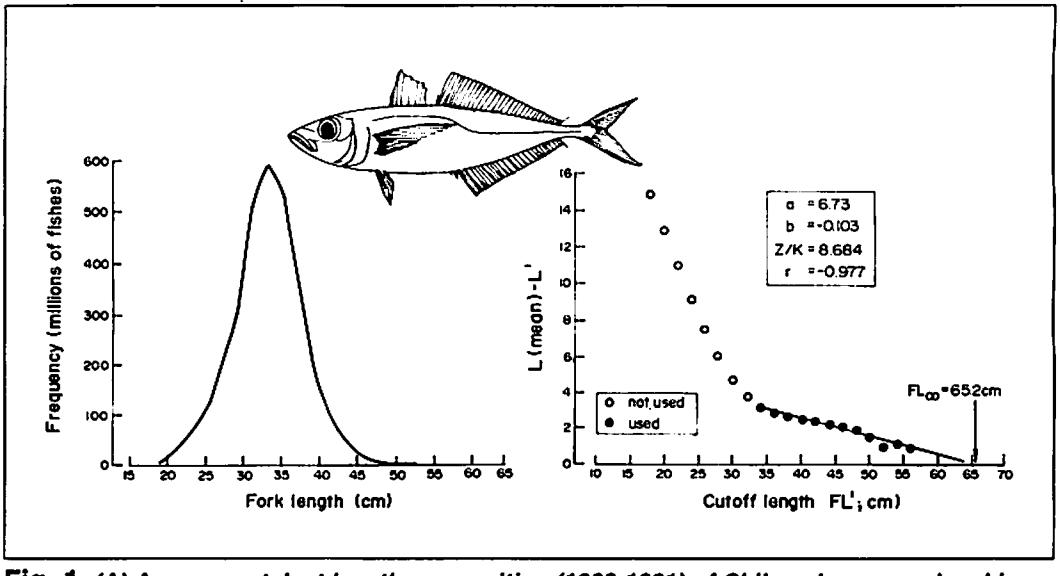

Fig. 1. *(A) Average catch at length composition (1982-1991) of Chilean horse mackerel in the central-southern region, with Talcahuano (37°S) as their main port of landings. (B) Modified Wetherall plot for estimating asymptotic length from the data shown in (A).*

Table 1. Growth parameters and growth performance index (ϕ) for the horse mackerel stocks (genus *Trachurus*), as reported from various authors.

Species and region	TL_∞ (cm)	K (year^{-1})	ϕ'	Source
***T. trachurus*, North Atlantic:**				
ICES Subarea VIIf-j	46.07	0.170	2.557	Trouvery (1977)
ICES Subarea VIIIb	47.86	0.156	2.553	Trouvery (1977)
ICES Subarea VIIIa	49.09	0.144	2.540	Trouvery (1977)
Celtic Sea/G. of Gascogne	45.28	0.201	2.615	Trouvery (1977)
English Channel	40.20	0.137	2.345	Nazarov (1978)
Celtic Sea/Bay of Biscay	44.94	0.123	2.395	Nazarov (1978)
North Sea	33.85	0.289	2.520	Nazarov (1978)
ICES Subarea IX/N	40.45	0.248	2.608	Lourdes et al. (1978)
ICES Subarea IX/S	58.11	0.122	2.615	Lourdes et al. (1978)
Galician shelf	41.57	0.195	2.528	Fariña (1983)
W. Great Britain/Ireland	41.59	0.223	2.586	Kerstan (1985)
Western Iberian waters	40.36	0.290	2.674	Borges (1991)
Western Iberian waters	42.93	0.240	2.646	Borges (1991)
Western Iberian waters	50.00	0.140	2.544	Borges (1991)
***T. trachurus capensis*, South-East Atlantic:**				
ICSEAF Division 1.6	54.30	0.127	2.573	Geldenhuys (1973)
ICSEAF Division 1.0	47.00	0.250	2.742	Kompowski and Slósarczyk (1975)
ICSEAF Division 1.3/1.4	56.40	0.110	2.544	Terré (1976)
ICSEAF Division 1.3/1.4	55.00	0.110	2.522	Wengrzyn (1976)
ICSEAF Division 1.3/1.4	62.60	0.109	2.631	Babayan and Bulgakova (1983)
ICSEAF Division 2.1	43.50	0.426	2.906	Uozumi and Kawahara (1983)
ICSEAF Division 1.3	52.40	0.130	2.553	Sosa (1981)
ICSEAF Division 2.1/2.2	50.30	0.427	3.034	Hecht (1990)
ICSEAF Div. 1.6/2.1/2.2	48.80	0.556	3.122	Naish et al. (1991)
***T. japonicus*, North-West Pacific:**				
Japan	51.20	0.280	2.866	Pauly (1980)
***T. indicus*, Indian Ocean:**				
Gulf of Aden	34.00[a]	0.390	2.654	Edwards and Shaher (1991)
***T. declivis*, South-West Pacific:**				
South-East Australia	46.40	0.200	2.634	Stevens and Hausfeld (1982)
Great Australian Bight	41.70	0.190	2.519	Stevens et al. (1984)
***T. symmetricus symmetricus*, North-East Pacific:**				
Southern California Bight	60.29	0.094	2.534	Wine and Knaggs (1975)
***T. symmetricus murphyi*, South-East Pacific:**				
Coastal waters off Chile	92.70[a]	0.140	3.080	Kaiser (1973)
Off Valparaíso (Chile)	116.49[a]	0.110	3.174	Pavez and Saa (1978)
Oceanic waters off Peru	79.07[a]	0.090	2.750	Abramov and Kotlyar (1980)
Off Talcahuano (Chile)	49.06[a]	0.180	2.637	Aguayo et al. (1981)
Oceanic waters off Chile	81.58[a]	0.090	2.777	Nekrasov (1982)
Oceanic waters off Chile	99.14[a]	0.120	3.072	Shevshuk and Chur (1984)
Central southern Chile	71.65[a]	0.070	2.556	Castillo and Arrizaga (1987)
Oceanic waters off Chile	105.14[a]	0.060	2.822	Nekrasov (1987)
Oceanic waters off Chile	85.39[a]	0.080	2.766	Nosov et al. (1989)
Oceanic waters off Chile	81.47[a]	0.111	2.867	Kochkin (in press)

[a]Total length transformed by using equation (2).

Table 2. Mean growth performance index (ϕ') of various species of *Trachurus*.

	ϕ'	s.d.	c.v.	n
T. trachurus	2.552	0.090	3.527	14
T. trachurus capensis	2.736	0.229	8.378	9
T. japonicus	2.866	-	-	1
T. indicus	2.654	-	-	1
T. declivis	2.577	0.081	3.156	2
T. symmetricus symmetricus	2.534	-	-	1
T. symmetricus murphyi	2.850	0.201	7.041	10

Acknowledgements

The authors are grateful to their friend Miguel Araya of the Universidad Arturo Prat, for his assistance in obtaining some papers used here. Special thanks to Dr. Alexander Grechina (Moscow) for her help in interpreting the Russian literature.

References

Abramov, A.A. and A.N. Kotlyar. 1980. Some biological features of the Peruvian jack mackerel, *Trachurus murphyi* Nichols, 1920. Invest. Mar. 6(6):89-100.

Aguayo, M., A. Estay and V. Ojeda. 1981. Determinación de edad y crecimiento del jurel (*Trachurus murphyi*) en las zonas de Arica-Coquimbo y Talcahuano. Inst. Fom. Pesq. (Chile), 88 p.

Babayan, V. and T.I. Bulgakova. 1983. Estimation of natural mortality and growth parameters for Cape horse mackerel (*Trachurus trachurus capensis*) in divisions 1.3+1.4. Collect. Sci. Pap. ICSEAF 10(1):49-53.

Borges, M.F. 1991. Biannual cohorts, growth parameters and migration effects of horse mackerel (*Trachurus trachurus* L.) in Western Iberian waters, using length frequency analysis. ICES C.M. 1991/H:52, 28 p.

Castillo, G. and A. Arrizaga. 1987. Edad y crecimiento del jurel *Trachurus symmetricus murphyi* (Nichols 1920) en aguas de Chile central. Biol. Pesq. 16: 19-33.

Edwards, R.R.C. and S. Shaher. 1991. The biometrics of marine fishes from the Gulf of Aden. Fishbyte 9(2): 27-29.

Fariña, A.C. 1983. Age and growth of the Galician Shelf horse mackerel (*Trachurus trachurus* L.). ICES C.M. 1983/G:26, 11 p.

Gayanilo, F.C., M. Soriano and D. Pauly. 1988. A draft guide to the Compleat ELEFAN. ICLARM Software 2, 65 p.

Geldenhuys, N.D. 1973. Growth of the South African maasbanker *Trachurus trachurus* Linnaeus and age composition of the catches, 1950-1971. Invest. Rep. Sea Fish. Branch S. Afr. 101, 24 p.

Hecht, T. 1990. On the life history of Cape horse mackerel *Trachurus trachurus capensis* off the south-east coasts of South Africa. S. Afr. J. Mar. Sci. 9: 317-326.

Kaiser, C.E. 1973. Age and growth of horse mackerel *Trachurus murphyi* of Chile. Trans. Am. Fish. Soc. 10B(3):591-595.

Kerstan, M. 1985. Age, growth, maturity, and mortality estimates of horse mackerel (*Trachurus trachurus*) from waters of Great Britain and Ireland in 1984. Arch. Fischereiwiss. 36(1/2):115-154.

Kochkin, P.N.. Edad y crecimiento del jurel (*Trachurus symmetricus murphyi*) del Océano Pacífico sur. Doc. Téc. Inst. Invest. Pesq. Talcahuano, Chile. (In press)
Kompowski, A. and W. Slósarczyk. 1975. Biological characteristics of Polish catches of the horse mackerel *Trachurus trachurus capensis* Castelnau, 1861 in the region of the south-west African Shelf. Acta Ichthyol. Pisc. 5(2):25-38.
Lourdes, M., C. Monteiro and M. Sobral. 1978. Preliminary study on age and growth of *Trachurus trachurus* L. in sub-area IX. Coun. Meet. ICES C.M. 1978/H:60, 11 p.
Muck, P. and G. Sanchez. 1987. The importance of mackerel and horse mackerel predation for the Peruvian anchoveta stock (a population and feeding model), p. 276-293. *In* D. Pauly and I. Tsukayama (eds.) The Peruvian anchoveta and its upwelling ecosystem: three decades of change. ICLARM Stud. Rev. 15, 351 p.
Munro, J.L. and D. Pauly. 1983. A simple method for comparing the growth of fishes and invertebrates. Fishbyte 1(1):5-6.
Naish, K.A., T. Hecht and A.I.L. Payne. 1991. Growth of Cape horse mackerel *Trachurus trachurus capensis* off South Africa. S. Afr. J. Mar. Sci. 10:29-35.
Nazarov, N.A. 1978. Age and growth rate of the northeast Atlantic horse mackerel. ICES C.M. 1978/H:22, 23 p.
Nekrasov, V.V. 1982. [Distribution, biology and fisheries potential of jack mackerel (*Trachurus symmetricus murphyi*) in the south-eastern Pacific]. VNIRO Internal Report, Moscow. 43 p. (in Russian)
Nekrasov, V.V. 1987. [Age and growth of jack mackerel, p. 44-46. *In* Collected papers on the biology and fisheries of Peruvian horse mackerel]. VNIRO, Moscow. (in Russian)
Nosov, E.V., N.P. Markina and P.V. Kalchugin. 1989. [Methods for evaluating spawning stock dynamics, age and growth of Peruvian horse mackerel], p. 3-63. *In* Arch. TINRO, Vladivostock. (in Russian)
Parrish, R.H. 1989. The South Pacific oceanic horse mackerel (*Trachurus picturatus murphyi*) fishery, p. 321-331. *In* D. Pauly, P. Muck, J. Mendo and I. Tsukayama (eds.) The Peruvian upwelling ecosystem: dynamics and interactions. ICLARM Conf. Proc. 18, 438 p.
Pauly, D. 1979. Gill size and temperature as governing factors in fish growth: a generalization of von Bertalanffy's theory of growth. Ber. Inst. Meereskd. Christian-Albrechts Univ. Kiel 63, 156 p.
Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temprature in 175 fish stocks. J. Cons. CIEM 39(3):175-192.
Pauly, D. 1986. On improving operation and use of the ELEFAN program. Part II. Improving the estimation of L_∞. Fishbyte 4(1):18-20.
Pauly, D. and J.L. Munro. 1984. Once more on growth comparison in fish and invertebrates. Fishbyte 2(1):21.
Pavez, P. and E. Saa. 1978. Determinación de edad y crecimiento del jurel *Trachurus murphyi* Nichols, 1920. Invest. Mar. 6(6):89-100.
Saila, S.B., C.W. Recksiek and M.H. Prager. 1988. Basic fishery science programs. A compendium of microcomputer programs and manual of operation. Elsevier, New York. 230 p.
Shevshuk, L.V. and V.N. Chur. 1984. [Methods for the estimation of growth in jack mackerel *Trachurus murphyi* in the southeastern Pacific], p. 97-104. *In* Fisheries studies of the open waters of the world ocean, VNIRO, Moscow. (in Russian)
Sosa, M. 1981. Edad y crecimiento del jurel (*Trachurus trachurus* Linneus) de la División 1.3 del área de ICSEAF. Collect. Sci. Pap. ICSEAF 8(2):255-266.
Stevens, J.D. and H.F. Hausfeld. 1982. Age determination and mortality estimates on an unexploited population of jack mackerel *Trachurus declivis* (Jenyns 1841) from south-east Australia. CSIRO Mar. Lab. Rep. 148, 14 p.
Stevens, J.D., H.F. Hausfeld and S.R. Davenport. 1984. Observations on the biology, distribution and abundance of *Trachurus declivis*, *Sardinops neopilchardus* and *Scomber australasicus* in the Great Australian Bight. CSIRO Mar. Lab. Rep. 164, 27 p.
Terré, J.J. 1976. Growth and fecundity of horse mackerel (*Trachurus trachurus*, Linneus) in ICSEAF Divisions 1.3 and 1.4. Collect. Sci. Pap. ICSEAF 3:39-44.
Trouvery, M. 1977. Croissance du chinchard *Trachurus trachurus* (Linné) dans le Golfe de Gascogne et sur le Plateau Celtique. Coun. Meet. ICES C.M. 1977/J:10, 17 p.
Uozumi, Y. and S. Kawahara. 1983. A preliminary growth estimation of preadult Cape horse mackerel (*Trachurus trachurus capensis*) on the Agulhas Bank on the basis of size composition. Collect. Sci. Pap. ICSEAF 10(1):203-208.
Venema, S.C., J. Møller-Christensen and D. Pauly. 1988. Training in tropical fish stock assessment: a narrative of experience, p. 1-15. *In* S. Venema, J. Møller-Christensen and D. Pauly (eds.) Contributions to tropical fisheries biology. Papers prepared by the participants at the FAO/DANIDA Follow-up Training Courses on Fish Stock Assessments in the Tropics. FAO Fish. Rep. 389, 519 p.
Wengrzyn, J. 1976. Results of investigations on age and growth rate of the horse mackerel (*Trachurus trachurus*) in south-west African waters. Collect. Sci. Pap. ICSEAF 3:51-57.
Wetherall, J.A. 1986. A new method for estimating growth and mortality parameters from length-frequency data. Fishbyte 4(1):12-24.
Wine, V. and E. Knaggs. 1975. Maturation and growth of jack mackerel, *Trachurus symmetricus*. Calif. Fish Game Mar. Res. Rep. 21:1-26.

L.S. Cubillos and **H.F. Arancibia** *are from the Instituto de Investigación Pesquera, Octava Región, Casilla 350, Talcahuano, Chile.*

NEWS ITEMS

Spring Lobster Workshop

A WORKSHOP on the fisheries management of, and artificial shelters for spiny lobsters, will be held in Havana, Cuba, on 17-21 October 1994. Spiny lobster is the most valuable commercial fishery in Cuban and adjacent waters. Scientists engaged in the exploitation of this important resource are invited. For further information, please contact Lic. Marisela Hernández Ceballos, Secretary, Organizing Committee, Centro de Investigaciones Pesqueras, 5ta. Ave. y 248, Barlovento, Santa Fé, La Habana, Cuba; Tel. (537) 227089/233614; Fax: (537) 311108/331534.

On Board

FROM 1989 TO 1993, the Organization of Eastern Caribbean States (OECS) Fisheries Unit published a newsletter called *On Board* dealing with the fisheries industry of the member countries (the British Virgin Islands, St. Kitts and Nevis, Dominica, Antigua and Barbuda, St. Lucia, Montserrat, St. Vincent and the Grenadines, and Grenade), and related development issues.

Edited by Mike Findlay, this 8-page Newsletter brought a lively mix of news items on industry developments, descriptions of local fisheries, report on training courses for the members of fishers cooperative and fisheries officers, etc.

On Board also reported on efforts to standardize the acquisition and archival of fisheries data, initiated by Peter Murray, the Data Management Officer of the OECS Fisheries Unit, an important area of work for that unit.

Unfortunately, due to lack of funds, *On Board* was discontinued *pro term*; some back issues can be obtained by writing to either of the above mentioned