Problems and dilemas in applying different techniques in fish population dynamics studies

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Problems and dilemmas in applying different techniques in fish population dynamics studies

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SUMMARY - Estimates of mortality coefficients (natural, fishing and total) for three species, Silver Hake (*Merluccius merluccius* L.), Striped Mullet (*Mullus barbatus* L.) and Pandora (*Pagellus erythrinus* L.) of the Adriatic Sea have been obtained by several procedures. Two methods of analysis of normal components of the frequency distributions and Pauly's formula, relating mortality with growth and temperature, have been applied to data collected during 1948-1949 in the "HVAR" cruise in the Adriatic Sea, where for many years because of the Second World War, there had not been trawl fishing. For that reason, the virgin state for the sampled populations could be assumed.

Key words: Populations dynamics, Hake, Mullet, Pandora.

RESUME - *"Problèmes et dilemmes de l'application de différentes techniques pour les études de dynamique des populations marines". Des estimations des coefficients de mortalité (naturelle, par pêche et totale) pour trois espèces de la mer Adriatique, merlu (Merluccius merluccius L.), rouget barbet (Mullus barbatus L.) et pageot rose (Pagellus erythrinus L.), ont été obtenues par diverses procédures. Deux méthodes d'analyse des composantes normales des distributions de fréquences ainsi que la formule de Pauly, qui met en rapport la mortalité avec la croissance et la température, ont été appliquées aux données collectées en 1948-1949 lors de la croisière "HVAR" sur la mer Adriatique, où il n'y avait pas eu de pêche au chalut pendant plusieurs années en raison de la Deuxième Guerre Mondiale. Dû à ce fait, on a présumé qu'il existait un état vierge chez les populations échantillonnées.*

Mots-clés : Dynamique des populations, merlu, rouget barbet, pageot rose.

Introduction

Taking into account available biological data of the fisheries expedition "HVAR" (Karlovac, 1959) carried out during 1948-1949 year in the Adriatic Sea by Institute of Oceanography and Fisheries-Split which covered great part of the continental shelf at the time when commercial bottom trawl fisheries in the Adriatic for about one decade was stopped due to the World War II the length frequencies data of Silver Hake (*Merluccius merluccius* L.), Striped Mullet (*Mullus barbatus* L.) and Pandora (*Pagellus erythrinus* L.), under "virgin stocks state" have been analysed in order to assess growth patterns of the species by applying Bhattacharya (1967) method of the resolution of a distribution into Gaussians components and trying to compare such findings with earlier results for the same species obtained either by otolits or scales aging.

On the same time the fish populations instantaneous dynamics parameters of Z, which under expedition conditions (no fishery) equals M thus F have been calculated on the base of available length frequency data of the above mentioned species analysing catch converted curves respecting Gayanilo *et al.* (1989), Gayanilo *et al.* (1994) techniques, Complete ELEFAN and FiSAT.

Estimates of M values, taking into the consideration Pauly's (1984) formula and average sea bottom temperature as well as other, mostly equations based on morphometric characteristics of species available data (Table 1).

Indices of relative abundances (cpue) of the species collected on 167 fixed stations represent species quantities caught during one-hour trawl haul, so called positive stations, are used for species: space and time (horizontal and vertical) distributions in the Adriatic.

Table 1.   Estimates of M values

	Merluccius merluccius	*Mullus barbatus*	*Pagellus erythrinus*
Asymptotic length (L∞)	83.27	27.75	27.78
Curvature parameter (K)	0.127	0.274	0.229
Initial condition parameter (to)	-0.730	-0.616	-1.004
L'	6	14	14
Lc or L50 (%)	4.85	12.11	11.30
L mean	14.72	14.03	14.16
L'mean	16.17	16.47	16.59
Z from length-converted catch curve	0.39	1.58	0.88
Z from Beverton and Holt's equations[†,††]	0.116 0.88	0.273 1.96	0.227 1.09
Z from Ault and Ehrhardt's equations[†††]	0.116	0.273	0.227
M from Pauly's equations[††††]	0.25	0.57	0.51

(1) - the mean length of fish of length L' and longer

$^{†}Z = K(L∞ - Lmean) / (L∞ - L')$

$^{††}Z = K(L∞ - Lmean) / (Lmean - Lc)$

$^{†††}[(L∞ - Lmax) / (L∞ - L')]exp(Z/K) = A(L') / A(Lmax)$

where:

$A(L') = Z(L'-Lmean) + K(∞ - Lmean), \quad A(Lmax) = Z(Lmax - Lmean) + K(L∞ - Lmean)$

$^{††††}ln(M) = -0152 - 0.279 \ln L∞ + 0.6543 \ln K + 0.463 \ln T$

Results

Silver Hake (*Merluccius merluccius* L.)

Indices of relative species abundance (cpue) of the Silver Hake (*Merluccius merluccius* L.) population in the Adriatic Sea pointed out that this species is distributed in the whole Adriatic (Fig. 1), thus approving that this population makes "common" and "shared" biological resource.
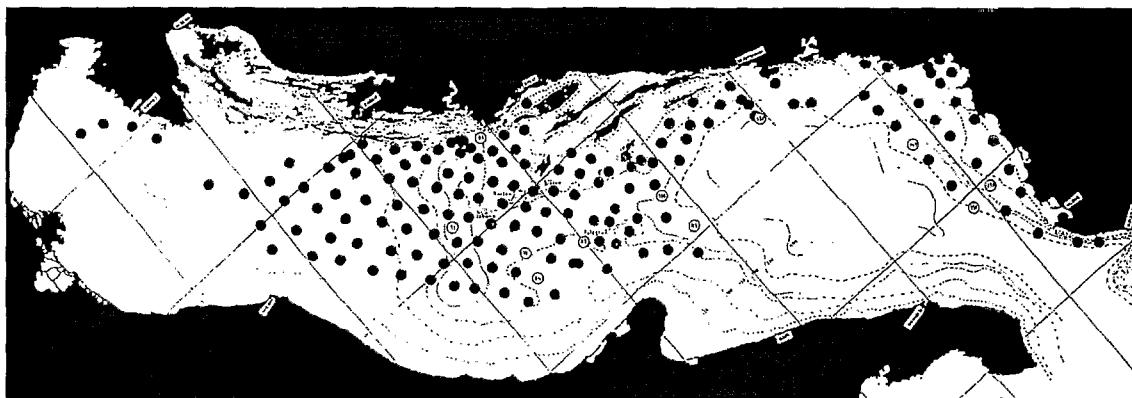

Fig. 1.   Distribution of the Silver Hake population in the Adriatic Sea during Expedition "Hvar" in 1948-1949.

Distribution of the population taking into account total body length confirm scientific conclusions that small-sized species prevail deeper sea waters, i.e., bellow 100 meters in the central open Adriatic (Jabuka Pit) where is main spawning ground of the population for northern and central Adriatic and where dominate juvenile individuals, mostly zero year class throughout the whole year (Fig. 2) positively effecting fishable Hake stock in the Adriatic on recruitment processes.
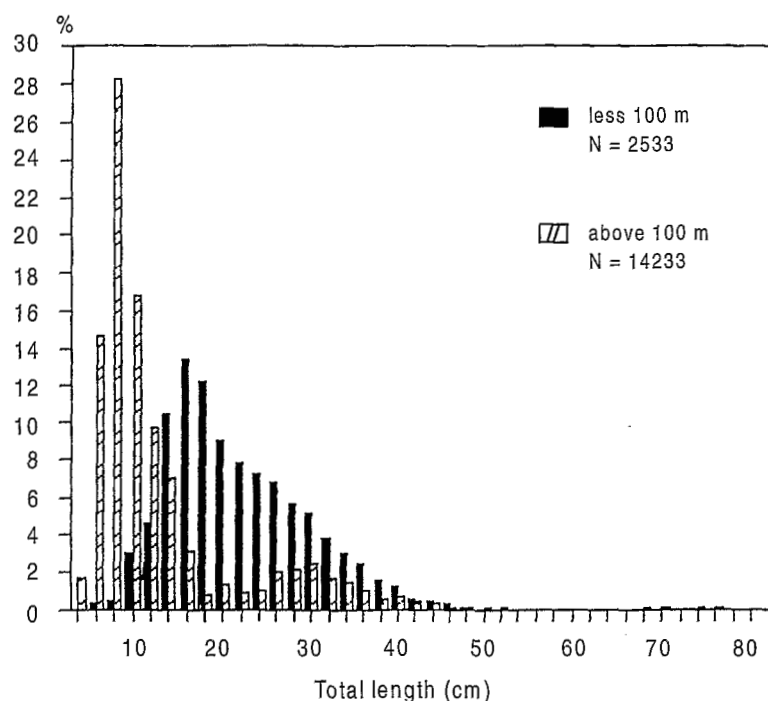

Fig. 2.   Length composition of the Silver Hake population in relation to sea depth.

Species migrations and spawning patterns in the central Adriatic (Jabuka Pit) in connection to spawning and food and feeding habits are studied and described by Zupanovic (1968) and Jukic (1975).

Results of the species growth characteristics achieved on the base of "HVAR" expedition length frequency data in 1948-1949 years by Bhattacharya technique and comparisons with earlier results attained on otolits and scale aging (Letaconnoux, 1955; Ghirardelli, 1959; Zupanovic, 1968; Dupon, 1972) pointed out no significant differences (Fig. 3).

Differences exist only within youngest (smallest) and oldest (longest) length classes, VI and VII year class, caused probably because of the poorer samples for oldest, in our case and difficulties to count up spring-summer and autumn-winter rings of the otolits in the case of earlier studies.

Application of covered catch curve for 16,766 analysed Hakes caught during 1948-1949 years it has been obtained Z = 0.39 = M in the case when the whole points of the absolute ages (years) on the catch curve were considered (Fig. 4).

These estimates of Z and M values could have been even higher if one take into the consideration not all points on the catch curve but solely first two sets of the points on the curve, till 8th years, which in that case would have totally different slopes of regression lines, thus significantly different but much higher Z and M values of that obtained by total catch curve where Z = 0.39.

Possible variations of the Z and M values, especially in the case of Hake population, depend using computer technique options, on subjective, criterions in fitting regression lines throughout of catch curve points that in case of Hake data analysis gave us trouble and brought us to dilemmas: "What Z and M value should be taken as good one?"
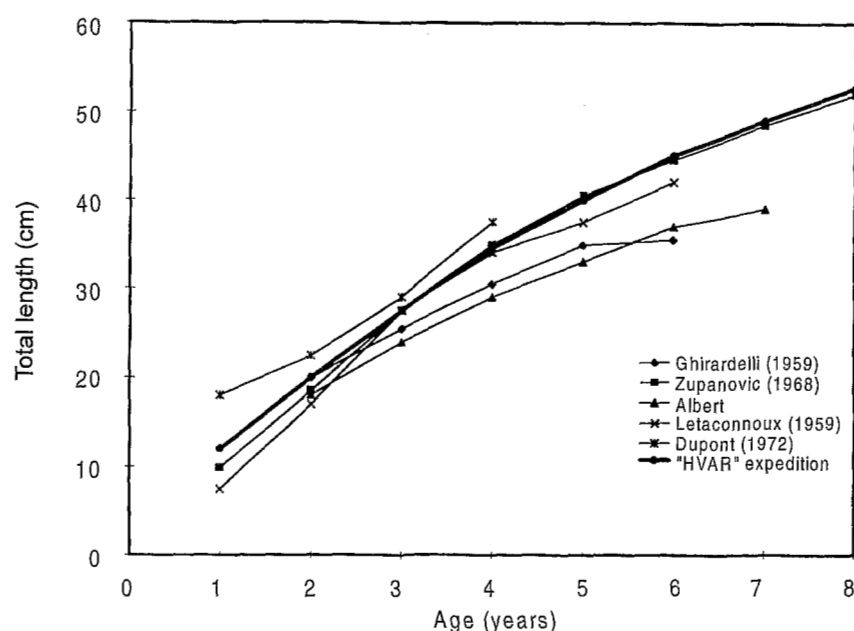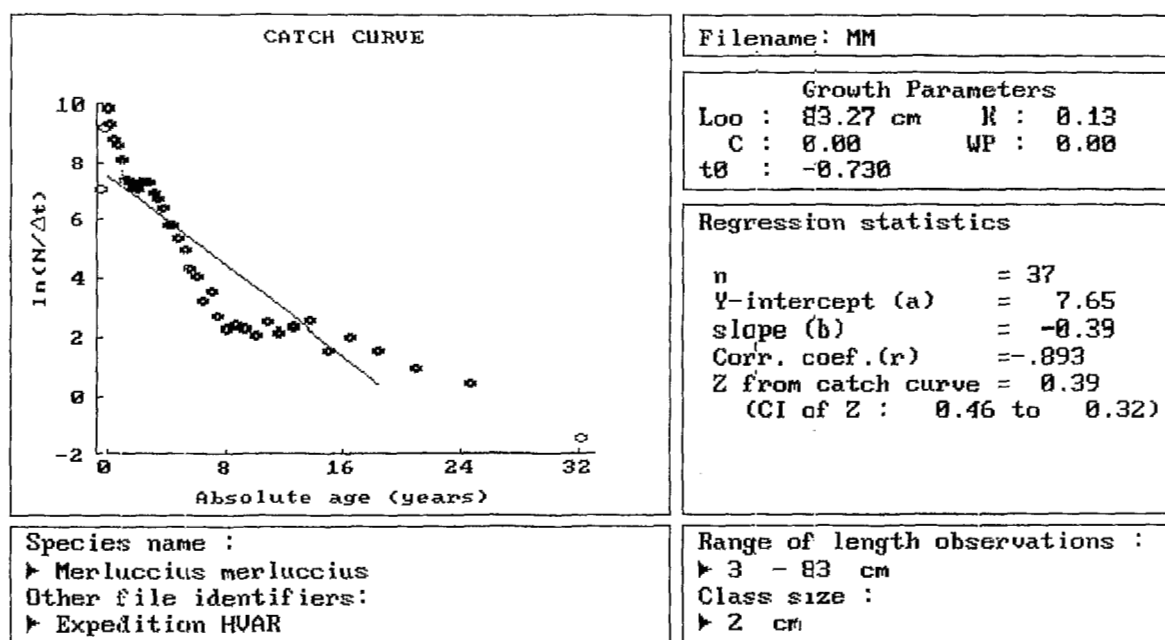
Fig. 3. Growth curve of Silver Hake.

Fig. 4. Catch curve: Hakes.

Striped Mullet (*Mullus barbatus* L.)

Catch per unit effort data of "HVAR" expedition for Striped Mullet (Fig. 5) pointed out that this species like Hake in the Adriatic represents "common" and "shared" commercial ground fish stock.

Except results for the deeper stations, i.e., bellow 150 meters, individuals were found out over the great part of the continental shelf. Migration patterns of the population in northern Adriatic and central Adriatic are described by Arneri and Jukic (1985).
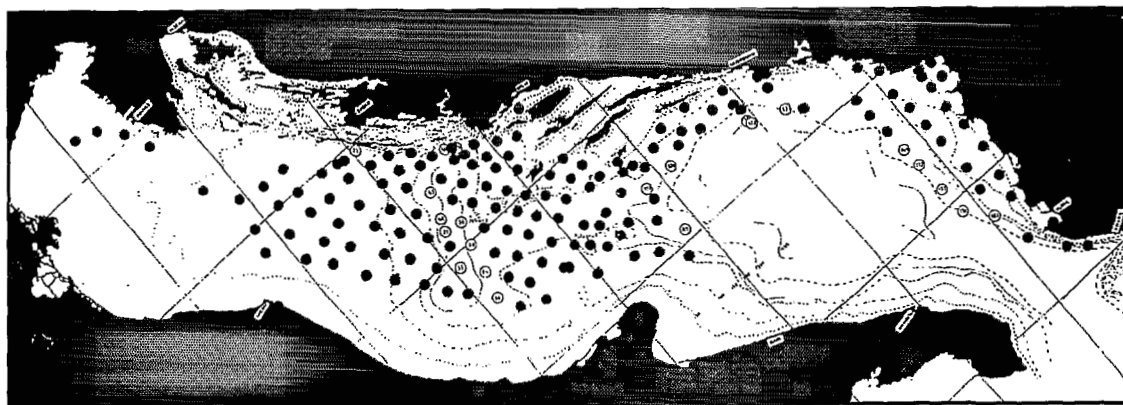
Fig. 5.   Distribution of the Striped Mullet population in the Adriatic Sea during "Hvar" expedition in 1948-1949.

Size distribution of the 15,933 analysed individuals of Striped Mullet population in accordance to sea depth, i.e., above and deeper of izobate of 100 meters approved that there have no been significant differences in size frequency distribution among small and bigger-sized individuals (Fig. 6).
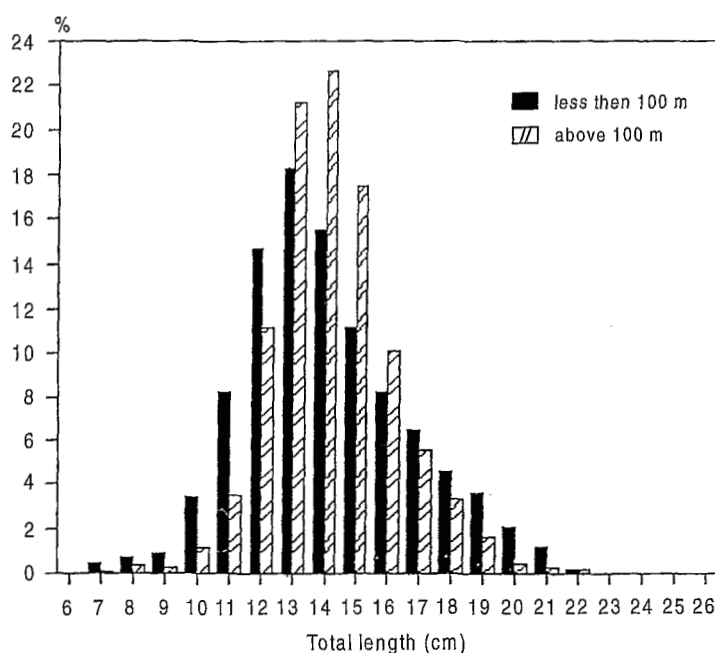

Fig. 6.   Length composition of the Striped Mullet population in relation to sea depth.

Comparisons of growth characteristics of the Striped Mullets obtained by length frequency data analysis using Bhattacharya approach and those obtained by scales aging (Bougis and Muzinic, 1958; Haidar, 1970; Jukic and Arneri, 1984), except (Sccacini, 1947) findings, significantly agreed to each other (Fig. 7).

Assessment of the Z value by catch converted curve of length frequency data in the case of Striped Mullet population during 1948-1949 year gave Z = 1.58 = M (Fig. 8).

Calculated M value, respecting average sea water temperature gave M = 0.57 which is much lower of that achieved by catch curve.
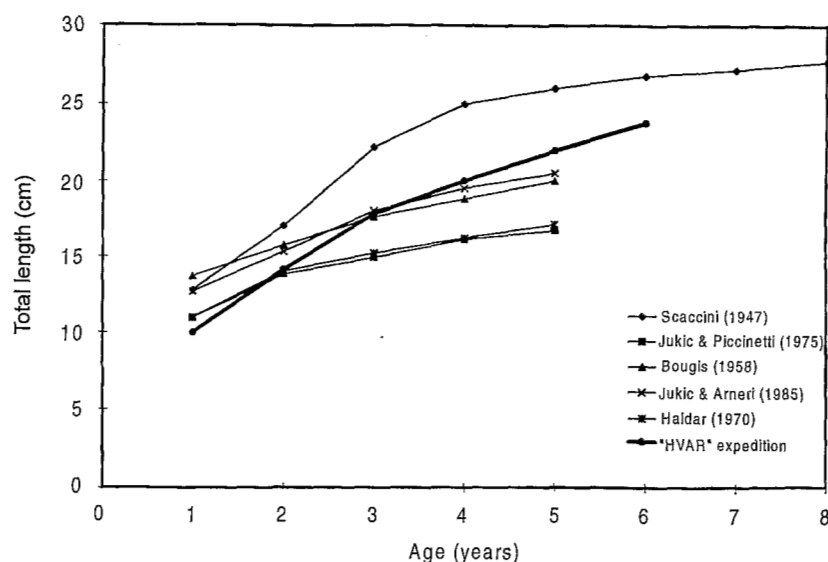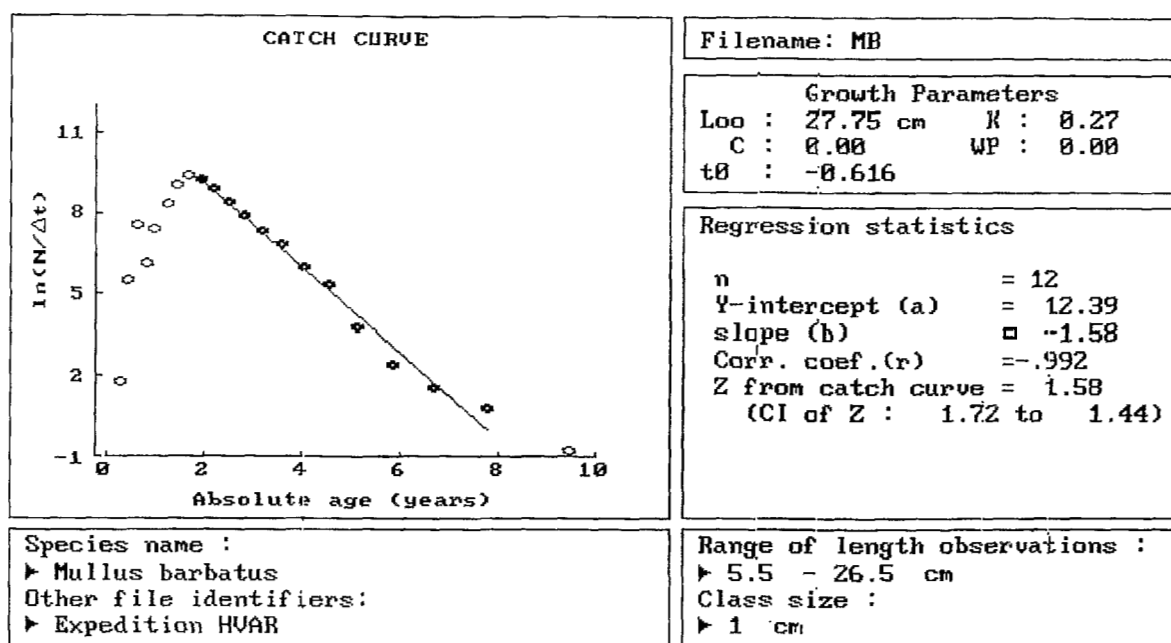
Fig. 7.   Growth curve of Striped Mullet.

Fig. 8.   Catch curve: Striped Mullet.

Pandora (*Pagellus erythrinus* L.)

Analysis of the indices of relative abundances of fish population Pandora (*Pagellus erythrinus* L.) in the Adriatic for "HVAR" expedition biological data proved that this species, in comparison to previous two species, can not be considered "common" Adriatic fish stock. It is dominantly distributed along the eastern Adriatic coast within recent sandy bottom sediments (Fig. 9).

Species vertical distribution proved by analysis of 3,021 individuals pointed out no significant relationship between species and sea depth but evident relation to the bottom sediments. Bigger-sized individuals prefer southern Adriatic and channels regions of the eastern Adriatic (Fig. 10).
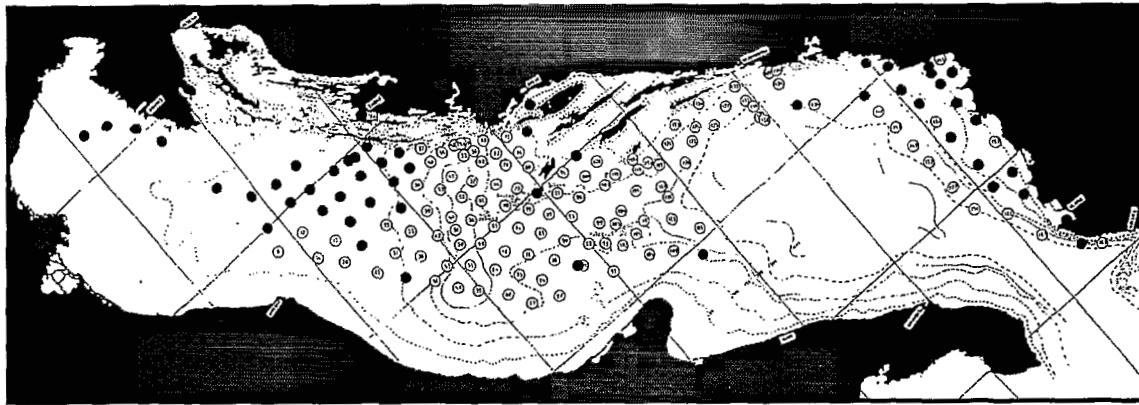
Fig. 9.   Distribution of the Pandora population in the Adriatic Sea during "Hvar" expedition in 1948-1949.
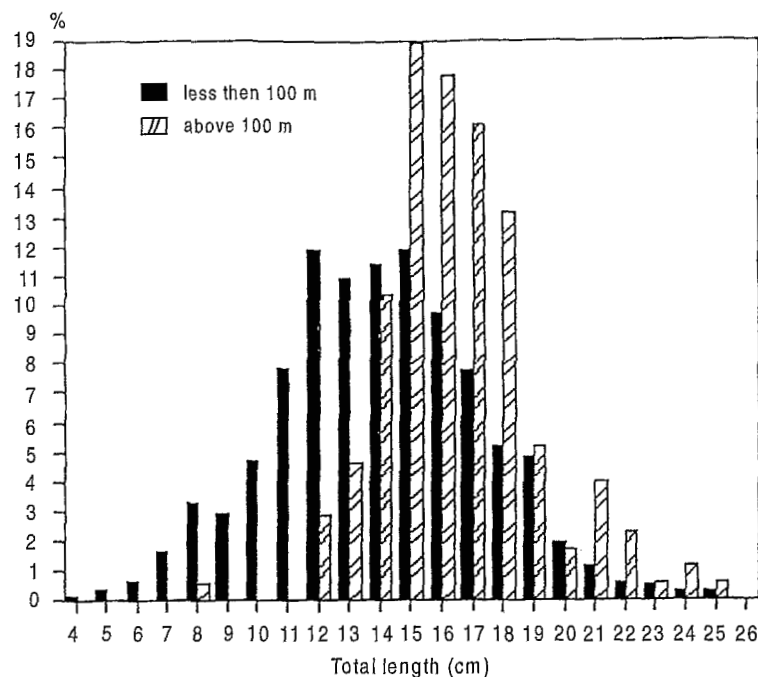

Fig. 10.   Length composition of the Pandora population in relation to sea depth.

Growth characteristics of Pandora assessed on the base of "HVAR" expedition length frequency data assessed by Bhattacharya technique and compared with earlier fisheries studies (Fig. 11) in which otholits readings were used (Rijavec and Zupanovic, 1965; Larrañeta, 1967; Girardin, 1981; Andaloro and Giarritta, 1985) slightly differ from each other. Generally speaking, obtained values of growth characteristics for corresponding ages obtained on the base of length frequency data for Pandora have been little bit lower for the whole life span. These differences are much more pronounced when one make comparison with growth characteristics of the species derived by Larrañeta (1967) and Girardin (1981) for the Pandora population from western Mediterranean where growth constant of K seems higher for all ages.

Calculation of the instantaneous mortality coefficients of Z and M using catch converted curve (Fig. 12) gave us Z = 0.88 = M, while M value obtained by Pauly (1984) formula gave different, smaller, value (M = 0.51).
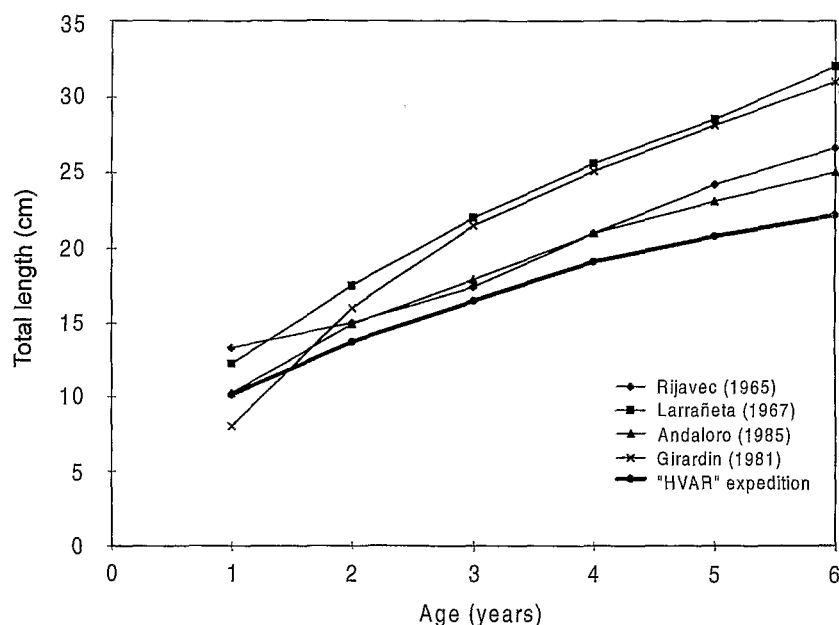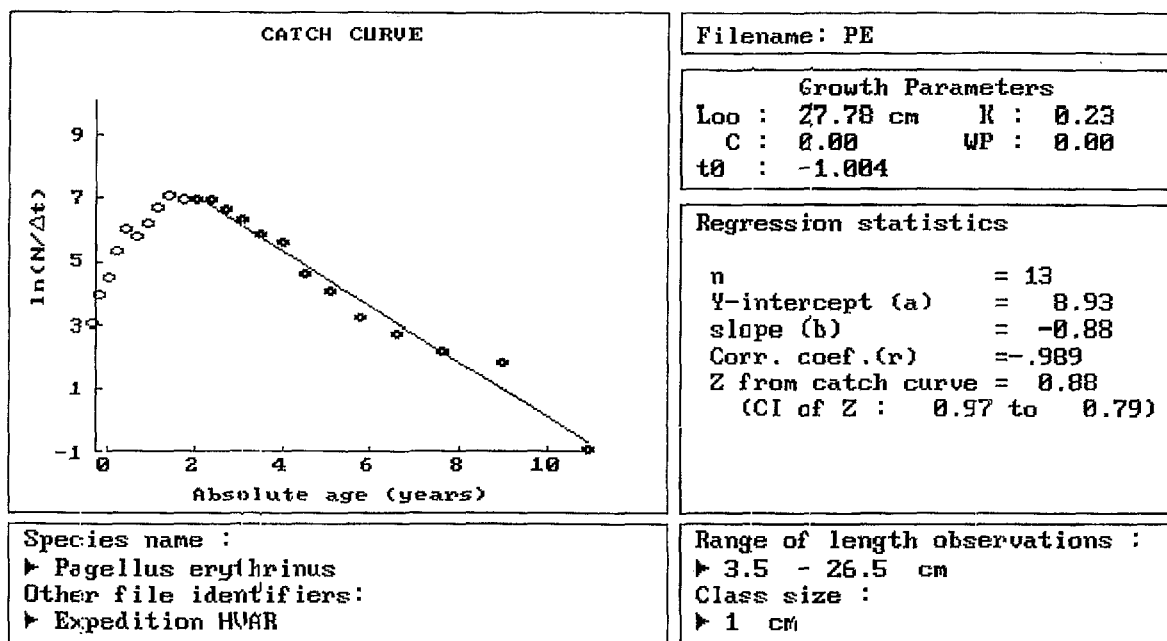
Fig. 11.   Growth curve of Pandora.

Fig. 12.   Catch curve: Pandora.

Selection curves of the bottom trawl cotton cod-end of 26 mm starched mesh size used during "HVAR" expedition during 1948-1949 year are given in Fig. 13.

In all cases "knife-edge", i.e., non-selective effects of cod-end are evident which proved that in Adriatic trawl fishery, where cod-end mesh size still has not attained necessary management measure, commercial and exploitable ground fish stocks enter the fishable phase immediately after its biological recruitments.
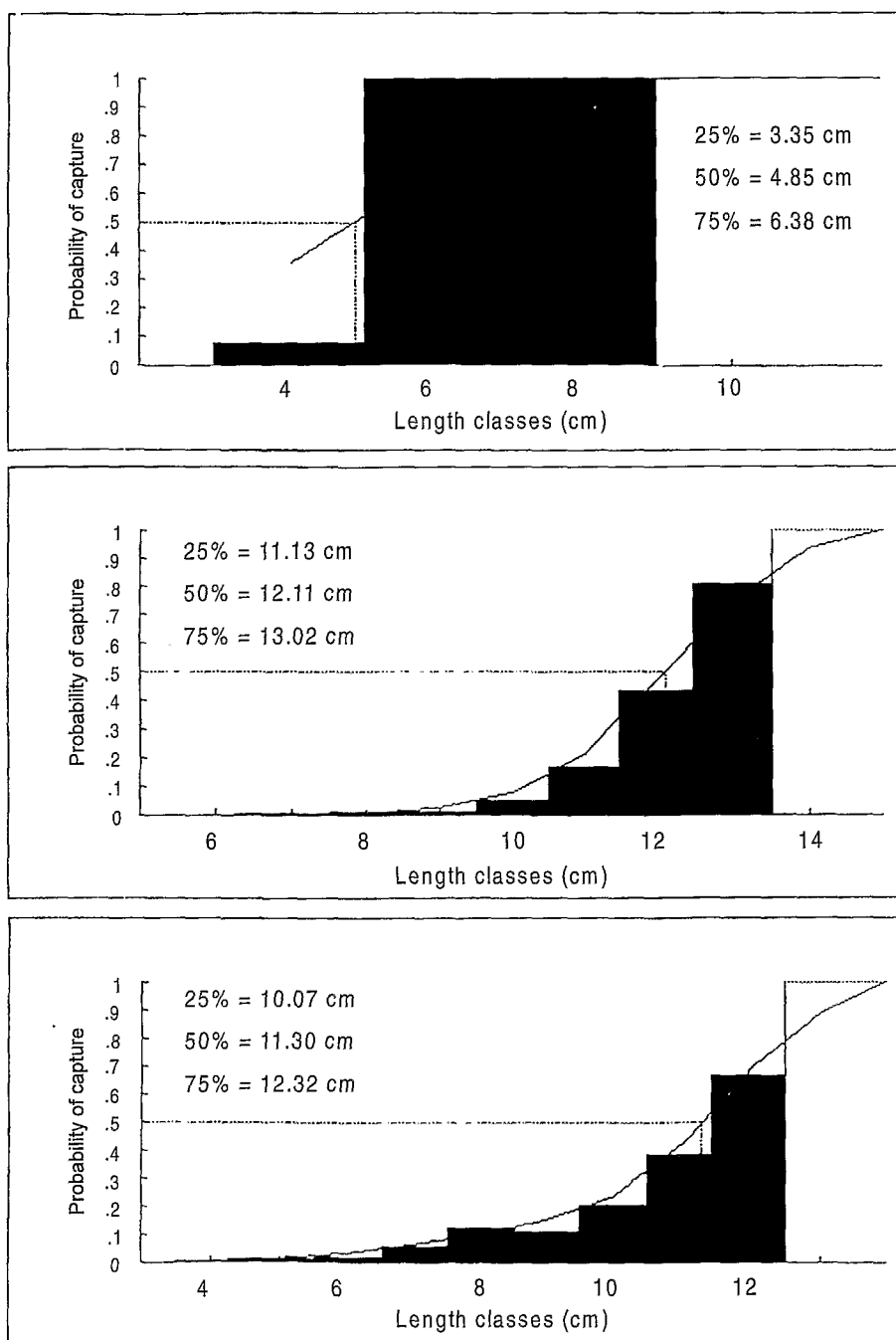
Fig. 13.   Characteristics of the trawl selectivity of the cotton cod-end 26 mm streched mesh-size.

Conclusions

Taking into account analyses of the length frequency data of: Hake, Striped Mullet and Pandora collected during 1948-1949 year in the Adriatic Sea under the scope of "Hvar" fisheries expedition that was carried out by the Institute of Oceanography and Fisheries-Split it has been possible to conclude the followings:

First, there have been no significant differences, except Pandora, in species growth characteristic obtained by Bhattacharya's method ant those by aging either otholits or scales.

Second, dilemmas and potential possibilities where by changing criterions in fitting regression lines throughout of points on catch curve, especially in the case of Hake population it is to believed that natural mortality coefficient M, at least for youngest specimens of Hake in Jabuka Pit, from which area the greatest part of smallest individuals derived in "Hvar" expedition, should have been even higher of assessed value M = 0.39 ?!

Third, application of Pauly (1984) formula for M respecting available bottom sea water temperature, supply us with M = 0.25 which generally are lower of that obtained by catch curve analysis.

References

Andaloro, F. and Giarritta, S.P. (1985). Contribution to the knowledge of the age, growth and feeding of Pandora, *Pagellus erythrinus* (L. 1758) in the Sicilian Channel. *FAO Fish. Rep.,* 336: 85-87.

Arneri, E. and Jukic, S. (1985). Some preliminary observations on the biology and dynamics of *Mullus barbatus* L. in the Adriatic Sea. *FAO Fish. Rep.,* 345: 79-87.

Bhattacharya, C.G. (1967). A simple method of resolution of a distribution into Gaussians components. *Biometrics,* 23: 115.

Bougis, P. and Muzinic, R. (1958). Sur la croissance de *Mullus barbatus* L. dans les eaux de Split. *Acta Adriatica,* 8(9): 14.

Dupon, E. (1972). La valeur de la méthode otolithometrique pour la détermination de l'âge du merlu (*Merluccius merlucius,* Pisces, Gadidae) en Méditerranée. *Bull. R. Sci. Nat. Belg.,* 48(1): 15.

Gayanilo, F.C., Soriano and Pauly, D. (1989). *A Draft Guide to the complete ELEFAN.* ICLARM, Manila, p. 70.

Gayanilo, F.C., Sparre, P. and Pauly, D. (1994). The FAO-ICLARM stock assessment tools (FiSAT) users guide. *FAO Computerized information series* (fisheries), 6: 186.

Ghirardelli, E. (1959). Contribution a la connaissance de la biologie du merlu (*Merluccius merluccius* L.) eu moyenne Adriatique. *Proc. Gen. Fish. Coun. Medit.,* 5: 489-494.

Haidar, Z. (1970). L'écologie du rouget (*Mullus barbatus* L.) en Adriatique orientale. *Acta Adriatica,* 14(1): 1-94.

Jukic, S. (1975). Trawl fishing grounds in the central Adriatic. *Acta Adriatica,* 17 (1): 86.

Jukic, S. and Arneri, E. (1984). Distribution of Hake (*Merluccius merluccius* L.), Striped Mullet (*Mullus barbatus* L.) and Pandora (*Pagellus erythrinus* L.) in the Adriatic Sea. *FAO Fish. Rep.,* 290: 85-91.

Karlovac, O. (1959). Istrazivanja naselja riba i jestivih beskralješnjaka vuèom u otvorenom Jadranu. *Izvj. Rib. Biol. Exp.* "Hvar" 1948-49, 5(1): 203.

Larrañeta, M.G. (1967). Crecimiento de *Pagellue erythrinus* de las costas de Castellón. *Inv. Pesq.,* 31(2): 185-258.

Letaconnoux, R. (1955). Rapport sur le merlu. Rapp. *P.-v. Reun. Cons. perm. int. Explor. Mer.,* 137: 40-43.

Pauly, D. (1984*). Fish population dynamics in tropical waters: a manual for use with programmable calculators.* ICLARM, Manila, p. 325.

Rijavec, L. and Zupanovic, Š. (1965). A contribution to the knowledge of biology of *Pagellus erythrinus* L. in the middle Adriatic. *Rapp. P.-v. Reun. Comm. int. Explor. scient. Mer Medit.,* 18(2): 195-200.

Scaccini, A. (1947) L'accrescimento e la proporzione dei sessi nella popolazione adritica di *Mullus barbatus* Rond. *Note Lab. Biol. Mar. Fano.*, 1(3): 17-24.

Zupanovic, Š. (1968). Study of hake (*Merluccius merluccius* L.) biology and population dynamics in the central Adriatic. *FAO Study and Rev.,* 32: 1-24.