遠洋水研報　第18号　昭和56年11月
Bull. Far Seas Fish. Res. Lab., No. 18. Nov. 1981.

Studies on the Merlucciid Fishes

Tadashi INADA*

Abstract

The so-called hakes or merlucciids, belonging to the genus *Merluccius* (family Merlucciidae), are anacanthine (Paracanthopterygian) fishes provided with one soft anal and two soft dorsal fins. Hakes are widely distributed in the world, inhabiting the continental shelf and slope, and are an important resource in the world fisheries.

The external and internal meristic and morphometric characters of all the hake species in the world are examined and compared in this study. Consequently, twelve full species are recognized by the characters of : number of gill-rakers, number of vertebrae and ribs, number of oblique rows of scales below lateral line canal, number of fin rays and morphometric characters such as head length, upper jaw length, diameter of eye and length of pectoral fin. Although the morphological differences of the external characters between some species are minor, it is recognizable by statistical analysis that these species have already diverged at the species level. The genus *Merluccius* and its twelve species are herein described in detail.

Fourteen internal characters, especially the skeletal system, are compared to clarify the differences between species, taking infraspecific variations into consideration. Some characters such as the shape of the interorbital foramen, hyomandibcular, cleithrum and postcleithrum show a few differences between some species, but other characters do not show any effective differences between these species because of their wide range of variations. Each of the characters is described in detail.

The distribution, biology and fishery for these twelve species are reviewed and additional data obtained by the author are included. Through the activities of Japanese vessels, the distributions of some species, especially those of the Southern Hemisphere, are clarified. Information on the biology of some species is still poor because of the lack of a fishery. On the other hand the bioiogy of some species of the Northern Hemisphere is well understood because they have been extensively studied. The sizes of standing stocks or potential yields of some species have also been studied.

The history of the taxonomy of merlucciids is briefly noted. The external and internal morphological characteristics found in each species are compared and summerized. A diagnostic key for twelve distinct species is presented. Geographical divergence of merlucciids through the history is also discussed based on some aspects appearing in some morphological characters in order to explain the present-day distributions of the twelve species.

Received Aug. 15, 1981. Contribution No.214 from the Far Seas Fisheries Research Laboratory.

* Japan Marine Fishery Resource Research Center, Kioicho 3-27, Chiyodaku, Tokyo 102, Japan.

Contents

Introduction

A great deal of work on the taxonomy, anatomy and biology of merlucciids has been done since LINNAEUS (1758) first described the European hake.

The first actual taxonomic revision appeared in 1937, published by NORMAN in the Discovery Report. In the report he clarified the confused synonymy of seven known species and indicated the differentiating characters between them. Following the basic system laid down by him, SVETOVIDOV (1948) presented a more detailed anatomical work and examined the systematic status of these seven species. Since then, some contributions, especially reports of new species, have been made by ichthyologists, and finally fifteen nominal species were described in the world, excluding the early synonyms. Of these investigations, GINSBURG (1954) studied the taxonomy of eight species, including two new American species, and FRANCA (1962) studied the taxonomy of eastern Atlantic representatives and treated them all as subspecies of *Merluccius merluccius*. Many problems still remain unsolved, especially with regard to the definition of species, and a detailed revision of all species of *Merluccius* has been very much needed.

Data on internal morphology were first given by SVETOVIDOV (1948), especially for the axial skeleton. Later, some ichthyologists studied the osteology of several species (MUJIB, 1967 ; ROJO, 1976 ; DE la HOZ and ARENAS, 1976; and others), and some characters for systematic studies (MARSHALL, 1966 ; MARSHALL and COHEN, 1973). But a detailed comparative anatomy for all species is still lacking and is highly desired for a complete understandings of merlucciid fishes.

Studies on distribution, biology and fisheries have been reported by many authors, especially HART (1948), who reviewed well these general studies. Extensive studies have been completed on the European hake by HICKLING (1927, 1930, 1933), on the Argentine hake by HART (1946), and on the Pacific hake by AHLSTROM and COUNTS (1955). More numerous studies have been published recently by many fisheries biologists on various species and on various aspects in connection with the development of the fisheries and their managements (CLAY and CLAY, 1979). Recently, excellent and modern summeries of the hake fishery literature were made by GRINOLS and TILLMAN (1970) and BOEREMA (1977). However, some species still require additional investigation of their biology. It seems necessary to again review the status of all the species in the world.

In the present work the author attempts to clarify the above-mentioned problems. This study is composed of four parts. In the first part the genus and species of *Merluccius* are described and brief remarks on each species are presented. The internal morphology, especially comparative osteology considering the infraspecific variations for each character, is investigated in the second part. The third part contains reviews of the biological features of all species, including a brief summary of their distributions and fisheries. In the final part, the author discusses the taxonomy of these species with diagnostic key and the geographical divergence through the history suggesting the present-day distributions of merlucciids.

This paper consists of a part of studies on the demersal fish resources in the Far Seas Fisheries Research Laboratory.

I. Materials and methods

The methodology employed in this study has been a basic, traditional procedure for each part. In the section on the description of genus and species, a total of 569 specimens (ranging 96.3-809.0 mm SL.) was measured for proportions and a total of 1404 specimens (ranging 96.3-1136.0 mm SL.) was examined for meristic characters. The specimens of *Merluccius albidus* and *M. merluccius smiridus* were obtained for examination from the U. S. National Museum (USNM) and the other specimens were examined at the Far Seas Fisheries Research Laboratory of Japan (FSFL). The data for each specimen are noted by species in the section on the description of species.

Counts and measurements were taken from formalin fixed materials for the following 28 measured characters and 10 meristic ones in accordance with the method of HUBBS and LAGLER (1947), except for certain modifications which are indicated in Fig. 1. The meristic characters examined were : first dorsal fin rays, second dorsal fin rays, anal fin rays, pectoral fin rays (including uppermost short ray), pelvic fin rays, branchiostegal rays, oblique rows of scales below lateral line canal, gill-rakers on the first arch (separating upper and lower limbs and excluding tubercles), vertebrae including terminal vertebra (separating abdominal and caudal), and ribs on the cervical vertebrae (see: glossary). Vertebrae and ribs were counted mainly from fresh materials by dissection and some were counted from radiographs. Statistical calculations of F-tests on variances and t-tests on means between two populations were conducted according to standard procedures. For the study of comparative anatomy, at least two specimens of each species were fixed in formalin and dissected and stained with alizarin red for examination of sutures. Several fresh specimens of some species were examined for infraspecific variations of internal morphology. The nomenclature for skull bones mainly followed previous studies on gadoids. Descriptions of distribution, biology and fisheries are mainly based on published papers and on data collected by Japanese vessels, especially from the Southern Hemisphere.

II. Description of genus and species with remarks

The genus *Merluccius* was first proposed by RAFINESQUE (1810a) for the species *Merluccius smiridus* (= *M. merluccius*), and many generic names have been used for species now placed in *Merluccius* (FOWLER, 1936 ; SVETOVIDOV, 1948 ; NORMAN, 1966 ; WHITLEY, 1968). JORDAN and GILBERT (1882) fixed the name *Merluccius* by designating *Gadus merluccius* LINNAEUS as the type species. MAURIN (1968 a and b) used the spelling *Merlucius*, because the original meaning for the name is derived from sea pike (*Maris* *lucius*) ; however, his use is incorrect.

A total of fifteen species has been recognized, excluding the early synonyms of *M. merluccius* and other species (Table 1). Recent studies revealed that *M. magnoculus* is a junior synonym of *M. albidus* (KARNELLA, 1973) and *M. polylepis* is a junior synonym of *M. australis* (INADA, 1981). In this study, the author tentatively treats *M. cadenati*

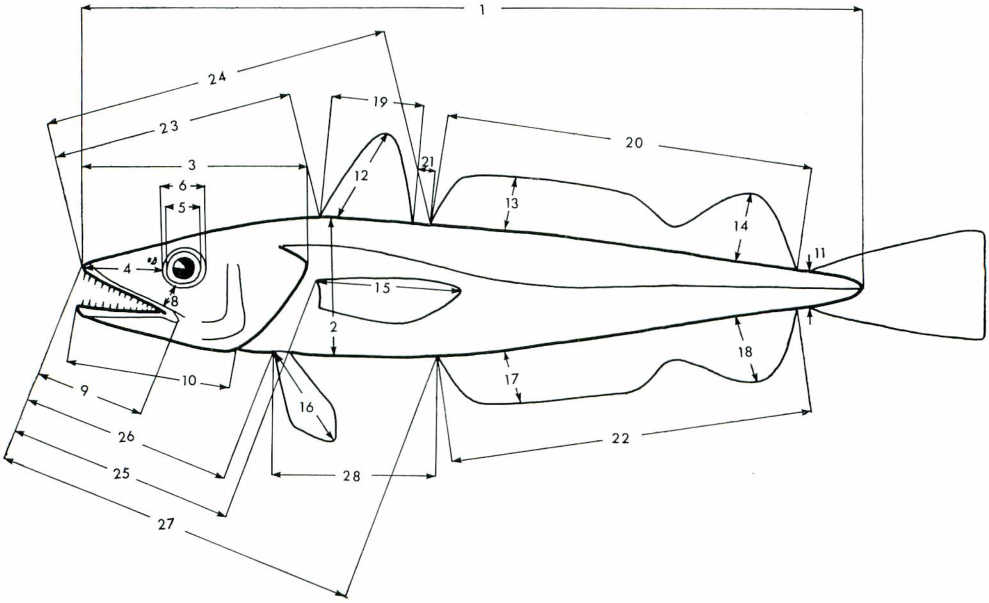

Fig. 1. Topography of measurements for merlucciids. 1. standard length (from tip of upper jaw to end of terminal vertebra ; 2. body depth (greatest) ; 3. head length (excluded opercular membrane) ; 4. snout length (from tip of upper jaw to anterior margin of orbit) ; 5. diameter of eye ; 6. diameter of orbit ; 7. interorbital width (defined by bony ridge) ; 8. suborbital width (least width from lower margin of orbit to upper jaw) ; 9. upper jaw length ; 10. lower jaw length (from tip of lower jaw to end of retroarticular bone) ; 11. caudal peduncle depth (least depth) ; 12. length of longest first dorsal fin ray ; 13. length of longest second dorsal fin ray (anterior lobe) ; 14. length of longest second dorsal fin ray (posterior lobe) ; 15. length of pectoral fin (from upper base to tip) ; 16. length of pelvic fin (from outer base to tip) ; 17. length of longest anal fin ray (anterior lobe) ; 18. length of longest anal fin ray (posterior lobe) ; 19. length of first dorsal fin base ; 20. length of second dorsal fin base ; 21. space between first dorsal and second dorsal fins (from posterior end of first dorsal fin to second dorsal fin origin) ; 22. length of anal fin base ; 23. length from tip of snout to first dorsal fin origin ; 24. length from tip of snout to second dorsal fin origin ; 25. length from tip of snout to pectoral fin insertion ; 26. length from tip of snout to pelvic fin insertion ; 27. length from tip of snout to anal fin origin ; 28. length from pelvic fin insertion to anal fin origin.

as a junior synonym of *M. polli*, and recognizes twelve species, which have wide geographical distributions and wide depth ranges, and which show minor morphological differences in various characters.

Table 1. List of the fifteen nominal species of *Merluccius*, excluding the early synoyms

Scientific name	English name	Original description
M. merluccius	European hake	*Gadus merluccius* LINNAEUS, 1758
M. bilinearis	Silver hake	*Stomodon bilinearis* MITCHILL, 1814
M. albidus	Offshore hake	*Gadus albidus* MITCHILL, 1818
M. gayi	Chilean hake	*Merlus giay* GUICHENOT, 1848
M. productus	Pacific hake	*Merlangus productus* AYRES, 1855
M. capensis	Shallow-water Cape hake	*Merluccius capensis* CASTELNAU, 1861
M. australis	New Zealand hake	*Gadus australis* HUTTON, 1872
M. angustimanus	Panama hake	*Merluccius angustimanus* GARMAN, 1899
M. hubbsi	Argentine hake	*Merluccius hubbsi* MARINI, 1933
M. polli	Benguela hake	*Merluccius polli* CADENAT, 1950
M. senegalensis	Senegalese hake	*Merluccius senegalensis* CADENAT, 1950
M. polylepis	Patagonian hake	*Merluccius polylepis* GINSBURG, 1954
M. magnoculus	Gulf hake	*Merluccius magnoculus* GINSBURG, 1954
M. paradoxus	Deep-water Cape hake	*Merluccius capensis paradoxus* FRANCA, 1960
M. cadenati	Mauritanian hake	*Merluccius cadenati* DOUTRE, 1960

Genus *Merluccius* RAFINESQUE

Merluccius RAFINESQUE, 1810. Caratt. Gen. Spec. Sicil. : 25 (type: *Merluccius smiridus* RAFINESQUE).

Onus RAFINESQUE, 1810, Ind Ittiol. sicil.:12 (type: *Onus riali* RAFINESQUE).

Merlangus RAFINESQUE, 1810, *ibid.*: 67 (type: *Gadus merluccius* LINNAEUS).

Stomodon MITCHILL, 1814, *Trans. Lit. Phil. Soc.*, **1**: 7 (type: *Stomodon bilinearis* MITCHILL).

Hydronus MINDING, 1832, Naturg. Fische : 83 (type : *Hydronus marlucius* MINDING).

Merlus GUICHENOT, 1848, *in* GAY, Hist. fisica polit. Chile, Zool., 2: 328 (type : *Merlus gayi* GUICHENOT).

Merlucius GRONOW, 1854, *ed.* GRAY, Cat. Fish.: 129 (type: *Merluccius lanatus* GRONOW).

Homalopomus GIRARD, 1856, *Proc. Acad. Nat. Sci. Philad.*: 132 (type : *Homalopomus trowbridgii* GIRARD).

Epicopus GÜNTHER, 1860, Cat. fish. Brit. Mus., 2: 232, 248 (type: *Merlus gayi* GUICHENOT).

Trachinoides BORODIN, 1934, *Bull. Vanderbilt mar. Mus.*, **1** (4): 120 (type: *Trachinoides maroccanus* BORODIN).

Huttonichthys WHITLEY, 1937, *Mem. Queensland Mus.*, **11** (2): 122 (type: *Gadus australis* HUTTON).

First dorsal fin rays I, 7-12 ; second dorsal fin rays 34-45 ; anal fin rays 35-46 ; pectoral fin rays 12-18 ; pelvic fin rays 7 ; branchiostegal rays 7 ; number of oblique raws of scales below lateral line canal 101-171 ; number of gill-rakers on first arch 1-7+7-19=8-25 ; number of vertebrae 21-29+25-31=48-58 ; number of ribs on cervical vertebrae 3-4.

Body depth (greatest) in percent of standard length 13.0-21.0 ; head length 24.4-33.5; caudal peduncle depth 3.3-5.8; length of longest first dorsal fin ray 9.6-15.5; length of longest second dorsal fin ray (anterior lobe) 6.0-9.6 ; length of longest second dorsal fin ray (posterior lobe) 8.6-12.7; length of pectoral fin 14.1-24.2; length of pelvic fin 10.4-20.6; length of longest anal fin ray (anterior lobe) 6.3-10.4 ; length of longest anal fin ray (posterior lobe) 7.8-12.0; length of first dorsal fin base 8.4-13.5; length of second dorsal fin base 41.1-50.2; space between first dorsal and second dorsal fins 1.3-5.3; length of anal fin base 36.7-48.9; length from tip of snout to first dorsal fin origin 27.5-34.9; length from tip of snout to second dorsal fin origin 39.2-47.8; length from tip of snout to pectoral fin insertion 23.6-33.3 ; length from tip of snout to pelvic fin insertion 21.2-30.4 ; length from tip of snout to anal fin origin 41.3-52.2 ; length from pelvic fin insertion to anal fin origin 18.2-27.6. Snout length in percent of head length 27.8-39.0; diameter of eye 11.6-22.9 ; diameter of orbit 13.8-27.7; interorbital width 20.8-31.0; suborbital width 3.6-9.7; upper jaw length 43.7-55.9; lower jaw length 56.0-69.6.

Body elongate, somewhat compressed, deepest at origin of first dorsal, its depth 0.4-0.8 times length of head; dorsal contour almost straight behind origin of first dorsal; ventral contour almost straight behind anus. Caudal peduncle narrow in depth, strongly compressed, about 1/3-1/4 depth of body. Head large, slender, about 1/3-1/4 length of body; upper profile almost straight or little concave above eye; dorsal surface of head flat. Mucous canals on head developed, but not pored. Interorbital broad, little elevated, its width 1.0-2.4 times diameter of eye. Snout long and depressed; its length 1.3-3.2 times of diameter of eye; its tip broad and rounded. Eye large to notably large, 0.2-0.5 times length of upper jaw. Nostrils small, a little in advance of anterior upper margin of eye; anterior nostril rounded in shape without tube; posterior one crescent in shape with a short flap anteriorly, situated close behind anterior one. Mouth moderately large and oblique; maxillary reaching below middle of eye or behind it, almost half length of head; lower jaw a little longer than upper jaw, projecting forward slightly before tip of upper jaw. No barbel on chin. Teeth on jaws well developed, sharp, in two irregular rows; outer teeth fixed, widely or moderately spaced; inner teeth larger and depressible to inner side; teeth on jaws larger at anterior part, considerably smaller at their posterior end; vomer with a biserial rows of smaller teeth, inner enlarged and depressible inward; no teeth on palatine and tongue. Opercle subtriangular in outline; its posterior part flexible, marging almost imperceptibly with soft membranous border, without spines. Gill opening rather wide; gill membranes united under anterior part of eye. Pseudobranchiae absent. Gill-rakers well developed; varying in shape and number by species. Scales deciduous, cycloid, thin and small; dorsal surface of head scaled, except anterior tip of snout; opercle scaled; maxillary, preorbital and suborbital regions scaleless ; cheek, preopercle and interopercle scaled only on their upper parts; ventral surface of head scaleless; scales on head smaller than those on body; those on anterior part of head very minute; caudal, pectoral and pelvic fins scaled at their fleshy bases; dorsal and anal fins scaleless. Lateral line almost straight or slightly curved anteriorly, beginning directly behind upper angle of gill opening and running almost parallel with dorsum above midline of body. Two dorsal and one anal fins; first dorsal fin roughly triangular in shape ; its second or third ray longest; origin of first dorsal fin slightly behind level of pectoral fin insertion; second dorsal and anal fins with a deep notch in rear part; rays in anterior lobe rather widely spaced; those in posterior lobe somewhat crowded; origin of anal fin beginning at same level or slightly behind origin of second dorsal fin; its shape similar to that of second dorsal fin. Pectoral fin rather long and narrow, high in position, its relative length becoming smaller with growth. Pelvic fin well developed, inserting at a moderate distance in advance of pectoral fin. Caudal fin usually truncate, becoming a little concave with growth; those of some species convex in young stages. Rays of fins segmented and branched including first ray of anal fin; first ray of first dorsal fin unsegmented and spiny.

Colour of body usually silvery when alive, darker dorsally, whitish ventrally; that of some species more blackish or almost black with white margined caudal fin; iris gold, pupil blue-black; inner wall of gill chamber and peritoneum dusky grey, light brown, solid black or dark silvery stippled and spotted with black.

1. *Merluccius merlucciius* (Linnaeus): European hake (Fig. 2)

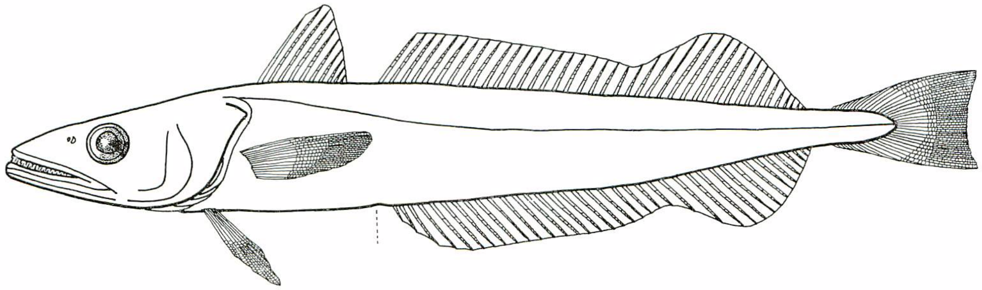

Fig. 2. *Merluccius merluccius* (Linnaeus, 1758), FSFL D1235, SL 467.8mm

Merluccius merluccius (Linnaeus, 1758)

Gadus merluccius Linnaeus, 1758, Syst. Nat., *ed.* X : 254 (type locality: 'Habitat in Oceano').

Gadus ruber Lacepède, 1803, Hist. nat. Poiss., 5: 671, 673 (Écosse, Fécamp, Dieppe, Boulogne).

Merluccius smiridus Rafinesque, 1810, Caratt. Gen. Spec. Sicil.: 25 (Sicilia).

Onus riali Rafinesque, 1810, Ind. Ittiol. sicil.: 12 (Sicilia).

Merlucius esculentus Risso, 1826, Hist. nat. Eur. mérid, 3 : 220 (Nice).

Merlucius vulgaris Fleming, 1828, Hist. Brit. Anim. : 195 (southern coast of England and Ireland).

Hidrouns marlucius Minding, 1832, Natug. Fische: 84 (Nordsee, Mittelmeer).

Merlucius sinuatus Swainson, 1838, Nat. Hist. Fishes, 1: 319, fig. 73 (Mediterranean).

Merlucius ambiguus Lowe, 1840, *Proc. zool. Soc. London*, 8: 37 (Madeira).

Merlucius lanatus Gronow, 1854, *ed.* Gray, Cat. Fish. : 130 ('Mari Gallico, Mediterraneo').

Merluccius argentatus Günther, 1862, Cat. fish., Brit. Mus., 4 : 346 (Iceland).

Merluccius linnei Malm, 1877, Göteb. Bohusl. Fauna: 489 (Göteborg, Vinga).

Onus guttatus Collett, 1890, *Bull. Soc. Zool. Fr*, **15** : 105 (Fayal, Azores).

Trachinoides maroccanus Borodin, 1934, *Bull. Vanderbilt mar. Mus.*, **1** (4): 120, pl.II (figs.2-3) (Casablanca).

Materials examined: (Table 2)

Table 2. Data of specimens of *Merluccius merluccius* used in this study

Merluccius merluccius merluccius

Catalogue No. (FSFL)	Date	Sampling position Lat. (N)	Sampling position Long.(W)	Depth (m)
D1140, D1202, D1205, D1206, D1208, D1216, D1219, D1234-D1236, D1240-D1242, D1246, D1253, D1263, D1274-D1276, D1278, D1280, D1283-D1285, D1290, D1808, D1853, D1854, D1859	Apr. 26, 1969	45°03′	02°24′	120
T261	Aug. 27, 1972	53°28.5′	13°16.0′	173
P730, P731, P733, P734, P778, P779, P785	Jan. 7, 1972	25°28.3′	16°04.5′	532
Q779, Q780, Q785, Q798	Dec. 7, 1974	25°31′	15°50′	201

Other specimens examined for counting of meristic characters :

Number of specimens not catalogued	Date	Sampling position Lat. (N)	Sampling position Long.(W)	Depth (m)
20	Dec. 7, 1974	25°20′	16°03′	239
18	Dec. 8, 1974	25°42′	15°24′	260
3	May 17, 1974	21°32′	17°35′	404
1	Nov. 9, 1974	21°46′	17°32′	104
1	Feb. 24, 1975	20°56′	17°22′	102

Merluccius merluccius smiridus

Catalogue No. (USNM)	Date	Sampling position Lat. (N)	Sampling position Long. (W)	Depth (fsm)
206553 (9 specimens)	Sept. 22, 1971	Tunis fish market		
219331 (2 specimens)	Mar. 30, 1967	37°03′	10°28.5′	75
219332 (6 specimens)	Dec. 7, 1966	36°45′	10°36′	—
219333 (3 specimens)	July 12, 1967	37°03.5′	10°16′	28-38

Description:

First dorsal fin rays I, 7-10 (average I, 8.7); second dorsal fin rays 36-40 (38.4); anal fin rays 36-40 (38.0); pectoral fin rays 13-15 (13.8); pelvic fin rays 7; branchiostegal rays 7; number of oblique row of scales 127-156 (141.2); number of gill-rakers on first arch 1-3(1.8)+7-9 (7.9) = 8-11 (9.7); number of vertebrae 23-25 (24.6) + 25-29 (26.4) = 49-54 (51.1); number of ribs 3-4 (4.0).

Body depth (greatest) in percent of standard length 13.6-17.9 (15.7); head length 25.1-30.5 (27.3); caudal peduncle depth 3.4-5.1 (4.5); length of longest first dorsal fin ray 10.3-13.1 (11.9); length of longest second dorsal fin ray (anterior lobe) 6.6-8.6 (7.8); length of longest second dorsal fin ray (posterior lobe) 8.8-11.0 (9.8); length of pectoral fin 14.1-18.7 (16.3); length of pelvic fin 14.0-19.1 (16.1); length of longest anal fin ray (anterior lobe) 6.5-8.8 (7.7); length of longest anal fin ray (posterior lobe) 8.2-10.6 (9.2); length of first dorsal fin base 8.4-10.5 (9.6); length of second dorsal fin base 46.0-50.2 (48.3); space between first dorsal and second dorsal fins 1.5-3.8 (2.7); length of anal fin base 44.2-48.8 (46.9); tip of snout to first dorsal fin origin 27.5-31.4 (29.6); tip of snout to second dorsal fin origin 39.4-43.4 (41.6); tip of snout to pectoral fin insertion 25.1-29.7 (27.3); tip of snout to pelvic fin insertion 21.5-26.1 (24.1); tip of snout to anal fin origin 41.3-47.9 (44.8); length between pelvic fin insertion and anal fin origin 18.2-25.0 (22.5). Snout length in percent of head length 30.2-34.5 (32.6); diameter of eye 13.6-19.4 (16.9); diameter of orbit 16.0-21.0 (18.9); interorbital width 21.5-28.4 (25.8); suborbital width 6.2-8.5 (7.2); upper jaw length 47.8-53.5 (51.7); lower jaw length 62.2-65.7 (63.9).

1. 1. *Merluccius merluccius merluccius* (LINNAEUS)

Merluccius merluccius merluccius (LINNAEUS, 1758)

Gadus merluccius LINNAEUS, 1758, Syst. Nat., *ed.* X : 254 (type locality: 'Habitat in Oceano').

Merluccius merluccius atlanticus CADENAT, 1950, Congr. pêche. pêcher. Un. franç. d'outre Mer: 128 (eastern Atlantic) / LETACONNOUX, 1953, Cons. Int. Explor. Mer. : 1-5 (description) / DOUTRE, 1960, *Rev. Trav. Inst. Scient. Tech. Peche,* **24** (4) : 514 (description).

Merlucius merlucius merlucius MAURIN, 1968, Theses l'Univ. Nancy : 13 (north-west Africa).

Description:

First dorsal fin rays I, 8-10 (I, 8.7) ; second dorsal fin rays 36-40 (38.5) ; anal fin rays 36-40 (38.3) ; pectoral fin rays 13-15 (13.9) ; pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 127-156 (141.5) ; number of gill-rakers on first arch 1-3 (1.9)+7-9 (7.9)=8-11 (9.8) ; number of vertebrae 23-25 (24.7) + 25-28 (26.1) =49-52 (50.8); number of ribs 4.

Body depth in percent of standard length 15.0-17.9 (16.5); head length 25.1-27.5

(26.6) ; caudal peduncle depth 4.2-5.1 (4.6) ; length of longest first dorsal fin ray 10.3-12.9 (11.7); length of longest second dorsal fin ray (anterior lobe) 6.6-8.6 (7.7); length of longest second dorsal fin ray (posterior lobe) 8.8-11.0 (9.8) ; length of pectoral fin 14.1-18.7 (16.3) ; length of pelvic fin 14.0-17.8 (15.5) ; length of longest anal fin ray (anterior lobe) 6.5-8.5 (7.6) ; length of longest anal fin ray (posterior lobe) 8.2-10.2 (9.1) ; length of first dorsal fin base 8.4-10.3 (9.5) ; length of second dorsal fin base 47.2-50.2 (48.6) ; space between first dorsal and second dorsal fins 2.1-3.8 (2.9); length of anal fin base 45.4-48.8 (47.2) ; tip of snout to first dorsal fin origin 27.5-30.1 (29.2); tip of snout to second dorsal fin origin 39.4-42.9 (41.3); tip of snout to pectoral fin insertion 25.1-28.8 (26.8); tip of snout to pelvic fin insertion 21.5-26.1 (24.0) ; tip of snout to anal fin origin 41.3-46.6 (44.6) ; length between pelvic fin insertion to anal fin origin 20.3-24.5 (22.5). Snout length in percent of head length 30.2-34.5 (32.8); diameter of eye 13.6-18.8 (16.5); diameter of orbit 16.0-20.7 (18.6); interorbital width 24.1-28.4 (26.2) ; suborbital width 6.2-8.5 (7.3) ; upper jaw length 47.8-53.2 (51.4); lower jaw length 62.5-65.7 (64.0).

1. 2. *Merluccius merluccius smiridus* RAFINESQUE

Merluccius merluccius smiridus RAFINESQUE, 1810

Merluccius smiridus RAFINESQUE, 1810, Caratt. Gen. Spec. Sicil. : 25 (type locality: Sicilia).

Merluccius merluccius mediterraneus CADENAT, 1950, Congr. pêche. pêcher. Un. franç. d'outre Mer: 128 (Mediterranean) / LETACONNOUX, 1953, Cons. Int. Explor. Mer.: 1-5 (description) / DOUTRE, 1960, *Rev. Trav. Inst. Scient. Tech. Peche*, **24** (4) : 514 (description).

Merlucius merlucius mediterraneus MAURIN, 1968, Theses l'Univ. Nancy:13 (north Africa).

Description:

First dorsal fin rays I, 7-10 (I, 8.7) ; second dorsal fin rays 36-40 (38.2) ; anal fin rays 36-40 (37.3); pectoral fin rays 13-15 (13.5) ; pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 133-143 (138.2); number of gill-rakers on first arch 1-2 (1.7)+7-8 (7.8)=8-10 (9.4); number of vertebrae 23-25 (24.6)+26-29 (27.2)=51-54 (51.7) ; number of ribs 3-4 (4.0).

Body depth in percent of standard length 13.6-17.6 (14.9); head length 27.5-30.5 (28.8) ; caudal peduncle depth 3.4-5.0 (4.3) ; length of longest first dorsal fin ray 10.8-13.1 (12.4) ; length of longest second dorsal fin ray (anterior lobe) 6.8-8.6 (7.9) ; length of longest second dorsal fin ray (posterior lobe) 8.8-10.9 (9.9); length of pectoral fin 14.7-17.6 (16.3) ; length of pelvic fin 15.0-19.1 (17.4) ; length of longest anal fin ray (anterior lobe) 6.9-8.8 (8.0); length of longest anal fin ray (posterior lobe) 8.5-10.6 (9.5) ; length of first dorsal fin base 8.8-10.5 (9.7) ; length of second dorsal fin base 46.0-50.0 (47.8); space between first dorsal and second dorsal fins 1.5-3.0 (2.3); length of anal fin base 44.2-48.3 (46.5); tip of snout to first dorsal fin origin 29.3-31.4 (30.3);

tip of snout to second dorsal fin origin 41.1-43.4 (42.2) ; tip of snout to pectoral fin insertion 27.0-29.7 (28.3) ; tip of snout to pelvic fin insertion 22.0-25.6 (24.2) ; tip of snout to anal fin origin 43.0-47.9 (45.2); length between pelvic fin insertion to anal fin origin 18.2-25.0 (22.5). Snout length in percent of head length 30.7-33.6 (32.1) ; diameter of eye 16.0-19.4 (17.7); diameter of orbit 17.6-21.0 (19.5); interorbital width 21.5-27.0 (25.0); suborbital width 6.5-7.8 (7.1) ; upper jaw length 50.6-53.5 (52.1) ; lower jaw length 62.2-64.9 (63.8).

Remarks:

The body of this species is rather slender compared with other species. This species has numerous scales, fewer fin rays and fewer gill-rakers, and has comparatively longer pectoral and pelvic fins. The colour of body is silvery whitish. Tip of pectoral fin reaches to the level of anal fin origin in young fish (below 200 mm SL.) but not in adults. Caudal margin is usualy truncate but is a little convex in larger fish.

This species was first described by LINNAEUS (1758) under the name of *Gadus merluccius*. This species has also been described by various names (FOWLER, 1936; NORMAN, 1937 ; SVETOVIDOV, 1948, 1973a ; SOLIMAN, 1973). This species was sometimes confused with *Stomodon bilinearis* (=*M. bilinearis*) and *M. albidus* of the northwestern Atlantic (GÜNTHER, 1862). JORDAN and EVERMANN (1917) designated *Gadus merluccius* LINNAEUS as type species of the genus *Merluccius* RAFINESQUE. Two populations, from the north-eastern Atlantic and from the Mediterranean have been separated by some authors. CADENAT (1950) treated these populations as two distinct subspecies of *M. merluccius*: *M. merluccius atlanticus* for the Atlantic population and *M. merluccius mediterraneus* for the Mediterranean one. His diagnosis for these subspecies was as follows: length of pectoral fin is longer than that of pelvic fin, its length is about equal of 2/3 head length, mean value of total vertebrae is 51 in Atlantic subspecies. On the other hand, length of pectoral fin is almost the same with that of pelvic fin, its length is about equal of half length of head, mean value of vertebrae is 52 in Mediterranean subspecies. LETACONNOUX (1953) noted the following characters for these subspecies: DI=10.01, DII=38.82, Vert.=51, G.R.=9.88 for *M. merluccius atlanticus*; and DI=9.52, DII=38.49, Vert.=52.04, G.R.=10.5 for *M. merluccius mediterraneus*. DOUTRE (1960) cited the study of CADENAT (1950) and accepted these two subspecies. FRANCA (1962) and CABO (1965; 1966) considered all the merluciids of Europe and Africa to be subspecies of *M. merluccius*. MAURIN (1968a and b) cited the difference of number of vertebrae between these two subspecies and used the name *Merlucius merlucius merlucius* for the Atlantic subspecies in place of *Merluccius merluccius atlanticus*. According to the International Code of Zoological Nomenclature, the Mediterranean population must take the earliest available name for a species or subspecies described from the Mediterranean. *M. smiridus* RAFINESQUE, 1810 is the earliest available name for species or for subspecies of *Merluccius* in the Mediterranean. The Mediterranean subspecies therefore must be *Merluccius merluccius smiridus* RAFINESQUE, 1810. It is not correct to use the name *M.*

merluccius mediterraneus for the Mediterranean subspecies, and the name *M. merluccius atlanticus* for the Atlantic subspecies.

In this study, these two subspecies are separated by the number of total vertebrae. Subspecies *M. merluccius merluccius* has a range of 49-52 and mean value of 50.8. On the other hand, *M. merluccius smiridus* has a range of 51-54 and mean value of 51.7. The difference between the ranges and mean values for the two subspecies are highly significant statistically (Table 3). The range and mean value of relative length of pectoral fin to head length of both subspecies are as follows: range 1.48-1.93 (mean 1.65) for the subspecies *M. merluccius merluccius*, range 1.63-1.95 (mean 1.76) for *M. merluccius smiridus*. This does not show a clear difference between these subspecies (Fig. 3). The relative lengths of pectoral and pelvic fins differ with growth. Pectoral fin length is shorter than pelvic fin length in young individual (until about 300 mm SL.), but in the adult, pectoral fin length is longer than pelvic fin length in both subspecies. As a result, the criteria that CADENAT (1950) noted for separating these two subspecies are not suitable except for number of vertebrae.

This species differs clearly from almost all other species in the total number of gill-rakers except for *M. polli*, *M. albidus* and *M. australis*. This species also differs

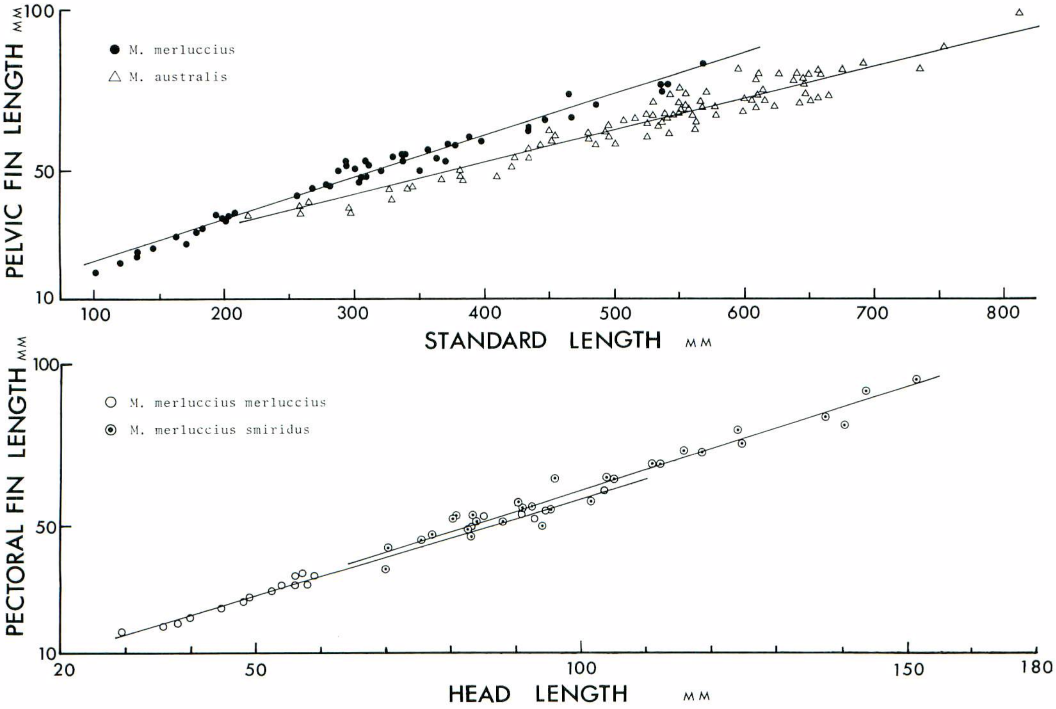

Fig. 3. Companisons between *M. merluccius* and *M. australis* on the relationship of standard length to pelvic fin length (upper) and between *M. merluccius merluccius* and *M. merluccius smiridus* on the relationship of head length to pectoral fin length (lower).

Table 3. Results of the statistical analyses between two populations on the various meristic counts using the methods of F-tests on variances and t-test on means. The table shows the cases that are detected the significant differences.

population	character	Degree of Freedom	Mean	variance	F	t
M. m. merluccius	total number of vertebrae	45	50.76	0.586	1.05	4.63**
M. m. smiridus		18	51.74	0.649		
M. merluccius	total number of vertebrae	64	51.05	0.795	1.07	39.76**
M. australis		179	55.92	0.691		
M. merluccius	number of anal fin rays	57	37.97	1.020	1.33	27.40**
M. australis		176	43.23	1.800		
M. merluccius	total number of vertebrae	64	51.05	0.795	1.04	33.05**
M. polli		157	55.27	0.734		
M. merluccius	number of 1st. dorsal fin rays	59	9.68	0.322	1.10	17.40**
M. albidus		43	11.73	0.389		
M. senegalensis	total number of gill-rakers	209	14.71	0.822	1.54*	63.21**
M. paradoxus		51	24.70	1.935		
M. senegalensis	total number of gill-rakers	209	14.71	0.822	1.17	40.60**
M. productus		68	20.04	1.130		
M. senegalensis	number of abdominal vertebrae	178	26.47	0.385	1.02	23.26**
M. hubbsi		48	24.14	0.375		
M. senegalensis	number of anal fin rays	34	38.37	0.530	1.84*	21.70**
M. australis		176	43.23	1.800		
M. senegalensis	total number of vertebrae	178	53.66	0.707	1.14	16.71**
M. capensis		30	50.87	0.916		
Mauritanian population***	total number of gill-rakers	181	10.43	0.412	1.03	6.76**
Angola population***		55	9.77	0.400		
Mauritanian population***	total number of vertebrae	121	55.48	0.533	1.24	6.14**
Angola population***		35	54.58	0.821		
M. capensis	total number of vertebrae	30	50.87	0.916	5.90**	18.48**
M. bilinearis		19	55.05	0.155		
M. capensis	total number of vertebrae	30	50.87	0.916	1.15	30.51**
M. australis		179	55.92	0.691		
M. capensis	total number of gill-rakers	44	18.00	1.727	1.30	18.68**
M. hubbsi		77	14.04	1.025		
M. capensis	total number of gill-rakers	44	18.00	1.727	1.42	29.95**
M. australis		209	13.06	0.858		
M. paradoxus	total number of gill-rakers	51	24.70	1.935	1.23	27.16**
M. bilinearis		41	17.48	1.280		
M. bilinearis	total number of vertebrae	19	55.05	0.155	5.87**	18.64**
M. gayi		114	51.00	0.912		
M. bilinearis	total number of vertebrae	19	55.05	0.155	1.65	26.46**
M. hubbsi		92	51.05	0.421		
M. bilinearis	total number of gill-rakers	41	17.48	1.280	1.25	17.02**
M. hubbsi		77	14.04	1.025		
M. productus	total number of vertebrae	19	53.55	0.263	1.86	11.63**
M. gayi		114	51.00	0.912		
M. angustimanus	total number of gill-rakers	43	17.05	0.806	1.66*	17.52**
M. gayi		116	20.83	1.341		
M. angustimanus	total number of gill-rakers	43	17.05	0.649	1.58	16.90**
M. hubbsi		77	14.04	1.025		
M. g. gayi	total number of vertebrae	93	51.27	0.563	1.16	7.79**
M. g. peruanus		20	49.81	0.762		
M. g. gayi	total number of gill-rakers	79	21.13	1.756	1.15	3.70**
M. g. peruanus		36	20.19	1.324		
M. hubbsi	total number of vertebrae	92	51.04	0.421	1.32	40.93**
M. polli		157	55.27	0.734		
M. hubbsi	total number of gill-rakers	77	14.04	1.025	1.46*	36.15**
M. polli		222	10.27	0.493		

* Significant at 5% level ** Significant at 1% level *** population of *M. polli*

from *M. bilinearis* and *M. albidus* in the number of oblique rows of scales. The differences in the total number of vertebrae and the number of anal fin rays between this species and *M. australis* show highly statistical significant differences (Table 3). This species also differs from *M. australis* in the relative length of the pelvic fin (Fig. 3). The difference in the total number of vertebrae between this species and *M. polli*, and the difference in the number of 1st dorsal fin rays between this species and *M. albidus* show highly statistical significant differences (Table 3).

This species is closely related to the African species (*M. senegalensis*, *M. polli* and *M. capensis*) in the combination of several meristic and morphometric characters on one hand, and is also related to *M. albidus* by some characters such as the number of gill-rakers and oblique rows of scales on the other hand. This species is also close to *M. australis* in the slender body shape and smaller scales and fewer gill-rakers.

2. *Merluccius senegalensis* CADENAT: Senegalese hake (Fig. 4)

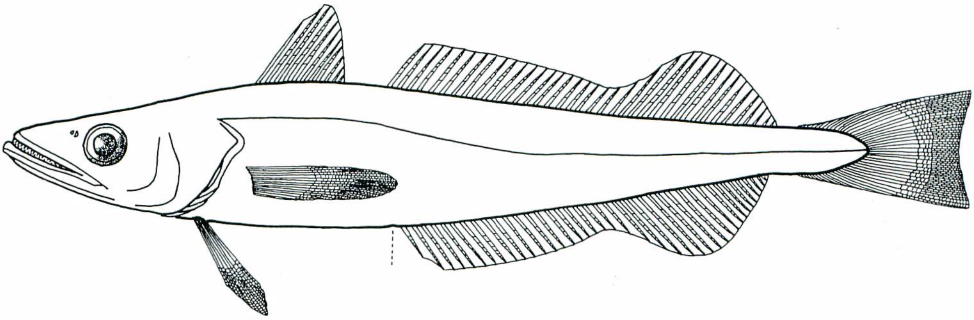

Fig. 4. *Merluccius senegalensis* CADENAT, 1950, FSFL EI012, SL 434.0mm

Merluccius senegalensis CADENAT, 1950

Merluccius senegalensis CADENAT, 1950, Congr. pêche. pêcher. Un. franç. d'outre Mer: 129 (type locality: Dakar).

Merluccius merluccius senegalensis: FRANCA, 1962, *Mem. Junta Inv. Ultram.*, **2** (36): 25 (taxonomy).

Merlucius senegalensis MAURIN, 1965, *Rapp. Com. Int. Explor. Sci. Medit.*, **18** (2): 216 (north-west Africa).

Merlucius merluccius senegalensis CABO, 1965, *Publ. Tec. Junta Estud. Pesca*, **4**: 18 (Cape Cantín to Cape Roxo).

Materials examined: (Table 4)

Description:

First dorsal fin rays I, 9-10 (average I, 9.5); second dorsal fin ray 38-41 (39.8); anal fin rays 37-40 (38.4); pectoral fin rays 14-16 (14.8); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 124-155 (137.6); number of gill-rakers on first arch 2-4 (3.4)+10-14 (11.4)=13-18 (14.7); number of vertebrae 25-28 (26.5)+25-29 (27.2)=51-56 (53.7); number of ribs 4.

Table 4. Data of specimens of *Merluccius senegalensis* used in this study

Catalogue No. (FSFL)	Date	Sampling position		Depth (m)
		Lat. (N)	Long. (W)	
D1193	Mar. 9, 1969	17°24′	19°56′	—
EI038	Mar. 6, 1969	19°45′	17°15′	—
EI010, EI011, EI016, EI140, EI145, EI146. EI148	Dec. 15, 1971	19°40.7′	17°04.0′	113
EI012, EI104, EI018, EI020, EI022, EI023, EI029, EI141, EI149	Dec. 14, 1971	18°29.5′	16°37.7′	310
N828	Dec. 14, 1971	18°21.6′	16°31.3′	158
N604, N608, N666	Dec. 16, 1971	20°38.1′	17°42.0′	275
EI015, EI017, EI021, EI026, EI028, EI033, EI035, EI037	Dec. 11, 1971	17°16.9′	16°44.6′	360
EC065	Mar. 13, 1975	20°13′	17°31′	54
M216	Mar. 15, 1975	20°14′	17°29′	48
EI142, EI144	Mar. 15, 1975	20°17′	17°28′	50
ED206	Mar. 12, 1975	20°16′	17°31′	59

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position		Depth (m)
		Lat. (N)	Long. (W)	
20	Nov. 10, 1974	21°14′	17°35′	314
20	Nov. 24, 1974	20°28′	17°35′	87
20	Dec. 31, 1974	21°03′	17°36′	290
20	May 21, 1974	20°50′	17°28′	—
20	Mar. 2, 1975	21°08′	17°37′	280
20	Mar. 9, 1975	20°25′	17°31′	60
19	Feb. 24, 1975	20°56′	17°22′	102
18	Dec. 30, 1974	20°58′	17°37′	283
9	Nov. 9, 1974	21°46′	17°23′	104
7	May 17, 1975	21°32′	17°35′	404
2	Dec. 8, 1974	25°42′	15°24′	260
2	Dec. 25, 1974	22°15′	17°04′	62

Body depth in percent of standard length 16.8-20.2 (18.3); head length 24.9-27.7 (26.5) ; caudal peduncle depth 4.5-5.8 (5.1) ; length of longest first dorsal fin ray 10.6-13.5 (12.5); length of longest second dorsal fin ray (anterior lobe) 6.4-9.0 (7.8); length of longest second dorsal fin ray (posterior lobe) 8.7-11.2 (10.0) ; length of pectoral fin 16.5-21.3 (18.9) ; length of pelvic fin 13.1-16.9 (15.0) ; length of longest anal fin ray (anterior lobe) 6.7-9.7 (8.2); length of longest anal fin ray (posterior lobe) 8.5-10.8 (9.6) ; length of first dorsal fin base 9.2-11.4 (10.2) ; length of second dorsal fin base 44.6-49.6 (47.4) ; space between first dorsal and second dorsal fins 2.0-4.2 (2.9); length of anal fin base 43.6-48.6 (45.9); tip of snout to first dorsal fin origin 27.7-30.4 (29.0); tip of snout to second dorsal fin origin 39.5-43.8 (41.8); tip of snout to pectoral fin insertion 25.4-28.2 (26.8); tip of snout to pelvic fin insertion 22.3-25.9 (24.5); tip of snout to anal fin origin 43.4-48.6 (45.9) ; length between pelvic fin insertion and anal fin origin 20.6-25.7 (22.9). Snout length in percent of head length 30.2-34.1 (32.5); diameter of eye 16.0-18.1 (16.9); diameter of orbit 17.1-20.8 (19.2); interorbital width 27.0-31.0 (28.6) ; suborbital width 4.9-7.7 (6.1) ; upper jaw length 47.1-50.6 (48.8); lower jaw length 59.5-63.2 (61.2).

Remarks:

This species shows intermediate values in meristic and proportional characters except for the interorbital width, which is rather great compared with other species. The tip of the pectoral fin usually reaches the level of the anal fin origin but sometimes does not in larger specimens. The caudal margin is usually truncate, but fish larger than 400 mm SL. has a concave caudal margin. The colour of body is dark silvery, blackish dorsally and silvery ventrally.

It was known that a different population was present in Cape Verde which had more numerous vertebrae than *M. merluccius* and was called "merlus noirs" (BELLOC, 1937). SVETOVIDOV (1948) cited BELLOC's observation and noted the possibility of the presence of some other species. HART (1948) considered that this population was presumably a local race of *M. merluccius*. LETACONNOUX (1950, 1952) studied the number of gill-rakers of this population which showed a quite different number from *M. merluccius*. In 1950, CADENAT described this population as a new species on the basis of some meristic characters (number of first dorsal fin rays, gill-rakers, vertebrae) and the blackish colour of the body. FRANCA (1952) and MAURIN (1954b, 1965, 1968a) studied the morphology of this species, comparing it with *M. merluccius* and recognized it as a distinct species *M. senegalensis*. FRANCA (1962) and CABO (1965, 1966) compared the characters of this species with *M. merluccius* and considered this species as a subspecies of *M. merluccius*.

This species differs from *M. merluccius*, *M. polli* and *M. albidus* in the total number of gill-rakers, from *M. bilinearis* and *M. albidus* in the number of oblique rows of scales, from *M. angustimanus* and *M. gayi* in the number of abdominal vertebrae, and from *M. polli*, *M. productus* and *M. angustimanus* in the number of ribs. The differrences in the total number of gill-rakers between this species and *M. paradoxus* and *M. productus*, the difference in the number of abdominal vertebrae between this species and *M. hubbsi*, and the difference in the number of anal fin rays between this species and *M. australis* show highly statistical significant differences (Table 3).

This species is very similar to *M. capensis* but the difference in the total number of vertebrae show highly statistical significant difference (Table 3). The relative length of head, snout and interorbital width also show clear differences between this species and *M. capensis* (Fig. 5).

This species is closely related to eastern Atlantic species (*M. capensis* and *M. merluccius*) on one hand, and also closely related to western Atlantic species (*M. bilinearis* and *M. albidus*) in other characters.

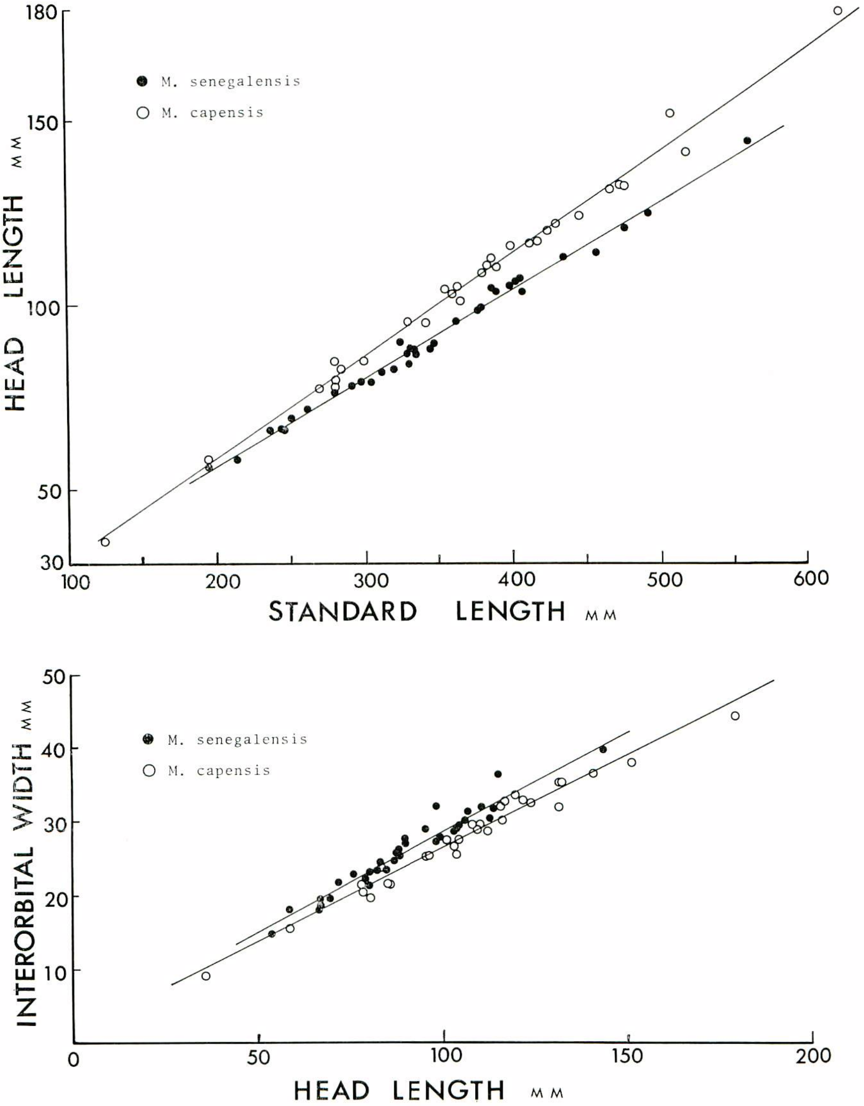

Fig. 5. Comparisons between *M. senegalensis* and *M. capensis* on the relationships of standard length to head length (upper) and head length to interorbital width (lower).

3. *Merluccius polli* CADENAT : Benguela hake (Fig. 6)

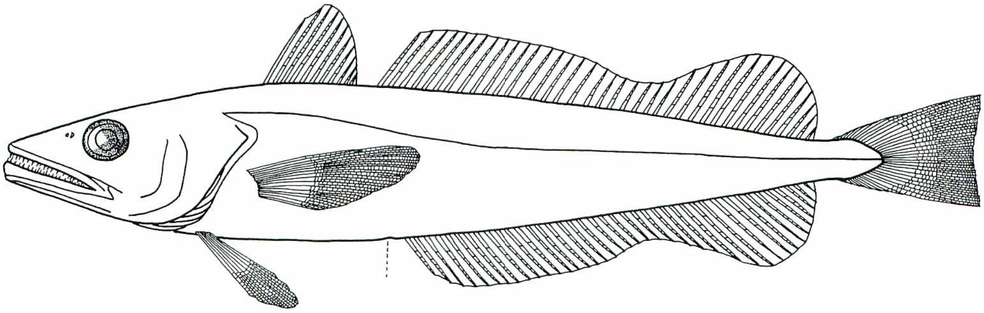

Fig. 6. *Merluccius polli* CADENAT, 1950, FSFL EG308, SL 433.0mm

Merluccius polli CADENAT, 1950

Merluccius polli CADENAT, 1950, Congr. pêche. pêcher. Un. franç. d'outre Mer : 129 (type locality: Congo).

Merluccius cadenati DOUTRE, 1960, *Rev. Trav. Inst. Scient. Tech. Peche,* **24** (4) : 517 (Cape Blanco to Cape Roxo).

Merluccius merluccius polli : FRANCA, 1962, *Mem. Junta Inv. Ultram.,* **2** (36) : 25 (taxonomy).

Merluccius merluccius cadenati : FRANCA, 1962, *Mem. Junta Inv. Ultram.,* **2** (36) : 25 (taxonomy).

Merlucius merluccius polli CABO, 1965, *Publ. Tec. Junta Estud. Pesca,* **4** : 20 (Port Gentil to Benguela).

Merlucius merluccius cadenati CABO, 1965, *Publ. Tec. Junta Estud. Pesca,* **4** : 18 (Cape Blanco to Cape Roxo).

Materials examined: (Table 5)

Description:

First dorsal fin rays I, 8-11 (average I, 9.8); second dorsal fin rays 37-41 (38.5); anal fin rays 36-42 (38.7) ; pectoral fin rays 14-16 (15.1) ; pelvic fin rays 7 ; branchiostegal rays 7; number of oblique rows of scales 102-127 (112.0); number of gill-rakers on first arch 1-3(2.1)+7-9(8.2)=8-12(10.3) ; number of vertebrae 23-28(26.2)+27-31(29.1) =53-57(55.3); number of ribs 3.

Body depth in percent of standard length 14.8-21.0 (18.0); head length 24.8-28.9 (27.3) ; caudal peduncle depth 4.2-5.3 (4.8); length of longest first dorsal fin ray 10.0-13.1 (11.3); length of longest second dorsal fin ray (anterior lobe) 6.8-9.5 (7.9); length of longest second dorsal fin ray (posterior lobe) 9.5-11.6 (10.4); length of pectoral fin 17.7-21.8 (19.6); length of pelvic fin 13.0-16.7 (14.7); length of longest anal fin ray (anterior lobe) 6.9-9.1 (7.9); length of longest anal fin ray (posterior lobe) 8.6-10.7 (9.9); length of first dorsal fin base 9.1-12.0 (10.6); length of second

Table 5. Data of specimens of *Merluccius polli* used in this study

Mauritanian population

Catalogue No. (FSFL)	Date	Sampling position		Depth (m)
		Lat.(N)	Long.(W)	
M578, M580, M583-M585, M575, M593, M599, M886	Jan. 21, 1975	05°07′	09°43′	193
M572, M566, M581, M582, M590-M592, M596, M597	Jan. 22, 1975	05°18′	09°57′	398
M552, M553, M555-M557, M559, M563-M565, M567, M568, M571, M573, EI030	Jan. 24, 1975	05°46′	10°32′	293
N222, N219, N334	Jan. 6, 1972	24°49.4′	16°38.2′	910
EI024, EI027	Dec. 11, 1971	17°16.9′	16°44.6′	360
S291	Dec. 19, 1971	21°19.4′	17°28.2′	132
V717	Dec. 16, 1971	20°32.3′	17°51.3′	490
S240	Dec. 19, 1971	21°21.5′	17°47.2′	729
Q725	Nov. 20, 1974	10°35′	17°15′	339

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position		Depth (m)
		Lat.(N)	Long.(W)	
21	Nov. 20, 1974	10°23′	17°08′	329
20	Jan. 7, 1975	10°48′	17°21′	381
20	Jan. 8, 1975	10°06′	17°09′	458
20	Jan. 21, 1975	05°06′	09°42′	193
20	Jan. 24, 1975	05°46′	10°32′	293
20	Jan. 23, 1975	05°35′	10°16′	320

Angola population

Catalogue No. (FSFL)	Date	Sampling position		Depth (m)
		Lat.(S)	Long.(E)	
EG301-EG303, EG305-EG309, EG320, EG321, EG323, EG324	Aug. 16, 1977	18°13′	11°20′	377
EG310, EG311, EG319, EG325-EG328	Aug. 16, 1977	18°21′	11°18′	388
EG330, EG333, EG336, EG337, EG339, EG341, EG342	June 6, 1977	19°23′	11°29′	448
EG344, EG345, EG347, EG348	June 6, 1977	19°38′	11°44′	366

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position		Depth (m)
		Lat.(S)	Long.(E)	
4	June 6, 1977	19°23′	11°29′	448
3	June 6, 1977	19°38′	11°44′	366
5	Aug. 16, 1977	18°21′	11°18′	388
23	Aug. 16, 1977	18°13′	11°20′	377

dorsal fin base 43.5-48.3 (46.2); space between first dorsal and second dorsal fins 1.9-3.9 (2.9); length of anal fin base 42.1-47.3 (45.0); tip of snout to first dorsal fin origin 27.5-31.1 (29.3); tip of snout to second dorsal fin origin 39.7-44.8 (42.4); tip of snout to pectoral fin insertion 25.0-30.4 (27.6); tip of snout to pelvic fin insertion 22.0-27.9 (24.4); tip of snout to anal fin origin 42.9-50.2 (46.3); length between pelvic fin insertion and anal fin origin 21.6-27.3 (24.2). Snout length in percent of head length 30.2-35.9 (32.2); diameter of eye 15.0-19.8 (17.2); diameter of orbit 16.4-21.8 (19.1); interorbital width 24.1-28.0 (25.9); suborbital width 5.3-8.5 (6.7); upper jaw length 45.3-51.3 (48.7); lower jaw length 56.1-62.4 (59.1).

Remarks:

This species has numerous vertebrae, larger scales, fewer gill-rakers, and rather smaller head and gape. Usually, the tip of pectoral fin reaches origin of anal fin and the margin of caudal fin is truncate, but in larger individuals the pectoral fin does not reach the anal fin origin, and the caudal margin is sometimes concave. This species is characterized by its blackish body colour and by the white margined caudal fin, especially in larger fish. In young fish smaller than 300 mm SL., the colour of body is blackish grey or brown.

This species was first described by CADENAT (1950) from off the mouth of the Congo River (6°S). Following his description this species has fewer scales on longitudinal line (about 100), more vertebrae (about 53) and fewer gill-rakers, which show clear differences from *M. merluccius*, *M. senegalensis* and *M. capensis*. CADENAT (1952), FRANCA (1952) and LETACONNOUX (1953) compared some characters of this species with those of *M. merluccius* and *M. senegalensis*. FRANCA (1952) also compared some characters of *M. polli* and *M. capensis* in specimens from Angola. POLL (1953) described this species in detail from specimens caught off Port Gentil (0°) to Tigres (18°S). FRANCA (1956a and b) discussed the distribution of this species. DOUTRE (1960) described a new species, *Merluccius cadenati* from off Mauritania and Senegal and noted that the body colour of *M. cadenati* was blackish in fish larger than 35cm and had more vertebrae (mean 55.55) compared with *M. polli* (53-54) and always five cervical vertebrae. FRANCA (1962) and CABO (1965, 1966) considered merlucciids from Europe and Africa as subspecies of *M. merluccius* and recognized *M. polli* and *M. cadenati* are the distinct subspecies. MAURIN (1965, 1968a and b) noted the species *M. cadenati* in his study on the merlucciids of the north and north-west Africa. WILLIAMS (1968) showed that *M. polli* and the unidentified *M.* spp. were taken throughout the survey areas from the Gambia border (13°N) to the Congo (6°S), but he did not show any characters of these species. MAURIN (1968b), JONES (1974) and QUERO (personal communication) suggested that *M. cadenati* might be the same species as *M. polli*.

The materials that the author used in this study are composed of specimens combined from Mauritania-Liberia and southern Angola. Careful examination of these specimens from the two localities failed to show any differences in meristic characters examined (Table 6). Specimens from both localities have the same number of vertebrae (53-57) and cervical vertebrae (5). Small differences can be seen in some proportional characters between specimens from the two localities, but these differences are not so large as to indicate specific divergence (Fig. 7). Statistical examinations in the total number of gill-rakers and the total number of vertebrae between both populations show small differences, which may indicate the subspecific divergence (Table 3). Differences of body depth in percent of standard length for these specimens are due to the gonad condition, i. e. the specimens from southern Angola have ripe gonads (Table 7). Com-

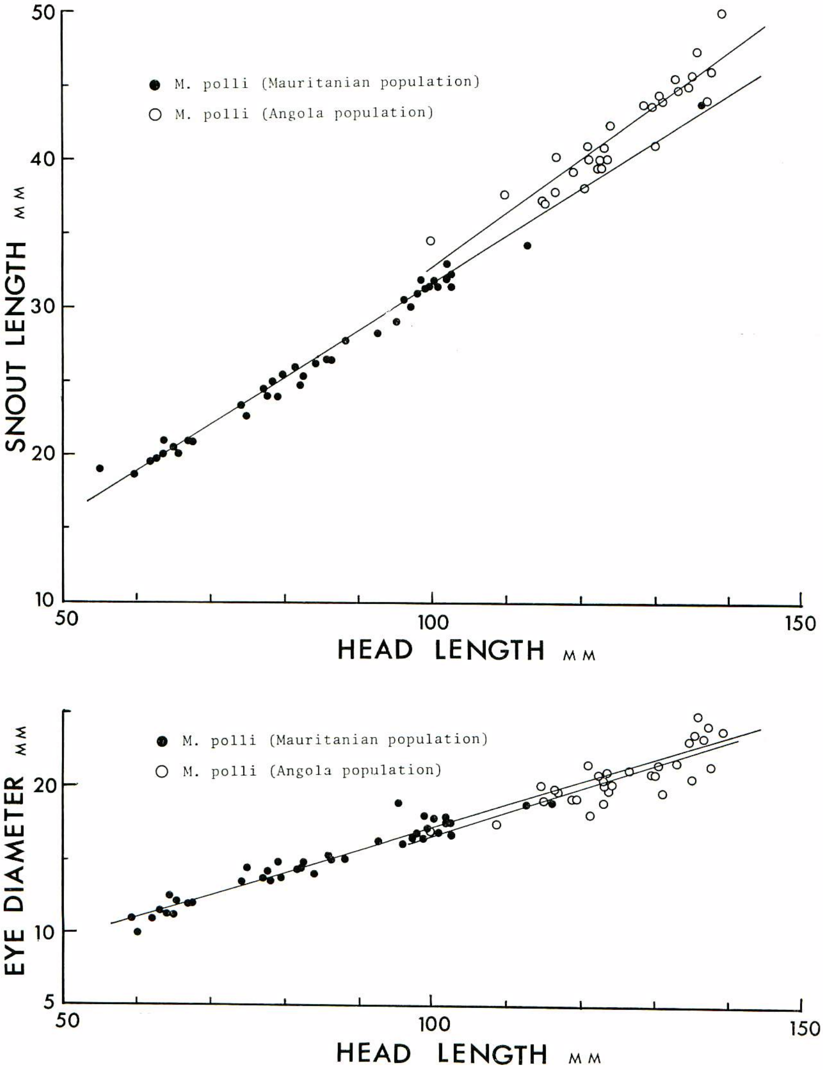

Fig. 7. Comparisons between two populations of *M. polli* on the relationships between head length to snout length (upper) and between head length to eye diameter (lower).

parison of these data with those of Poll (1953) as is shown in Table 7 shows differences in some proportional characters, but I believe that these are caused by geographical variation or a different method of measuring. Finally, specimens from Mauritania-Liberia and southern Angola belong to the same species and agree well with descriptions of *M. polli* by Cadenat (1950) and *M. cadenati* by Doutre (1960). In this study the author considers that these specimens are *M. polli* and tentatively consider *M. cadenati* as a junior synonym of *M. polli* until a careful comparison can be made of the type specimens and the unidentified species described by Williams (1968).

This species is closely related to *M. paradoxus* in having numerous vertebrae, and both species inhabit rather deep waters. This species is also closely related to *M. bilinearis* and *M. albidus* in having larger scales, and with *M. albidus* and *M. merluccius* in having fewer gill-rakers.

Table 6. Comparisons of body colour and 8 meristic characters of *M. polli* collected in various locations from Mauritania to southern Angola. Numeral in parentheses shows mean value.

Source of data	Present author	Present author	Cadenat (1950)	Poll (1953)	Doutre (1960)
Locality	Mauritania -Liberia	southern Angola	Congo	Congo, Angola	Mauritania, Senegal
No. of specimens	162	65	2	56	559*1)
Standard length (mm)	179—550	366—521	236,325	96—370	—
Body colour	blackish (over 30 cm), young brownish	blackish	—	brownish, sometimes blackish	blackish (over 35 cm)
1st dorsal fin rays	9-12 (10.4)	10-12(11.1)	10	10	7-12(10.6)
2nd dorsal fin rays	37-40(38.2)	37-41(38.7)	38,39	37	36-41(38.7)
Anal fin rays	36-40(38.3)	37-42(39.0)	36,37	38	—
Pectoral fin rays	15-16(15.6)	14-16(14.8)	—	—	—
Lateral line scales	102-127(111.7)*2)	104-123(112.5)*2)	98,105	ca. 110	ca. 100
Gilll-rakers	1-3(2.1)+7-9(8.3) =9-12(10.5)	1-3(2.0)+7-9(7.8) =8-11(9.8)	2+8=10	+7-8 =9-10	=9-12(10.4)
Vertebrae	25-28(26.4)+27-31 (29.1)=53-57(55.5)	24-27(25.7)+27-31 (28.9)=53-57(54.6)	=53	—	(26.8)+27-31 (28.9)=52-57 (55.6)
Cervical vertebrae	5*3)	5	—	—	5

Note : *1) for counting the number of gill-rakers.
*2) oblique rows of scales below the lateral line canal.
*3) based on one specimen.

Table 7. Comparison of 9 proportional characters of *M. polli* from Mauritania-Liberia and southern Angola, and of data by POLL (1953). Numeral in parentheses indicates mean value of each character.

Locality	Mauritania-Liberia (Present author)	southern Angola (Present author)	Congo-Angola (POLL, 1953)
Body depth in % of SL	14.8-18.3 (16.6)	18.3-21.0 (19.4)	14.3-20.0
Head length in % of SL	24.8-28.9 (27.4)	26.2-28.8 (27.2)	28.2-29.9
Diameter of eye in % of HL	16.2-19.8 (17.7)	15.0-18.2 (16.5)	20.0-25.6
Interorbital width in % of HL	24.1-27.5 (25.6)	25.0-28.0 (26.4)	20.0-25.6
Times of diameter of eye in snout length	1.6- 2.0 (1.8)	1.8- 2.3 (2.0)	1.2- 1.6
Times of interorbital width in snout length	1.1- 1.3 (1.2)	1.2- 1.3 (1.3)	1.3- 1.5
Times of diameter of eye in interorbital width	1.3- 1.6 (1.5)	1.5- 1.8 (1.6)	0.9- 1.2
Times of pectoral fin length in head length	0.65-0.75 (0.70)	0.68-0.78 (0.75)	ca. 0.67
Times of pelvic fin length in pectoral fin length	0.69-0.87 (0.79)	0.65-0.75 (0.70)	ca. 0.75 or smaller

4. *Merluccius capensis* CASTELNAU : Shallow-water Cape hake (Fig. 8)

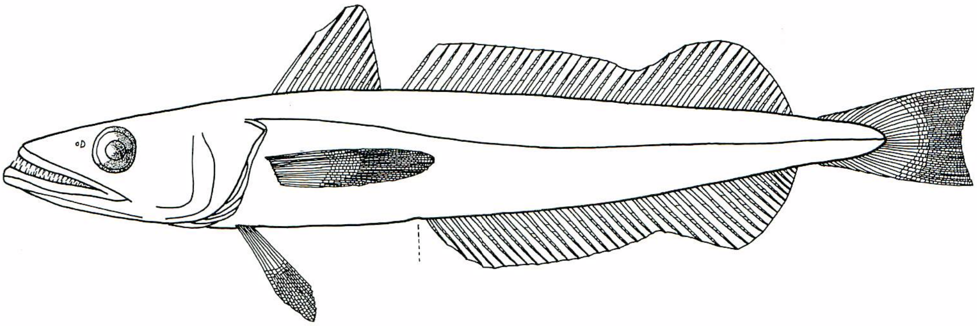

Fig. 8. *Merluccius capensis* CASTELNAU, 1861, FSFL S769, SL 445.0mm

Merluccius capensis CASTELNAU, 1861

Merluccius capensis CASTELNAU, 1861, Mém. poiss. Afr. austr.: 68 (type locality: South Africa).

Merluccius capensis capensis: FRANCA, 1960, *Mem. Junta Inv. Ultram.*, **2** (18): 3 (Bahia Farta to southernmost Africa).

Merluccius merluccius capensis: FRANCA, 1962, *Mem. Junta Inv. Ultram.*, **2** (36) : 25 (taxonomy).

Merlucius merluccius capensis CABO, 1965, *Publ. Tec. Junta Estud. Pesca*, **4**: 20 (Bahia Farta to Cape).

Materials examined: (Table 8)

Table 8. Data of specimens of *Merluccius capensis* used in this study

Catalogue No. (FSFL)	Date	Sampling position Lat.(S)	Long.(E)	Depth (m)
N883, S602, S605, S608, S610, S614, S619, S626, S652, S655, S657, V688	Nov. 21, 1971	35°06.3′	19°25.8′	160
M876, N861, S620, S623, S625, S632, S633, S635, S638	Nov. 21, 1971	35°00.0′	19°32.9′	140
S769-S772, S774, S778, S779	June 10, 1976	35°18.0′	20°58.0′	83
S300, S329	Nov. 21, 1971	35°33.7′	19°20.0′	227
B1749	Aug. 14, 1968	26°10.0′	13°50.0′	—

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position Lat.(S)	Long.(E)	Depth (m)
15	Oct. 21, 1977	18°34.0′	11°25.0′	244
13	Nov. 21, 1971	35°07.7′	19°28.8′	160

Description:

First dorsal fin rays I, 9-11 (average I, 10.1); second dorsal fin rays 38-43 (40.0); anal fin rays 37-41 (39.5); pectoral fin rays 14-16 (14.6); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 132-149 (140.8); number of gill-rakers on first arch 3-6 (4.6)+11-15 (13.4)=15-20 (18.0); number of vertebrae 23-26 (24.4)+24-28 (26.5)=49-53 (50.9); number of ribs 4.

Body depth in percent of standard length 14.7-19.9 (17.9); head length 27.3-30.2 (28.6); caudal peduncle depth 4.7-5.7 (5.2); length of longest first dorsal fin ray 11.6-14.4 (12.8); length of longest second dorsal fin ray (anterior lobe) 6.2-8.8 (7.5); length of longest second dorsal fin ray (posterior lobe) 8.9-10.9 (9.8); length of pectoral fin 17.2-19.9 (18.9); length of pelvic fin 14.2-17.1 (15.5); length of longest anal fin ray (anterior lobe) 6.7-9.2 (8.1); length of longest anal fin ray (posterior lobe) 8.6-11.6 (9.5); length of first dorsal fin base 9.6-12.6 (10.8); length of second dorsal fin base 44.5-47.8 (46.1); space between first dorsal and second dorsal fins 1.8-3.8 (2.7); length of anal fin base 41.6-47.7 (45.2); tip of snout to first dorsal fin origin 29.7-31.9 (30.7); tip of snout to second dorsal fin origin 42.4-45.5 (43.8); tip of snout to pectoral fin insertion 27.4-30.2 (28.8); tip of snout to pelvic fin insertion 23.8-29.0 (26.4); tip of snout to anal fin origin 42.7-49.6 (46.7); length between pelvic fin insertion and anal fin origin 18.5-24.8 (22.5). Snout length in percent of head length 31.9-36.5 (34.1); diameter of eye 14.9-22.7 (17.3); diameter of orbit 17.0-24.6 (19.2); interorbital width 24.1-28.6 (26.2); suborbital width 5.7-8.9 (7.2); upper jaw length 48.2-54.7 (51.7); lower jaw length 62.1-67.4 (64.8).

Remarks:

This species has fewer vertebrae, smaller scales and more numerous gill-rakers than almost other merlucciids. The body proportions of this species show rather intermediate values among the merlucciids. The tip of the pectoral fin usually reaches the origin of the anal fin. The posterior margin of caudal fin is truncate or slightly concave. The colour of body is silvery, somewhat brownish dorsally and whitish ventrally.

This species was first described by Castelnau (1861), but sometimes has been regarded as a subspecies of *M. merluccius* by many authors (Franca, 1962 ; Cabo, 1965, 1966; van Eck, 1969). Regan (1903), Barnard (1925), Norman (1937), Svetovidov (1948) and Quero (1973) recognized *M. capensis* as a full species.

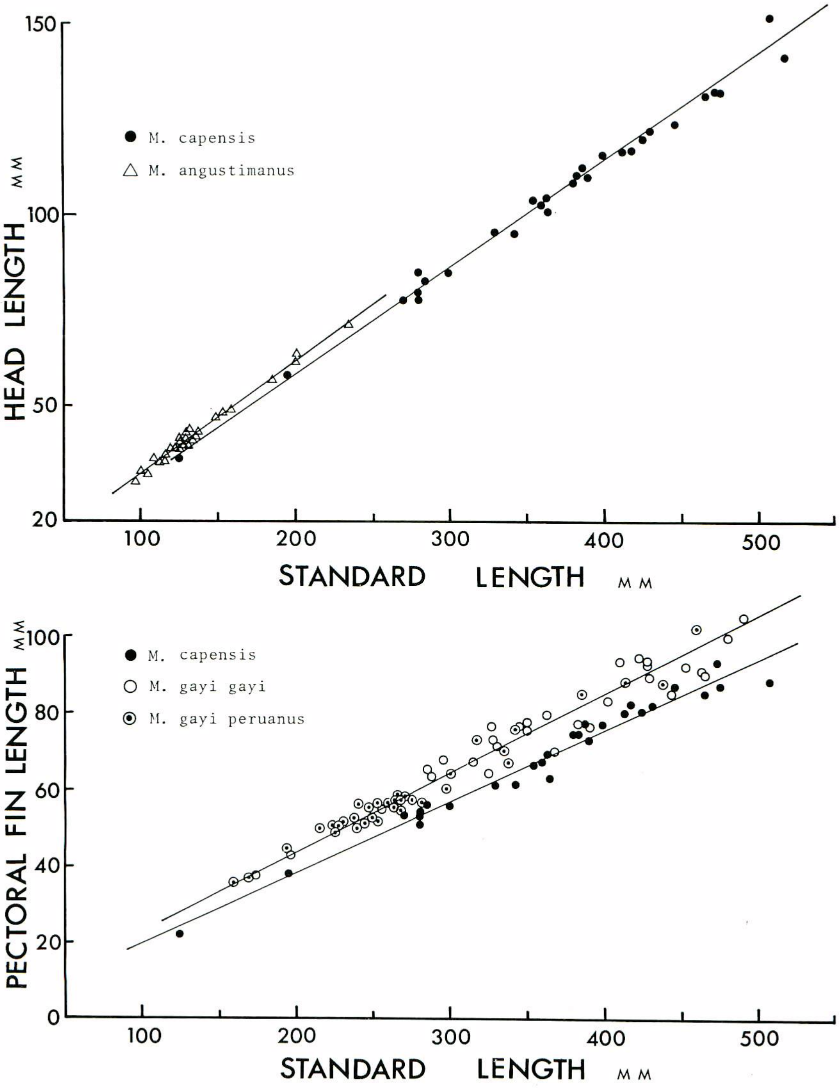

Fig. 9. Comparisons between *M. capensis* and *M. angustimanus* on the relationship of standard length to head length (upper) and between *M. capensis* and *M. gayi* on the relationship of standard length to pectoral fin length (lower).

This species differs from *M. merluccius*, *M. polli* and *M. albidus* in the total number of gill-rakers, from *M. polli*, *M. bilinearis*, *M. albidus* and *M. gayi* in the number of oblique rows of scales, from *M. polli*, *M. productus* and *M. angustimanus* in the number of ribs, from *M. paradoxus* in the total number of vertebrae and from *M. productus* in the number of caudal vertebrae. The differences in the total number of vertebrae between this species and *M. senegalensis*, *M. bilinearis* and *M. australis*, and the differences in the total number of gill-rakers between this species and *M. hubbsi* and *M. australis* show highly statistical significant differences (Table 3). The relative length of head compared to standard length shows differences between this species and *M. angustimanus*, and that of pectoral fin to standard length also shows the differences between this species and *M. gayi* (Fig. 9).

This species is closely related to *M. senegalensis* in general characters and to *M. merluccius* and *M. hubbsi* in some characters, but is quite different from *M. polli* and *M. paradoxus* in many characters, distributions of which are overlapping with this species in some areas.

5. *Merluccius paradoxus* FRANCA : Deep-water Cape hake (Fig. 10)

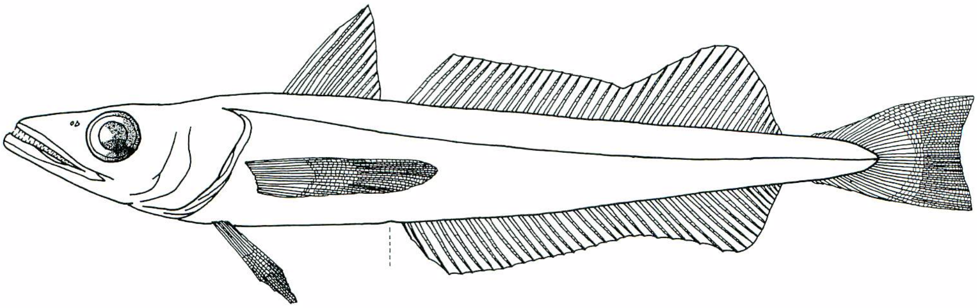

Fig. 10. *Merluccius paradoxus* FRANCA, 1960, FSFL S695, SL 437.0mm

Merluccius paradoxus FRANCA, 1960

Merluccius capensis paradoxus FRANCA, 1960, *Mem. Junta Inv. Ultram.*, **2** (18) : 4 (type locality: South-west Africa).

Merluccius merluccius paradoxus: FRANCA, 1962, *Mem. Junta Inv. Ultram.*, **2** (36) : 26 (taxonomy).

Merluccius paradoxus : QUERO, 1973, *Rev. Trav. Inst. Pêches Marit.*, **37** (1) : 118 (Cape Frio to East London).

Materials examined: (Table 9)

Description:

First dorsal fin rays I, 9-11 (average I, 9.8) ; second dorsal fin rays 38-42 (39.8); anal fin rays 38-41 (39.8); pectoral fin rays 14-16 (14.6) ; pelvic fin rays 7 ; branchio-

Table 9. Data of specimens of *Merluccius paradoxus* used in this study

Catalogue No. (FSFL)	Date	Sampling position		Depth (m)
		Lat. (S)	Long. (E)	
S 301, S 316, S 324, S 326-S 328, S 336, S 338, S 339	Nov. 22, 1971	35°33.7′	19°20.0′	227
S 661, S 671	Nov. 21, 1971	35°17.1′	19°13.1′	185
N886, S 342, S 345, S 347, S 352, S 354, S 624, S 690, S 691, S 694, S 695, S 698, S 699, S 686	Nov. 22, 1971	35°36.4′	19°00.8′	540
A1336	Jan. 13, 1971	26°00.2′	13°40.9′	440
S 640, S 647, S 673, S 658	Nov. 22, 1971	35°41.5′	18°52.9′	980
L 144	June 19, 1977	33°07.7′	44°05.0′	780

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position		Depth (m)
		Lat.(S)	Long.(E)	
23	Dec. 28, 1977	24°32′	13°26′	490
5	June 19, 1977	33°07.0′	44°05.0′	780

stegal rays 7; number of oblique rows of scales 121-143 (130.4); number of gill-rakers on first arch 4-7 (5.6)+13-18 (14.9)=18-23 (20.4); number of vertebrae 26-28 (27.0)+28-30 (28.9)=54-58 (55.9); number of ribs 4.

Body depth in percent of standard length 15.7-20.5 (18.2); head length 26.0-28.6 (27.3); caudal peduncle depth 4.2-5.4 (4.8); length of longest first dorsal fin ray 11.8-15.0 (13.3); length of longest second dorsal fin ray (anterior lobe) 6.7-9.1 (7.9); length of longest second dorsal fin ray (posterior lobe) 9.6-11.9 (10.6); length of pectoral fin 19.1-23.6 (21.2); length of pelvic fin 12.9-16.3 (14.8); length of longest anal fin ray (anterior lobe) 7.5-9.1 (8.2); length of longest anal fin ray (posterior lobe) 9.0-10.7 (9.9); length of first dorsal fin base 9.0-11.6 (10.7); length of second dorsal fin base 45.0-48.2 (46.8); space between first dorsal and second dorsal fins 1.8-3.6 (2.8); length of anal fin base 44.0-48.5 (46.1); tip of snout to first dorsal fin origin 28.4-31.1 (29.8); tip of snout to second dorsal fin origin 40.8-45.1 (42.9); tip of snout to pectoral fin insertion 26.0-30.3 (27.8); tip of snout to pelvic fin insertion 23.0-27.0 (25.3); tip of snout to anal fin origin 43.4-48.0 (45.8); length between pelvic fin insertion and anal fin origin 19.9-23.9 (22.0). Snout length in percent of head length 30.6-35.3 (32.8); diameter of eye 16.8-21.5 (19.1); diameter of orbit 18.7-24.1 (21.5); interorbital width 22.5-28.0 (25.0); suborbital width 5.2-8.9 (6.8); upper jaw length 46.0-51.6 (48.2); lower jaw length 57.8-64.7 (60.6).

Remarks:

This species has numerous vertebrae and gill-rakers, longer pectoral fin and rather smaller gape. The tip of pectoral fin reaches or extends beyond the origin of anal fin. The colour of body is dark brownish dorsally and silvery whitish ventrally.

FRANCA (1954) recognized two forms of *M. capensis* in the Cape region, and he

(FRANCA, 1960b) first described *M. paradoxus* as a subspecies, *M. capensis paradoxus*. Later, FRANCA (1962) refered *M. paradoxus* as a subspecies of *M. merluccius* and called it as *M. merluccius paradoxus*, which has been used by several authors (CABO, 1965, 1966 ; VAN ECK, 1969). QUERO (1973) treated the subspecies as a distinct species, *M. paradoxus*.

This species differs from *M. capensis*, *M. angustimanus*, *M. gayi* and *M. hubbsi* in the total number of vertebrae, from *M. productus* in the number of abdominal vertebrae, from *M. polli*, *M. productus* and *M. angustimanus* in the number of ribs, from *M. merluccius*, *M. polli*, *M. albidus*, *M. hubbsi* and *M. australis* in the total number of gill-rakers and from *M. bilinearis* in the number of oblique rows of scales. The differences in the total number of gill-rakers between this species and *M. senegalensis* and *M. bilinearis* show highly statistical significant differences (Table 3). This species is clearly different from *M. bilinearis* in the relative length of upper jaw to head length (Fig. 11).

This species is closely related to *M. polli* and *M. australis* by the numerous vertebrae and general apperance, and these three species live in rather deep-waters for merlucciids. Close relationship between species from South Africa, southern South America, and even New Zealand can ba seen in some other demersal fishes such as *Macruronus* spp. and *Genypterus* spp.. This may also suggest close realtionships between *M. paradoxus* and *M. australis*.

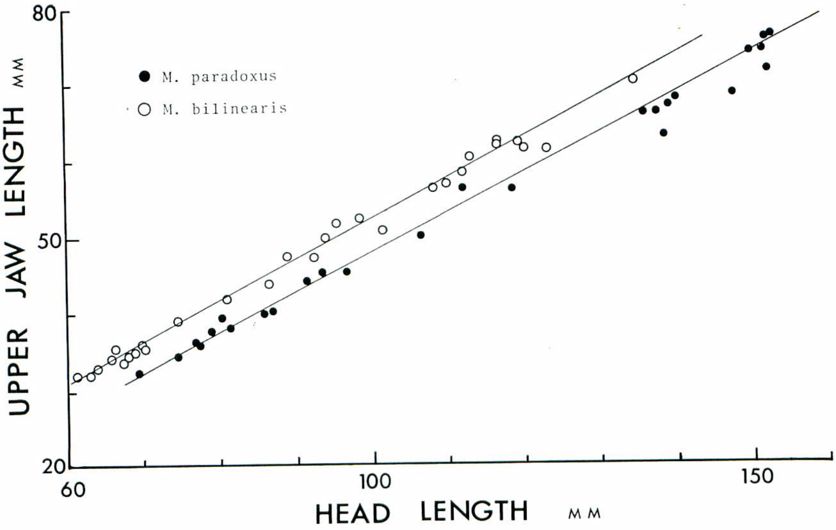

Fig. 11. Comparison between *M. paradoxus* and *M. bilinearis* on the relationship of head length to upper jaw length.

6. *Merluccius bilinearis* (MITCHILL) : Silver hake (Fig. 12)

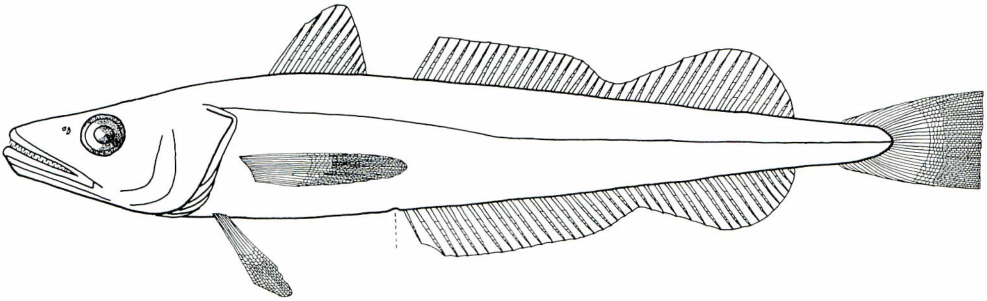

Fig. 12. *Merluccius bilinearis* (MITCHILL, 1814), FSFL B2368, SL 420.0mm

Merluccius bilinearis (MITCHILL, 1814)

Stomodon bilinearis MITCHILL, 1814, *Trans. Lit. Phil. Soc.*, **1**: 7 (type locality: New York).

Merluccius vulgaris (nec FLEMING 1828) : GÜNTHER, 1862, Cat. fish. Brit. Mus., 4 : 344 (bibliography).

Merluccius bilinearis: GILL, 1863, *Proc. Acad. Nat. Sci. Philad.*: 247 (coasts of eastern North America from Virginia northwards).

Materials examined: (Table 10)

Table 10. Data of specimens of *Merluccius bilinearis* used in this study

Catalogue No. (FSFL)	Date	Sampling position Lat.(N)	Long.(W)	Depth (m)
b1414, b1416, b1418, b1481, b1483, b1484, d0752, d0755	Nov. 9, 1969	43°37.0′	59°45.0′	206-216
d0758, d0811, d0820, d0853-d0856, d0858-d0860, d0882, d0883, d0890	Feb. 17, 1970	40°08.8′	68°48.5′	151-178
B2361, B2363, B2365, B2366, B2368, B2652, B2659	Feb. 11, 1970	40°05.5′	70°27.0′	167-192
A1990	May 23, 1967	37°04.0′	74°46.0′	—
D1864	Nov. 14, 1969	42°42.5′	66°55.0′	196

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position Lat.(N)	Long.(W)	Depth (m)
5	Feb. 18, 1970	43°50.0′	64°18.5′	170
3	Nov. 9, 1969	43°37.0′	59°45.0′	206-216
2	Feb. 11, 1970	40°05.5′	70°27.0′	167-192
2	July 15, 1970	42°30′	67°00′	—

Description:

First dorsal fin rays I, 10-12 (average I, 11.3); second dorsal fin rays 37-42 (39.5); anal fin rays 37-42 (39.9) ; pectoral fin rays 13-16 (14.6) ; pelvic fin rays 7 ; branchiostegal rays 7 ; number of oblique rows of scales 101-110 (105.8) ; number of gill-rakers on first arch 3-5 (4.1)+12-15 (13.3)=16-20 (17.5); number of vertebrae 26-29 (27.3)+27-29 (27.8)=53-57 (55.1); number of ribs 4.

Body depth in percent of standard length 15.0-18.5 (16.5); head length 24.4-27.4 (25.8); caudal peduncle depth 3.9-5.0 (4.5); length of longest first dorsal fin ray 11.3-14.4 (12.9); length of longest second dorsal fin ray (anterior lobe) 6.5-8.4 (7.5); length of longest second dorsal fin ray (posterior lobe) 8.6-11.6 (10.1); length of pectoral fin 18.1-22.8 (20.3); length of pelvic fin 14.0-18.5 (16.2); length of longest anal fin ray (anterior lobe) 6.7-9.7 (8.3); length of longest anal fin ray (posterior lobe) 8.0-11.3 (9.4); length of first dorsal fin base 10.7-12.9 (12.1); length of second dorsal fin base 44.4-47.4 (46.0); space between first dorsal and second dorsal fins 2.3-4.1 (3.2); length of anal fin base 44.5-48.9 (46.6); tip of snout to first dorsal fin origin 27.5-29.7(29.0); tip of snout to second dorsal fin origin 41.5-45.0 (44.0); tip of snout to pectoral fin insertion 23.6-27.8 (26.2); tip of snout to pelvic fin insertion 22.9-26.6 (24.8); tip of snout to anal fin origin 42.3-48.8 (45.9); length between pelvic fin insertion and anal fin origin 19.5-25.8 (23.0). Snout length in percent of head length 31.2-35.1 (33.3); diameter of eye 14.7-21.1 (17.2); diameter of orbit 16.4-23.8 (19.5); interorbital width 24.0-29.8 (26.5); suborbital width 6.7-9.7 (8.0); upper jaw length 50.0-54.4 (52.2); lower jaw length 61.6-67.9 (64.8).

Remarks:

This species has small head, rather longer pectoral and pelvic fins, larger gape and numerous gill-rakers. The scales of this species are larger and the number of oblique rows of scales is less. In young fish, the tip of pectoral fin reaches or extends over the level of the anal fin origin, but the relative length of pectoral fin becomes smaller by growth. The shape of the caudal margin also changes by growth, i.e., smaller fish has truncated caudal margin and larger fish has slightly concave one. The colour of body is usually silvery white.

This species was first described by MITCHILL (1814) as *Stomodon bilinearis*. Later, GILL (1863) refered it to the genus *Merluccius*. This species was regarded as identical with the European hake (*M. merluccius*) by GÜNTHER (1862). Although the general appearance of the two species is very similar, this species is easily distinguished from the European hake by the greater number of first dorsal fin rays, and by the larger size of the scales (GOODE, 1884).

This species differs from *M. merluccius*, *M. senegalensis*, *M. capensis*, *M. paradoxus*, *M. productus*, *M. angustimanus*, *M. hubbsi* and *M. australis* in the number of oblique rows of scales, from *M. merluccius*, *M. polli*, *M. albidus* and *M. australis* in the total number of gill-rakers, from *M. angustimanus* in the total number of vertebrae, from *M. productus* and *M. gayi* in the number of abdominal vertebrae, and from *M. polli*, *M. productus* and *M. angustimanus* in the number of ribs.

The differences in the total number of vertebrae between this species and *M.*

capensis, *M. gayi* and *M. hubbsi*, and the differences in the total number of gill-rakers between this species and *M. paradoxus* and *M. hubbsi* show highly statistical significant differences (Table 3). This species is also different from *M. senegalensis* in the relative length of upper jaw to head length and from *M. capensis* in the relative length of head to standard length (Fig. 13).

This species is closely related to *M. senegalensis* and *M. merluccius* in general characters and also with three species from the Pacific Ocean in the number of gill-rakers.

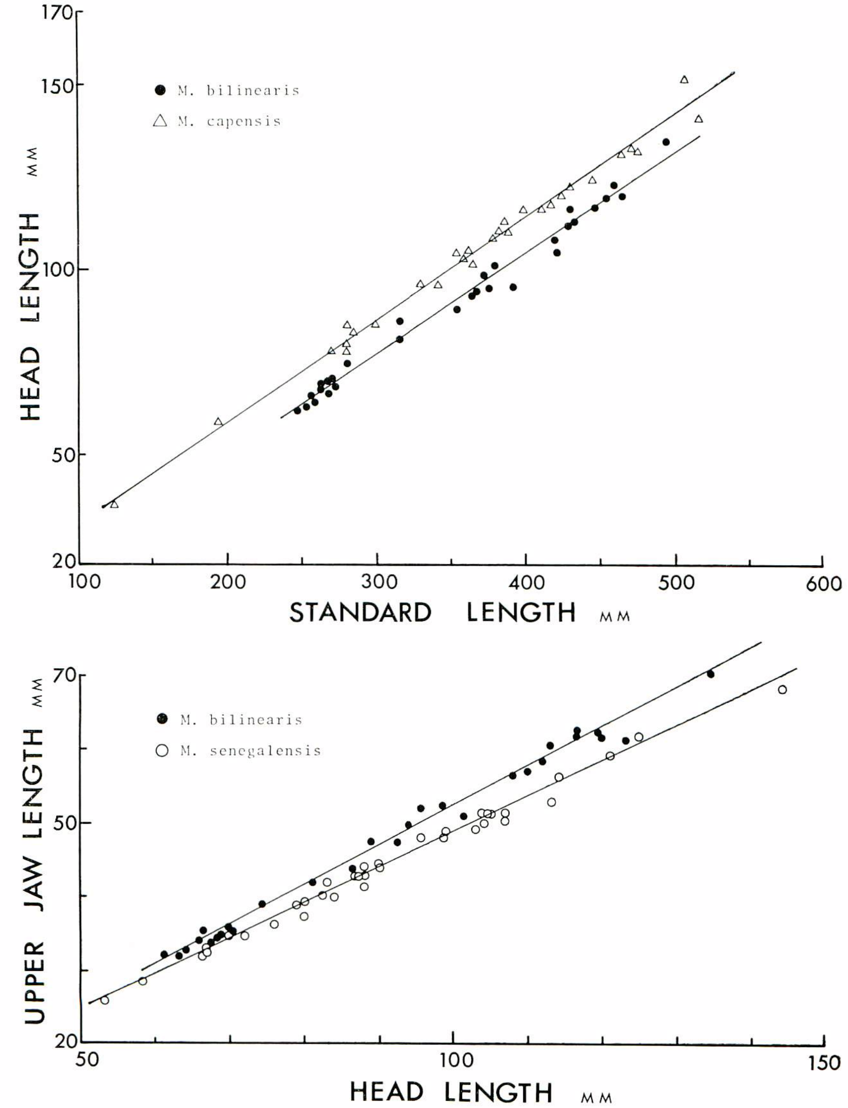

Fig. 13. Comparisons between *M. bilineasis* and *M. capensis* on the relationship of standard length to head length (upper) and between *M. bilinearis* and *M. senegalensis* on the relationship of head length to upper jaw length (lower).

7. *Merluccius albidus* (MITCHILL) : Offshore hake (Fig. 14)

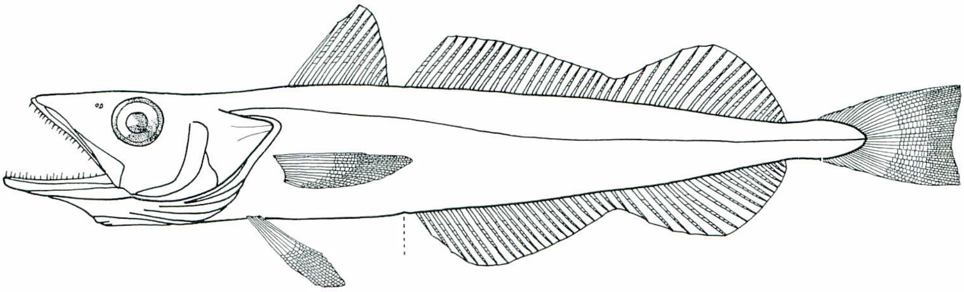

Fig. 14. *Merluccius albidus* (MITCHILL, 1818), FSFL EG978, SL 332.0mm

Merluccius albidus (MITCHILL, 1818)

Gadus albidus MITCHILL, 1818, *J. Acad. Nat. Sci. Philad.*, **1** : 409 (type locality : New York).

Merluccius albidus: DE KAY, 1842, N.H. New York, 3 : 280 (Sandy Hook).

Merluccius vulgaris (nec FLEMING, 1828) : GÜNTHER, 1862, Cat. fish. Brit. Mus., 4: 344 (bibliography).

Merluccius bilinearis (nec MITCHILL, 1814) : NORMAN, 1937, *Discovery Rept.*, **16** : 47 (bibliography).

Merluccius magnoculus GINSBURG, 1954, *Fish. Bull.*, **96**(56) : 194 (off Pensacola, Florida).

Materials examined: (Table 11)

Table 11. Data of specimens of *Merluccius albidus* used in this study

Catalogue No.	Date	Sampling position Lat.(N)	Long.(W)	Depth (fsm)
EJ201(FSFL), 206201(USNM)	July 26, 1969	35°47.3′	74°49.6′	125-200
EJ200(FSFL), 208234(USNM)	Nov. 18, 1968	15°45′	80°45′	360
EJ202(FSFL), 208203(USNM)	Sept. 9, 1964	11°30′	60°46′	200-240
EJ203(FSFL), 208167(2 specimens, USNM)	Feb. 27, 1964	27°52.5′	92°29′	150
EJ204, EJ205(FSFL), 208216(USNM)	Aug. 18, 1970	24°32′	83°36′	205
EJ206(FSFL), 205237(3 specimens, USNM)	Nov. 22, 1968	12°24′	82°24′	335
EJ207(FSFL), 206206(2 specimens, USNM)	Aug. 8, 1970	24°28′	86°26′	190
EJ208(FSFL), 207153(USNM)	June 10, 1970	19°32′	93°46′	600
EJ230(FSFL), 208235(USNM)	Nov. 20, 1968	14°01′	81°50′	265
EG971-EG973, EG979(FSFL)	Nov. 26, 1965	24°27′	83°32′	196-221
EG977, EG978(FSFL)	Apr. 10, 1964	23°19′	97°16′	225
208166(2 specimens, USNM)	Oct. 23, 1962	29°11.5′	88°11.5′	150
205243(USNM)	June 2, 1962	12°23′	82°29′	200
33032(USNM)	Off Cape Charles, Virginia			
190356(USNM)	June 19, 1960	29°43′	80°12′	165
208182(USNM)	Nov. 20, 1968	14°24′	81°48′	215
208174, 208183(USNM)	Nov. 20, 1968	13°58′	81°53′	220
208223(USNM)	Nov. 22, 1963	24°28′	83°33′	210
155728(2 specimens, USNM)	Feb. 7, 1940	32°09′	79°02′	100-175
208215(USNM)	June 5, 1962	14°23′	81°45′	250
205235(USNM)	May 11, 1969	7°35′	53°29′	360
208169(USNM)	May 24, 1964	10°24′	75°50′	65
206199(USNM)	June 3, 1965	18°05.5′	67°21.5′	12

Description:

First dorsal fin rays I, 10-12 (average I, 10.7); second dorsal fin rays 35-39 (37.3); anal fin rays 35-41 (37.4); pectoral fin rays 12-16 (14.2); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 104-119 (111.3); number of gill-rakers on first arch 1-3(1.9)+7-9(8.0)=8-11(9.8); number of vertebrae 23-26 (24.4)+27-30 (28.6)=51-55(53.0); number of ribs 4.

Body depth in percent of standard length 13.0-16.4 (14.8); head length 26.8-31.7 (29.5); caudal peduncle depth 3.5-4.6 (4.1); length of longest first dorsal fin ray 12.0-15.0 (13.0); length of longest second dorsal fin ray (anterior lobe) 6.5-9.2 (8.0); length of longest second dorsal fin ray (posterior lobe) 8.8-11.8 (10.3); length of pectoral fin 16.9-22.3 (18.8); length of pelvic fin 13.8-20.6 (16.2); length of longest anal fin ray (anterior lobe) 7.1-9.5 (8.3); length of longest anal fin ray (posterior lobe) 8.7-11.0 (9.6); length of first dorsal fin base 9.5-13.1 (11.0); length of second dorsal fin base 41.9-47.3 (44.3); space between first dorsal and second dorsal fins 1.3-2.6 (1.9); length of anal fin base 39.5-45.8 (42.5); tip of snout to first dorsal fin origin 29.7-33.6 (31.5); tip of snout to second dorsal fin origin 42.2-46.5 (44.1); tip of snout to pectoral fin insertion 28.1-31.6 (29.8); tip of snout to pelvic fin insertion 23.1-30.4 (26.8); tip of snout to anal fin origin 44.6-52.0 (48.2); length between pelvic fin insertion and anal fin origin 19.9-26.3 (23.2). Snout length in percent of head length 31.0-37.2 (33.3); diameter of eye 15.4-22.9 (19.2); diameter of orbit 17.1-27.7 (21.5); interorbital width 20.8-26.5 (24.5); suborbital width 5.7-7.9 (6.8); upper jaw length 48.5-55.2 (51.9); lower jaw length 61.9-69.6 (65.8).

Remarks:

This species has less slender body than the other species and has larger head, eye and gape, rather larger pelvic fin and narrow interorbital width. It also has numerous vertebrae, fewer gill-rakers and fin rays, rather larger scales and fewer oblique rows of scales. The length of the pectoral fin is variable. The tendency is that the smaller fish has relatively longer pectoral fin (reaches or extends over the anal fin origin) and the larger one has shorter pectoral fin (does not reach the anal fin origin). The caudal margin is truncate in smaller fish and concave in larger fish. The colour of body is usually silvery white.

This species was first described by MITCHILL (1818) as *Gadus albidus*. Later, DE KAY (1842) referred this species to the genus *Merluccius*. GÜNTHER (1862) included this species in the synonymy of *Merluccius vulgaris* (= *M. merluccius*). This species has been treated as the synonym of *Merluccius bilinearis* by many authors until GINSBURG (1954) recognized it as a distinct species. KARNELLA (1973) showed that *Merluccius magnoculus*, which was described as a new species by GINSBURG (1954), is a junior synonym of *M. albidus*.

This species differs from all of the other species except for *M. merluccius*, *M. polli* and *M. australis* in the total number of gill-rakers and from *M. merluccius*, *M.*

senegalensis, *M. capensis*, *M. productus* and *M. australis* in the number of oblique rows of scales. The differences of the number of first dorsal fin rays and total vertebrae between this species and *M. merluccius* are very large. Moreover, some proportional characters such as the relative length of the pectoral fin, anal fin base and snout tip to the first dorsal fin origin show considerable differences between this species and *M. merluccius*. Though it is difficult to separate this species from *M. polli* by meristic characters, this species differs from *M. polli* by some proportional characters such as relative length of the upper jaw, anal fin base and snout tip to the first dorsal fin origin (Fig. 15). Moreover, this species differs from *M. polli* in the silvery colour of the body.

This species is closely related to *M. merluccius* and *M. polli* in having fewer gill-rakers.

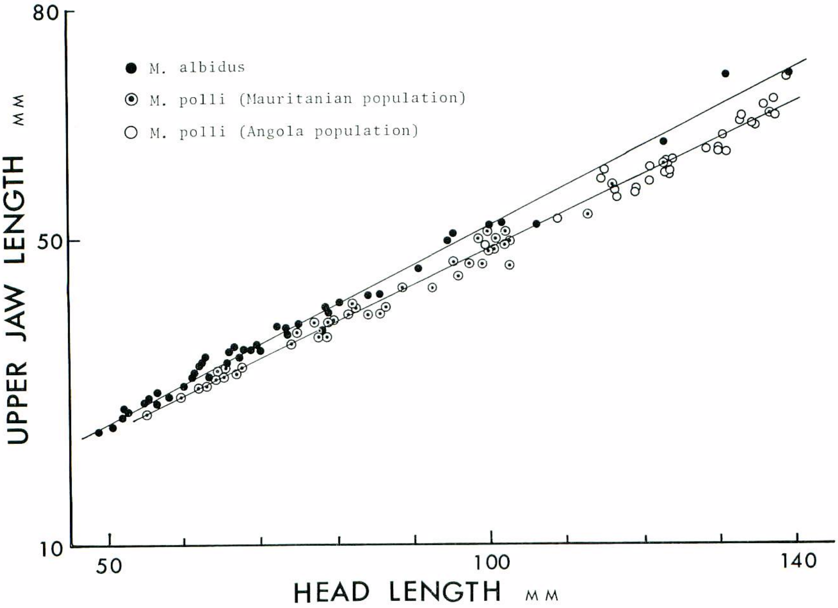

Fig. 15. Comparison between *M. albidus* and *M. polli* on the relationship of head length to upper jaw length.

8. *Merluccius productus* (AYRES) : Pacific hake (Fig. 16)

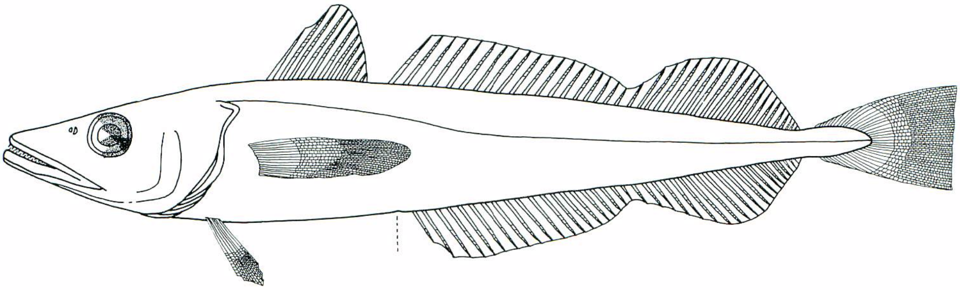

Fig. 16. *Merluccius productus* (AYRES, 1855), FSFL D1954, SL 496.0mm

Merluccius productus (AYRES, 1855)

Merlangus productus AYRES, 1855, *Proc. Cal. Acad. Nat. Sci.*, **1** : 64 (type locality : San Francisco).

Homalopomus trowbridgii GIRARD, 1856, *Proc. Acad. Nat. Sci. Philad.* : 132 (Astoria, Oregon).

Gadus productus: GÜNTHER, 1862, Cat. fish. Brit. Mus., 4: 338 (coast of California).

Merluccius productus: GILL, 1863, *Proc. Acad. Nat. Sci. Philad.* : 247 (bibliography).

Materials examined: (Table 12)

Table 12. Data of specimens of *Merluccius productus* used in this study

Catalogue No. (FSFL)	Date	Sampling position Lat.(N)	Long.(W)	Depth (m)
B1851, D1954-D1958, D1993	June 16, 1967	47°31.0′	124°58.0′	—
D2101-D2104, D2106, D2108, D2110, D2113-D2115, D2117, D2118	Sept. 3, 1970	44°22.0′	124°46.0′	175
D2131-D2140, D2142	Sept. 2, 1970	43°53.0′	124°51.0′	294
M367, U801, U808, U811, EI013, EI025, EI036, EI041	Oct. 29, 1974	32°49.7′	119°20.0′	362
M372, Q143, Q148, U604, U617, U619	Oct. 17, 1974	41°18.2′	124°26.0′	172
M767, EI004, EI006, EI008	Oct. 17, 1974	40°53.0′	124°34.0′	570

Other specimens examined for counting of meristic characters :

Number of specimens not catalogued	Date	Sampling position Lat.(N)	Long.(W)	Depth (m)
13	Sept. 3, 1970	44°22.0′	124°46.0′	175
9	Oct. 17, 1974	40°53.0′	124°34.0′	570
1	June 16, 1967	47°31.0′	124°58.0′	—
1	Sept. 2, 1970	43°53.0′	124°51.0′	294

Description:

First dorsal fin rays I, 9-12 (average I, 10.3); second dorsal fin rays 39-44 (40.9); anal fin rays 39-44 (41.1); pectoral fin rays 14-17 (15.6); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 125-144 (132.6); number of gill-rakers on first arch 3-6 (4.4)+14-17(15.6)=18-23(20.1); number of vertebrae 23-25(23.9)+29-31 (29.7)=53-54 (53.5); number of ribs 3.

Body depth in percent of standard length 14.7-18.2 (16.5); head length 24.7-28.9 (26.3) ; caudal peduncle depth 3.3-4.4(3.9) ; length of longest first dorsal fin ray 9.6-12.9 (11.4); length of longest second dorsal fin ray (anterior lobe) 6.1-8.3 (7.2); length of longest second dorsal fin ray (posterior lobe) 8.8-11.0 (9.6); length of pectoral fin 17.4-21.9 (20.2); length of pelvic fin 10.4-13.9 (12.1); length of longest anal fin ray (anterior lobe) 6.9-8.9 (8.0); length of longest anal fin ray (posterior lobe) 7.9-10.2 (9.2); length of first dorsal fin base 8.7-11.9 (10.8); length of second dorsal fin base

44.4-48.8 (46.8); space between first dorsal and second dorsal fins 1.9-3.7 (2.9); length of anal fin base 42.4-47.2 (44.8); tip of snout to first dorsal fin origin 27.9-32.1 (29.2); tip of snout to second dorsal fin origin 39.2-45.5 (42.3); tip of snout to pectoral fin insertion 24.6-29.0 (26.8); tip of snout to pelvic fin insertion 23.0-27.5 (24.8); tip of snout to anal fin origin 42.7-48.3 (45.6); length between pelvic fin insertion and anal fin origin 18.9-25.2 (22.0). Snout length in percent of head length 31.1-35.4 (33.5); diameter of eye 12.7-20.0 (16.3); diameter of orbit 16.1-22.6 (19.0); interorbital width 24.0-28.8 (26.4) ; suborbital width 4.9-8.9 (7.2); upper jaw length 45.8-50.9 (48.0); lower jaw length 59.2-63.8 (61.3).

Remarks:

This species has numerous gill-rakers and fin-rays, and has smaller head, shorter pelvic fin and medium sized snout, eye and gape. The tip of the pectoral fin usually reaches or extends beyond the level of the anal fin origin. Caudal margin is concave. The longer pectoral and concaved caudal margin are characteristic of three Pacific species, *M. productus*, *M. angustimanus* and *M. gayi*.

This species was first described by AYRES (1855) from San Francisco as *Merlangus productus*. At almost the same time, GIRARD (1856) reported the species from off Oregon under the name *Homalopomus trowbridgii*. Later, GÜNTHER (1862) referred *Merlangus productus* to the genus *Gadus*, and GILL (1863) referred this species to the genus *Merluccius*.

This species differs from *M. merluccius*, *M. polli*, *M. albidus*, *M. hubbsi* and *M. australis* in the total number of gill-rakers, from *M. bilinearis* and *M. albidus* in the number of oblique rows of scales, from *M. angustimanus* in the total number of vertebrae, from *M. capensis* in the number of caudal vertebrae, from *M. paradoxus* and *M. bilinearis* in the number of abdominal vertebrae, and from *M. senegalensis*, *M. capensis*, *M. paradoxus* and *M. bilinearis* in the number of ribs. The difference in the total number of vertebrae between this species and *M. gayi* shows a highly statistical significant difference (Table 3). The relative length of the pelvic fin shows the difference between this species and *M. gayi* (Fig. 17). The difference in the total number of gill-rakers between this species and *M. senegalensis* shows a highly statistical significant difference (Table 3). The relative length of the caudal peduncle depth to standard length shows quite difference between this species and *M. senegalensis* (Fig. 17).

This species is very closely related to M. *angustimanus* and *M. gayi* in the number of gill-rakers and the size of scales, and the number of difference between caudal vertebrae and abdominal vertebrae (Fig. 18). These three Pacific species have rather numerous gill-rakers, larger scales and numerous abdominal vertebrae compared with other merlucciids. These are also closely related to the north western Atlantic species, *M. bilinearis* and *M albidus* in some characters.

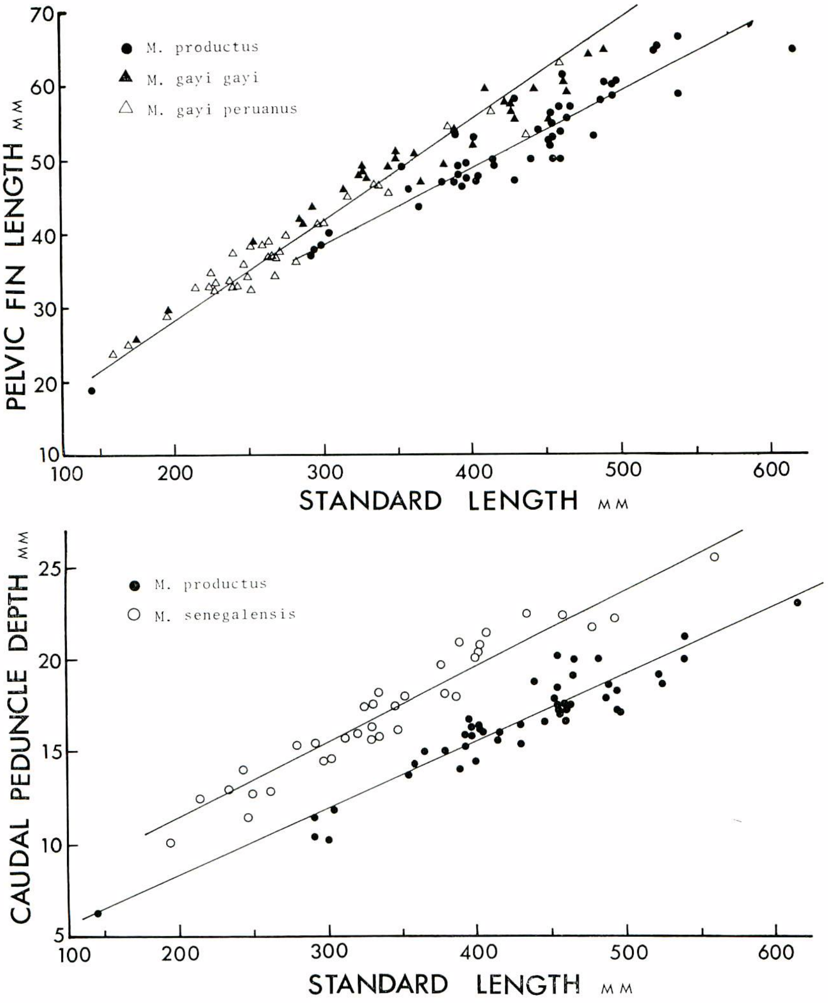

Fig. 17. Comparisons between *M. productus* and *M. gayi* on the relationship of standard length to pelvic fin length (upper) and between *M. productus* and *M. senegalensis* on the relationship of standard length to caudal peduncle depth (lower).

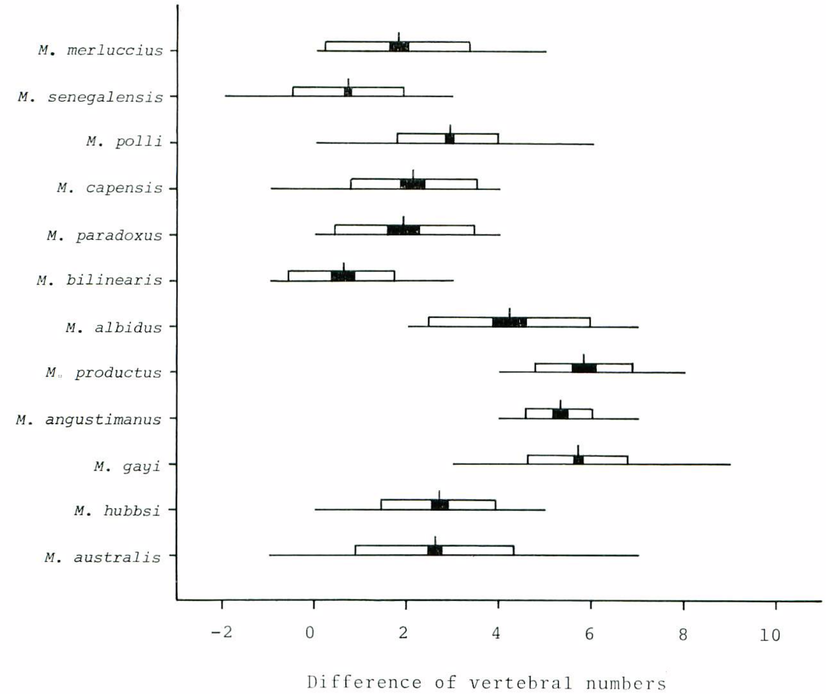

Fig. 18. Graphic comparison of difference of vertebral numbers (caudal vertebrae number minus abdominal vertebrae number) for 12 species. The mean value is represented by mid-point, standard deviation by open bar, two times of the standard error by black bar, and range of the value by line, for respective species.

9. *Merluccius angustimanus* GARMAN : Panama hake (Fig. 19)

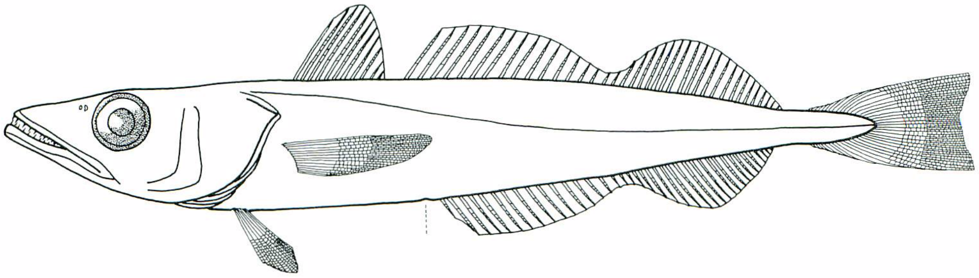

Fig. 19. *Merluccius angustimanus* GARMAN, 1899, FSFL EI048, SL 200.5mm

Merluccius angustimanus GARMAN, 1899

Merluccius angustimanus GARMAN, 1899, *Mem. Mus. Comp Zool.*, **24** : 183, pl. 41 (fig.1) (type locality: Gulf of Panama).

Merluccius gayi (nec GUICHENOT, 1848) : NORMAN, 1937, *Discovery Rept.*, **14**: 48 (bibliography).

Merluccius angusticeps: HILDEBRAND, 1946, *Bull. U. S. Nat. Mus.*, (189): 159 (Peru, misspelling?).

Materials examined: (Table 13)

Table 13. Data of specimens of *Merluccius angustimanus* used in this study

Catalogue No. (FSFL)	Date	Sampling position Lat.(N)	Long.(W)	Depth (m)
EI412, EI413, EI421, EI424	Nov. 1, 1974	26°15.3′	113°38.8′	102
EI040, EI042, EI043, EI044, EI056, EI058	Nov. 2, 1974	25°22.2′	113°00.2′	125
EI450-EI454, EI459, EI490, EI492	Nov. 2, 1974	25°31.4′	112°51.7′	212
EI019, EI045-EI049, EI282, EI284, EI455, EI464, EI475, EI489	Nov. 3, 1974	24°31.0′	112°30.3′	465

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position Lat.(N)	Long.(W)	Depth (m)
11	Nov. 1, 1974	26°15.3′	113°38.8′	102
4	Nov. 2, 1974	25°31.4′	112°51.7′	212

Description:

First dorsal fin rays I, 9-12 (average I, 9.8); second dorsal fin rays 36-40 (37.6); anal fin rays 36-39(37.3); pectoral fin rays 14-17(16.0); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 121-134 (124.8); number of gill-rakers on first arch 3-5(4.0)+12-14(13.1)=16-18(17.1); number of vertebrae 21-23(22.6)+27-29(27.8) =49-52(50.4); number of ribs 3.

Body depth in percent of standard length 16.0-17.9 (16.9); head length 30.1-33.5 (31.9); caudal peduncle depth 3.6-4.7 (3.9); length of longest first dorsal fin ray 10.8-14.6 (13.1); length of longest second dorsal fin ray (anterior lobe) 7.1-8.8 (7.9); length of longest second dorsal fin ray (posterior lobe) 9.5-12.3 (10.9); length of pectoral fin 20.3-24.2 (22.2); length of pelvic fin 13.1-15.8 (14.3); length of longest anal fin ray (anterior lobe) 7.4-10.1 (9.1); length of longest anal fin ray (posterior lobe) 9.3-11.4 (10.2); length of first dorsal fin base 9.5-12.1 (10.8); length of second dorsal fin base 41.1-44.4 (42.8); space between first dorsal and second dorsal fins 1.4-3.2 (2.6); length of anal fin base 36.7-41.8 (39.6); tip of snout to first dorsal fin origin 31.1-34.9 (33.0); tip of snout to second dorsal fin origin 43.1-47.4 (45.8); tip of snout to pectoral fin insertion 30.4-33.3 (31.7); tip of snout to pelvic fin insertion 25.2-29.8 (27.4); tip of snout to anal fin origin 47.4-52.2 (49.8); length between pelvic fin insertion and anal fin origin 20.6-26.3 (23.8). Snout length in percent of head length 27.8-32.7 (30.2); diameter of eye 16.0-21.2 (18.8); diameter of orbit 19.7-24.6 (21.7); interorbital width 25.4-29.4 (27.0); suborbital width 3.6-6.6 (5.0); upper jaw length 44.4-48.5 (46.8); lower jaw length 56.0-61.7 (58.8).

Remarks:

This species is relatively smaller body with a maximum recorded length of 322mm SL. Characteristics of this species are fewer vertebrae, more numerous gill-rakers, larger head and eye, shorter snout and smaller gape. The pectoral fin is longer and its tip always reaches to or extends beyond the level of the anal fin origin. The caudal margin is truncate or concave.

This species was first described by GARMAN (1899) based on specimens from the Gulf of Panama. He described this species in detail but did not compare it with other species. NORMAN (1937) referred this species to the synonymy of *M. gayi*, with reservations. HILDEBRAND (1946) cited this species as *M. angusticeps* by mistake in his catalogue of the shore fishes of Peru. Later, GINSBURG (1954) examined specimens from off the southern part of California and noted that this population is a distinct species because the differences in some characters from *M. gayi* and *M. productus* seem to be of species magnitude. On the other hand, BERRY (1965) proposed that all eastern Pacific hakes from Alaska to southern Chile were represented by two species. He concluded that *M. polylepis* from southern Chile was a valid species and the other four foms, *M. productus*, *M. angustimanus*, *M. gayi gayi* and *M. gayi peruanus*, were a single species, *M. gayi*. He postulated that the meristic and morphometric characters which have been used to separate the last four merely reflected environmentally induced differences which varied clinally over the geographic range. TESTAVERDE and ARTUNGUAGE (1974) reported the occurence of this species from off the Pacific coast of Colombia. These specimens have values of modal range (and mean value) of 13-17 (15.7) for total gill-raker counts, whereas those of *M. productus*, *M. gayi gayi* and *M. gayi peruanus* are 17-22 (20.5), 17-23 (20.1) and 18-25 (21.0) respectively. Recently, VROOMAN and PALOMA (1976) reported on the Dwarf hake off the coast of Baja California and noted that this small hake is so significantly different from *M. productus* that it might be a separate species. Dwarf hake differs from GARMAN's description of *M. angustimanus* in two ways. (1) Dwarf hake has about 135 lateral line scales compared to 110 for *M. angustimanus*, (2) *M. angustimanus* pectoral fins reach to the 5th anal ray or beyond but Dwarf hake pectorals seldom reach that far and frequently do not even reach to the anal fin origin. Moreover, Dwarf hake matures at age one or two but *M. angustimanus* from the Gulf of California matures at age 3. *M. angustimanus* reaches a slightly larger maximum size and also lives about two years longer. Dwarf hake has a slightly shorter length from snout to tip of pectoral fin and shorter pectoral fin lengths and much shorter length from snout to anal fin origin. *M. angustmanus* has smaller eye diameter. Dwarf hake has significantly more vertebrae, anal fin rays, second dorsal rays, and gill-rakers on the first gill arch than *M. angustimanus*. The best meristic character to separate the two is the number of vertebrae, with a mean of 47.02 for *M. angustimanus* and 50.52 for Dwarf hake (VROOMAN, personal communication). I consider the Dwarf hake to be a local population or race of *M. angustimanus* and treat it tentatively as the same species until a comparative examination can be made on specimens from Baja California to the Gulf of Panama.

This species differs from *M. merluccius*, *M. polli*, *M. albidus* and *M. australis* in the total number of gill-rakers, from *M. bilinearis* and *M. australis* in the number of oblique rows of scales, from *M. polli*, *M. paradoxus*, *M. bilinearis*, *M. productus* and *M. australis* in the total number of vertebrae, from *M. senegalensis* in the number of abdominal vertebrae, and from *M. senegalensis*, *M. capensis*, *M. paradoxus* and *M. bilinearis* in the number of ribs. The differences in the total number of gill-rakers between this species and *M. gayi* and *M. hubbsi* show highly statistical significant differences (Table 3). The relative length of head shows the difference between this species and *M. hubbsi* (Fig. 20). The total number of gill-rakers shows a geographic clinal change by latitude among three Pacific species, *M. poductus*, *M. angustimanus* and *M. gayi*. The ranges and mean values of these species are as follows: *M. productus* 17-23 (mean 20.2), southern California population of *M. angustimanus* 16-18 (17.1), Colombia population of *M. angustimanus* 13-17 (15.7), *M. gayi peruanus* 17-23 (20.2) and *M. gayi gayi* 18-25 (21.0) (including data by GINSBURG (1954) and TESTAVERDE and ARTUNGUAGE (1974)). These numbers increase with latitude clinally (from the equator to the north or south) but the differences in these numbers between the three species are large enough to warrant species recognition. This species is also closely related to the Atlantic species, *M. albidus* in some characters such as head length and diameter of eye.

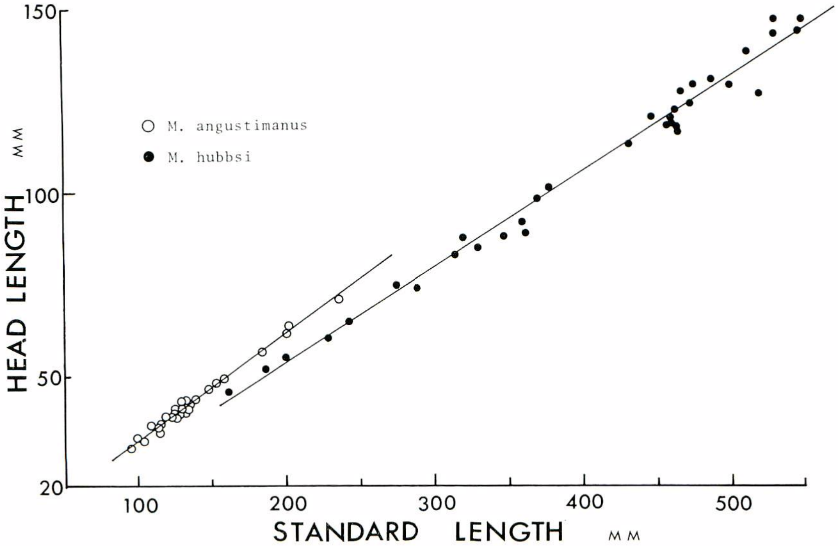

Fig. 20. Comparison between *M. angustimanus* and *M. hubbsi* on the relationship of standard length to head length.

10. *Merluccius gayi* (GUICHENOT): Chilean hake (Fig. 21)

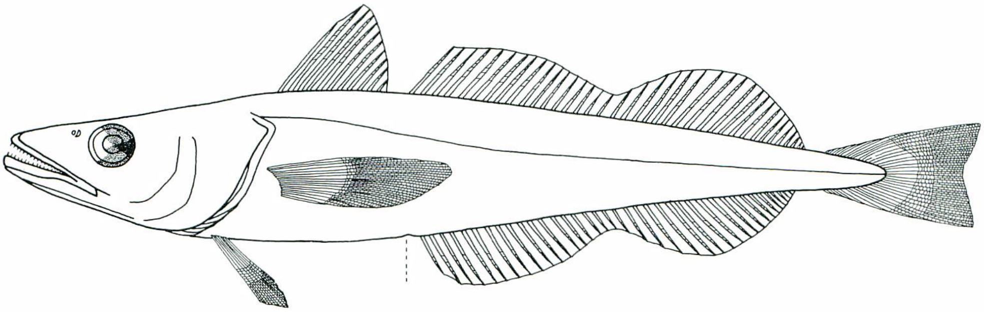

Fig. 21. *Merluccius gayi* (GUICHENOT, 1848), FSFL M877, SL 414.0 mm.

Merluccius gayi (GUICHENOT, 1848)

Merlus gayi GUICHENOT, 1848, *in* GAY, Hist. fisica polit. Chile, Zool., 2 : 328, pl.8 (fig.2) (type locality: off the coast of Chile).

Merluccius gayi: KAUP, 1858, *Arch. Naturg.*, **24**(1): 87 (bibliography).

Epicopus gayi GÜNTHER, 1860, Cat. fish. Brit. Mus., 2: 232, 248 (coast of Chile).

Materials examined: (Table 14)

Table 14. Data of specimens of *Merluccius gayi* used in this study

Merluccius gayi gayi

Catalogue No. (FSFL)	Date	Sampling position		Depth (m)
		Lat.(S)	Long.(W)	
EI001-EI003, EI005, EI007, EC110, EC111, EC115, EC116, EC144, EC149, EC180, EC181, EC183, EC185, EC189, EC192, EC195, EC197, EC198, EK400-EK409	Jan. 18, 1969	36°41.0′	73°21.0′	130

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position		Depth (m)
		Lat.(S)	Long.(W)	
60	Dec. 28, 1977	40°41′	75°15′	173-200
6	May 26, 1979	44°11′	74°53′	210
4	May 28, 1979	44°28′	75°20′	330
3	May 24, 1979	43°59′	75°14′	400
2	May 23, 1979	43°54′	75°13′	370
2	May 25, 1979	44°04′	75°06′	357
2	May 25, 1979	44°03′	74°55′	236
1	May 24, 1979	44°07′	75°15′	570

Merluccius gayi peruanus

Catalogue No. (FSFL)	Date	Sampling position		Depth (m)
		Lat.(S)	Long.(W)	
EI283, EI286, EI289	Feb. 7, 1973	port of Talara		
M877, M881, M882, M885, M892, M896, M897, S080-S083, S085, S086, S090, S091, S093, S095, S096, S098, S099, EJ241-EJ252	Dec. 12, 1968	07°56′	80°06′	176

Description:

First dorsal fin rays I, 9-12 (average I, 10.2); second dorsal fin rays 36-42 (38.9); anal fin rays 36-42 (39.1); pectoral fin rays 15-18 (16.1); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 106-130 (116.5); number of gill-rakers on first arch 3-6(4.9)+13-19(15.9)=18-25 (20.8); number of vertebrae 21-24 (22.6)+26-30(28.4)=48-53(51.0); number of ribs 3-4(3.1).

Body depth in percent of standard length 14.2-19.3 (17.5); head length 26.0-32.4 (29.6); caudal peduncle depth 3.5-4.9 (4.2); length of longest first dorsal fin ray 10.0-14.6 (13.0); length of longest second dorsal fin ray (anterior lobe) 7.3-9.6 (8.5); length of longest second dorsal fin ray (posterior lobe) 9.3-11.9 (10.5); length of pectoral fin 19.0-23.5 (21.5); length of pelvic fin 12.3-15.5 (14.0); length of longest anal fin ray (anterior lobe) 8.0-10.4 (9.2); length of longest anal fin ray (posterior lobe) 8.8-11.1 (10.1); length of first dorsal fin base 9.3-13.5 (11.1); length of second dorsal fin base 41.8-48.3 (44.5); space between first dorsal and second dorsal fins 1.6-3.8 (2.6); length of anal fin base 38.0-46.3 (41.9); tip of snout to first dorsal fin origin 29.7-33.9 (31.7); tip of snout to second dorsal fin origin 41.8-47.8 (44.8); tip of snout to pectoral fin insertion 27.3-32.6 (30.2); tip of snout to pelvic fin insertion 25.3-28.9 (27.2); tip of snout to anal fin origin 43.6-52.1 (48.1); length between pelvic fin insertion and anal fin origin 19.4-27.1 (22.9). Snout length in percent of head length 29.3-34.1 (31.6); diameter of eye 14.9-18.9 (16.9); diameter of orbit 16.9-22.0 (19.1); interorbital width 24.3-28.3 (26.7); suborbital width 4.8-8.4 (6.6); upper jaw length 43.7-50.2 (46.8); lower jaw length 56.5-65.7 (59.8).

10. 1. *Merluccius gayi gayi* (GUICHENOT)

Merluccius gayi gayi (GUICHENOT, 1848)

Merlus gayi GUICHENOT, 1848, *in* GAY, Hist. fisica polit. Chile, Zool., 2:328, pl. 8 (fig.2) (type locality: off the coast of Chile).

Merluccius gayi gayi: GINSBURG, 1954, *Fish. Bull.*, **96** (56): 202 (off the coast of Chile).

Description:

First dorsal fin rays I, 9-12 (I, 10.1); second dorsal fin rays 37-42 (39.5); anal fin rays 36-42 (39.9); pectoral fin rays 15-17 (16.0); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 108-128 (116.3); number of gill-rakers on first arch 3-6(5.0)+15-19(16.2)=19-25(21.1); number of vertebrae 21-24 (22.8)+27-30(28.5)=49-53(51.3); number of ribs 3-4 (3.1).

Body depth in percent of standard length 16.2-18.4 (17.2); head length 26.0-30.5 (28.5); caudal peduncle depth 3.6-4.4 (4.0); length of longest first dorsal fin ray 11.4-14.1 (13.0); length of longest second dorsal fin ray (anterior lobe) 7.3-9.6 (8.4); length of longest second dorsal fin ray (posterior lobe) 9.3-11.9 (10.5); length of pectoral fin 19.0-23.4 (21.3); length of pelvic fin 12.3-15.1 (13.9); length of longest anal fin ray (anterior lobe) 8.2-10.4 (9.2); length of longest anal fin ray (posterior lobe) 8.8-11.1 (9.9); length of first dorsal fin base 9.3-12.0 (10.7); length of second dorsal fin base 43.9-48.3 (45.8); space between first dorsal and second dorsal fins 1.9-3.7 (2.6); length of anal fin base 41.1-46.3 (43.4); tip of snout to first dorsal fin origin 29.7-32.7 (30.8); tip of snout to second dorsal fin origin 41.8-45.3 (43.6); tip of snout to pectoral fin insertion 27.3-30.8 (29.2); tip of snout to pelvic fin insertion 25.3-28.6 (26.6); tip of snout to anal fin origin 43.6-49.5 (46.8); length between pelvic fin insertion to anal fin origin 19.4-24.1 (21.8). Snout length in percent of head length 29.3-34.1 (31.7); diameter of eye 15.6-18.9 (17.1); diameter of orbit 17.6-22.0 (19.4); interorbital width 24.3-28.0 (26.4); suborbital width 5.4-8.4 (6.7); upper jaw length 43.7-48.5 (46.2); lower jaw length 57.8-63.2 (59.7).

10. 2. *Merluccius gayi peruanus* GINSBURG

Merluccius gayi peruanus GINSBURG, 1954

Merluccius gayi peruanus GINSBURG, 1954, *Fish. Bull.*, **96** (56): 202 (type locality: Paita, Peru).

Merluccius gayi : EVERMANN and RADCLIFFE, 1917, *Bull. U. S. Nat. Mus.*, **95** : 158 (Paita and Callao, Peru).

Description:

First dorsal fin rays I, 9-12 (I, 10.3); second dorsal fin rays 36-40 (37.7); anal fin rays 36-39 (37.6); pectoral fin rays 15-18 (16.3); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 106-130 (116.8); number of gill-rakers on first arch 3-5 (4.8)+13-17 (15.4)=18-22 (20.2) ; number of vertebrae 21-23 (22.1)+26-29 (27.8) =48-51(49.8); number of ribs 3.

Body depth in percent of standard length 14.2-19.3 (17.7); head length 28.1-32.4 (30.5) ; caudal peduncle depth 3.5-4.9 (4.4); length of longest first dorsal fin ray 10.0-14.6 (13.0); length of longest second dorsal fin ray (anterior lobe) 7.6-9.3 (8.5); length of longest second dorsal fin ray (posterior lobe) 9.7-11.8 (10.6); length of pectoral fin 19.9-23.5 (21.6); length of pelvic fin 12.3-15.5 (14.1); length of longest anal fin ray (anterior lobe) 8.0-10.2 (9.2); length of longest anal fin ray (posterior lobe) 9.2-11.0 (10.1); length of first dorsal fin base 9.7-13.5 (11.5); length of second dorsal fin base 41.8-45.2 (43.5); space between first dorsal and second dorsal fins 1.6-3.8 (2.6); length of anal fin base 38.0-42.4 (40.6); tip of snout to first dorsal fin origin 30.3-33.9 (32.4) ; tip of snout to second dorsal fin origin 43.0-47.8 (45.7) ; tip of snout to pectoral fin insertion 27.6-32.6 (31.0); tip of snout to pelvic fin insertion 25.7-28.9 (27.6); tip of snout to anal fin origin 46.6-52.1 (49.3); length between pelvic fin insertion to anal fin origin 20.6-27.1 (23.8). Snout length in percent of head length 29.5-33.0 (31.4); diameter of eye 14.9-18.1 (16.7); diameter of orbit 16.9-21.5 (19.0); interorbital width 25.9-28.3 (27.0); suborbital width 4.8-7.6 (6.4); upper jaw length 44.6-50.2 (47.4); lower jaw length 56.5-65.7 (59.8).

Remarks:

Head, snout, eye and gape of this species are of moderate size. This species also has larger scales, fewer vertebrae and numerous gill-rakers. The caudal margin is usually concave. Pectoral fin is longer and its tip reaches or extends over the level of anal fin origin.

This species was first described by GUICHENOT (1848) as *Merlus gayi*. Later, KAUP (1858) referred the species to *Merluccius*. This species has been confused with *M. hubbsi* for a long time because the southern limit of its distribution has not been known correctly. NORMAN (1937) restricted the distribution to the coasts of Chile and Peru, and he included *M. angustimanus* from Panama as a synonym of *M. gayi*. HILDEBRAND (1946) described the species in detail and discussed differences with *M. productus*, *M. hubbsi* and *M. angustimanus*.

GINSBURG (1954) separated the species into two subspecies. One is named *M. gayi peruanus* for the Peruvian population, and the other is named *M. gayi gayi* for the Chilean population. According to his description, meristic characters of the two subspecies are as follows : total number of gill-rakers, 3-6+14-19=18-25 for *M. gayi gayi*, 4-6+13-17=17-23 for *M. gayi perauus* ; number of dorsal fin rays, 10-13+37-42 for *M. gayi gayi*, 11-12+36-40 for *M. gayi peruanus*; number of anal fin rays, 39-42 for *M. gayi gayi*, 36-39 for *M. gayi peruanus* ; number of pectoral fin rays, 15-17 for *M. gayi gayi*, 15-18 for *M. gayi peruanus*; number of scales (oblique rows over lateral line), ca. 124-141 for *M. gayi gayi*, ca. 141 for *M. gayi peruanus*. He noted that *M. gayi gayi* had more numerous second dorsal and anal fin rays, higher gill-raker counts, shorter head and maxillary than *M. gayi peruanus*, and that these differences were of the magnitude that signified subspecies. Some characters of the two populations from Chile and Peru in this study also show considerable differences in the ranges and mean values. The total number of vertebrae is 49-53 (mean 51.3) for the Chilean population and 48-51 (49.8) for the Peruvian population. The total number of gill-rakers is 19-25 (21.1) for the Chilean population and 18-22 (20.2) for the Peruvian population. The differences in these characters between the two populations are statistically highly significant (Table 3). The relative length of the head in these populations also shows the differences (Fig. 22). The distributions of these two populations are almost separated in the area between southern Peru and northern Chile. The above data suggest that the differences between the two populations should be recognized at the subspecific level. Within the subspecies *M.gayi gayi*, no significant differences were found in meristic characters by localities or by sex, but in some proportional characters, statistical differences were found (LEIBLE and MARTINEZ, 1974; MARTINEZ and LEIBLE, 1974).

This species differs from *M. merluccius*, *M. polli*, *M. albidus*, *M. hubbsi* and *M. australis* in the total number of gill-rakers, from *M. paradoxus* in the total number of vertebrae, from *M. senegalensis* and *M. bilinearis* in the number of abdominal vertebrae and from *M. capensis* and *M. australis* in the number of oblique rows of scales. GINSBURG

(1954) noted that the differences of *M. angustimanus* and *M. productus* from *M. gayi* in some characters were comparatively abrupt, and considering its extent, it was properly treated as a full species. The difference in the total number of gill-rakers between this species and *M. angustimanus*, and the difference in the total number of vertebrae between this species and *M. productus* show highly statistical significant differences (Table 3).

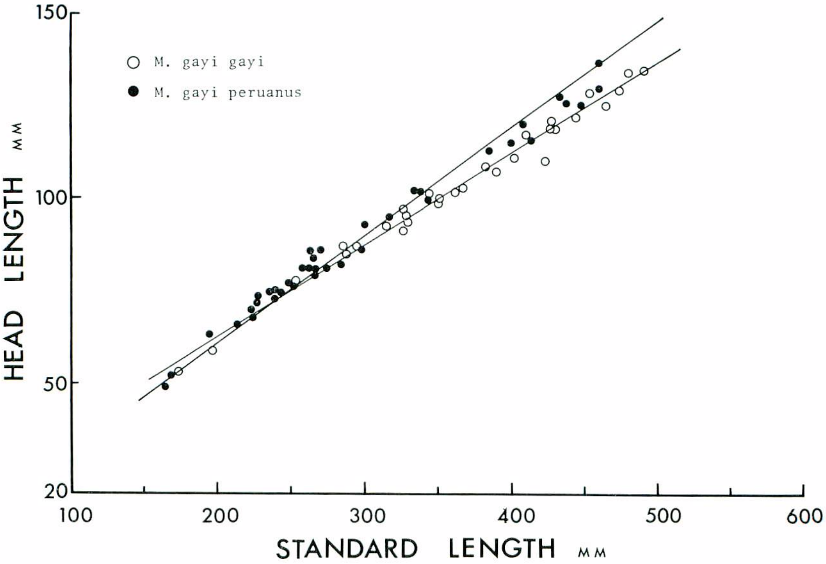

Fig. 22. Comparson between *M. gayi gayi* and *M. gayi peruanus* on the relationship of standard length to head length.

11. *Merluccius hubbsi* MARINI: Argentine hake (Fig. 23)

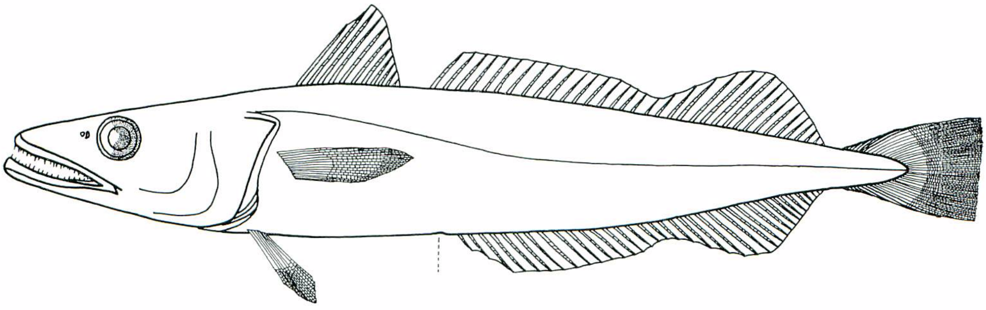

Fig. 23. *Merluccius hubbsi* MARINI, 1933, FSFL ED895, SL 512.0 mm.

Merluccius hubbsi MARINI, 1933

Merluccius hubbsi MARINI, 1933, *Rev. Physis*, **11**: 322, photo., (type locality: coast of the province of Buenos Aires and Patagonia).

Merluccius gayi (nec GUICHENOT, 1848): CUNNINGHAM, 1871, *Trans. Linn. Soc. London*,

27 : 472 (eastern entrance of the Strait of Magellan).

Merluccius bilinearis (nec MITCHILL, 1814) : RIBEIRO, 1915, Arch. Mus. Nac. : 1-2, fig., (North America to Rio de Janeiro).

Merluccius gayi hubbsi : MANN, 1954, *Inv. Zool. Chil.*, **2** (5) : 83 (Patagonia).

Merluccius merluccius hubbsi : ANGELESCU *et al.*, 1958, Sec. Mar., Buenos Aires : 164 (bibliography).

Materials examined : (Table 15)

Table 15. Data of specimens of *Merluccius hubbsi* used in this study

Catalogue No. (FSFL)	Date	Sampling position Lat.(S)	Long.(W)	Depth (m)
ED893, ED894, ED897	Dec. 23, 1969	51°01′	59°40.2′	116
B1920	Dec. 24, 1969	51°24′	61°18′	132
ED896	Dec. 27, 1969	48°05.8′	65°07.5′	104
M425, M431, M432, M433, M435, M440, M441, M442, M443, M444, M445, M447	Jan. 8, 1970	45°15′	65°45′	91
M429, M434, M438, M439, V860, ED895, ED898	Jan. 13, 1970	50°00′	60°00′	169
M426, M428, M430, M436, M446, M449, V864	Jan. 16, 1970	53°04.5′	67°53.5′	40
M875, M884, M895	Jan. 22, 1970	43°46′	60°34′	107

Other specimens examined for counting for meristic characters :

Number of specimens not catalogued	Date	Sampling position Lat.(S)	Long.(W)	Depth (m)
44	Data from HANAMURA (1971)			
20	Apr. 27, 1978	51°00′	65°09′	135
19	Apr. 23, 1978	47°00′	62°03′	127
12	Aug. 11, 1978	52°29′	66°32′	108
8	Apr. 20, 1978	44°58′	60°02′	208
8	Apr. 23, 1978	46°59′	60°42′	221
5	Apr. 29, 1978	51°00′	62°01′	200
5	Apr. 29, 1978	51°00′	64°01′	144
2	Apr. 26, 1978	49°00′	65°01′	115
2	Apr. 30, 1978	50°58′	59°54′	133
1	May 1, 1978	48°59′	63°04′	144
1	Apr. 27, 1978	51°00′	65°09′	135
1	Apr. 29, 1978	51°00′	62°58′	169
1	May 6, 1978	53°59′	67°02′	51
1	Apr. 27, 1978	51°00′	65°09′	135

Description:

First dorsal fin rays I, 9-12 (average I, 10.6); second dorsal fin rays 34-40 (37.5); anal fin rays 36-41 (38.0); pectoral fin rays 13-16 (14.3); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 120-142 (128.6); number of gill-rakers on first arch 2-5 (3.5) + 9-12 (10.6) = 12-16 (14.0); number of vertebrae 23-26 (24.1) + 25-28 (26.8) = 50-53 (51.1); number of ribs 3-4 (3.1).

Body depth in percent of standard length 14.8-18.9 (16.3); head length 24.4-28.0 (26.4); caudal peduncle depth 4.1-5.1 (4.6); length of longest first dorsal fin ray 10.2-15.5 (12.2); length of longest second dorsal fin ray (anterior lobe) 6.1-8.8 (7.3); length of longest second dorsal fin ray (posterior lobe) 8.8-12.5 (10.3); length of pectoral fin 15.1-21.2 (17.2); length of pelvic fin 11.3-16.1 (13.5); length of longest anal fin ray (anterior lobe) 6.3-8.8 (7.6); length of longest anal fin ray (posterior lobe) 7.8-10.7 (9.5); length of first dorsal fin base 10.3-13.0 (12.0); length of second dorsal fin base 42.0-47.3 (45.1); space between first dorsal and second dorsal fins 1.6-5.3 (2.8); length of anal fin base 42.3-48.6 (45.5); tip of snout to first dorsal fin origin 28.1-31.1 (29.7); tip of snout to second dorsal fin origin 41.8-46.7 (44.2); tip of snout to pectoral fin insertion 26.0-28.7 (27.1); tip of snout to pelvic fin insertion 21.2-26.5 (24.5); tip of snout to anal fin origin 44.8-48.6 (46.7); length between pelvic fin insertion to anal fin origin 20.5-27.6 (23.3). Snout length in percent of head length 31.0-35.1 (33.0); diameter of eye 15.5-20.7 (17.6); diameter of orbit 16.8-22.5 (19.4); interorital width 24.0-28.2 (26.2); suborbital width 6.0-8.2 (7.3); upper jaw length 47.3-52.2 (49.7); lower jaw length 61.1-65.7 (63.3).

Remarks:

This species has rather shorter head and pectoral fin, medium sized snout, eye and gape, and larger scales. The distal margin of the caudal fin is usually truncate, but that of smaller fish is sometimes convex. The colour of body is silvery white.

This species has been confused with *M. gayi* and *M. bilinearis* by many authors. MARINI (1933) studied the morphological differences of this species and described it as a distinct species, *Merluccius hubbsi*. Following his description, the tip of pectoral fin of this species does not reach the cloaca, whereas that of other species reaches or extends over the cloaca, and he applied this criterion for the separation of this species from the other merlucciids. NORMAN (1937) noted of this character that this species might be readily distinguished from *M. gayi*, which had a longer pectoral fin, extending to or beyond the origin of anal fin. On the other hand, SVETOVIDOV (1948) stated that the pectoral fin of this species extends slightly beyond the origin of anal fin. On the bases of this study the relative length of pectoral fin changes with growth. The tip of the pectoral fin of this species in specimens under 300-400 mm SL. reaches or extends beyond the level of the anal fin origin, whereas fish over 400 mm SL. it does not reach there, although the relative length of the pectoral fin of this species is usually shorter than those of the other merlucciids. ROJO and CAPEZZANI (1971) studied the morphometric and meristic characters of this species and showed no significant differences in them by sex, size and localities. But they did not examine the relative length of the pectoral fin. SVETOVIDOV (1948) noted that the pelvic fin of this species is much longer than the pectoral fin, but as far as the specimens that I examined in this study the length of pectoral fin of this species is always much longer than that of the pelvic fin.

This species differs from *M. merluccius*, *M. paradoxus*, *M. albidus*, *M. productus* and *M. gayi* in the total number of gill-rakers, from *M. bilinearis* and *M. australis* in the number of oblique rows of scales, and from *M. paradoxus* in the total number of vertebrae. The difference in the number of abdominal vertebrae between this species and *M. senegalensis* shows a highly statistical significant difference (Table 3). The interorbital width to head length ratio shows considerable differences between these species (Fig. 24). The differences in the total number of gill-rakers between this species and *M. capensis* and *M. angustimanus* show highly statistical significant differences

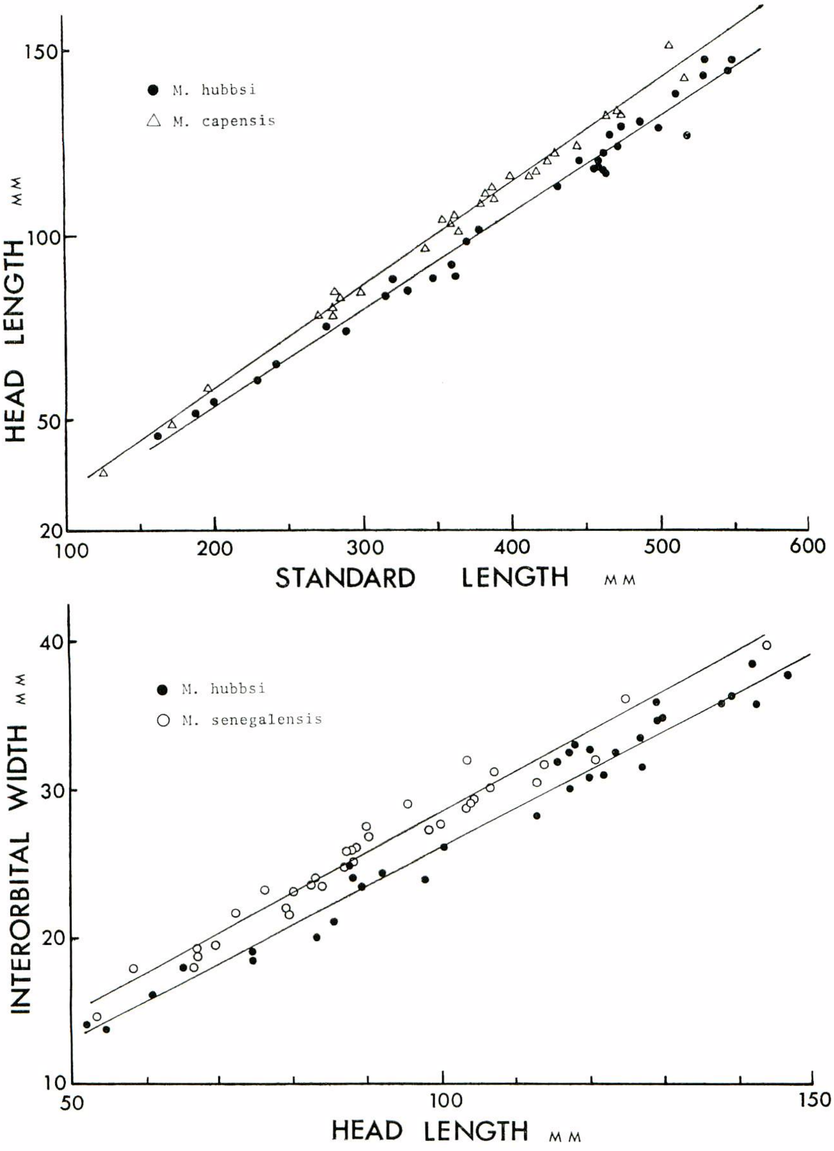

Fig. 24. Comparisons between *M. hubbsi* and *M. capensis* on the relationship of standard length to head length (upper) and between *M. hubbsi* and *M. senegalensis* on the relationship of head length to interorbital width (lower).

(Table 3). The relative length of the head also shows difference between this species and *M. capensis* (Fig. 24). The differences in the total number of vertebrae and the total number of gill-rakers between this species and *M. polli* and *M. bilinearis* show highly statistical significant differences (Table 3).

This species is closely related to the Pacific species, *M. angustimanus* and *M. gayi* on one hand, and to the Atlantic species, *M. senegalensis* and *M. capensis*, but is clearly different from *M. australis*.

12. *Merluccius australis* (HUTTON): New Zealand hake (Fig. 25)

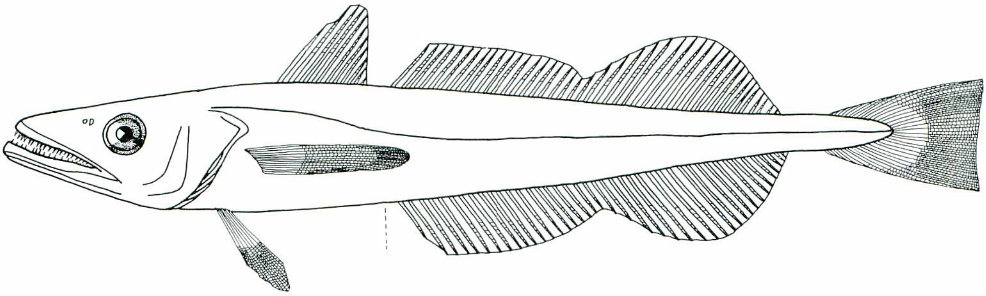

Fig. 25. *Merluccius australis* (HUTTON, 1872), FSFL EI189, SL 452.0 mm

Merluccius australis (HUTTON, 1872)

Gadus australis HUTTON, 1872, Fish. New Zeal.: 45, pl. 7 (Fig. 72) (type locality: Cook Strait, New Zealand).

Merluccius gayi (nec GUICHENOT, 1848): GÜNTHER, 1880, *Rept. Voy. Challenger*, **1** (6): 22 (Gray Harbor, Strait of Magellan).

Merluccius australis : NORMAN, 1937, *Discovery Rept.*, **16** : 48 (bibliography).

Merlangius (Huttonichthys) australis : WHITLEY, 1937, *Mem. Queensland Mus.*, **11** (2) : 122 (bibliography).

Merluccius polylepis GINSBURG, 1954, *Fish. Bull.*, **96** (56) : 195, fig. 2 (Castro, Chile).

Merluccius gayi australis : MANN, 1954, *Inv. Zool. Chil.*, **2** (5): 81 (Subantarctic to Talcahuano).

Merluccius gayi hubbsi: (nec MARINI, 1933) MANN, 1954, *Inv. Zool. Chil.*, **2**(5): 83 (Cape Horn to Puerto Montt).

Merluccius gayi polylepis : ANGELESCU *et al.*, 1958, Sec. Mar., Buenos Aires: 155 (bibliography).

Materials examined: (Table 16)

Description:

First dorsal fin rays I, 9-12 (average I, 10.3); second dorsal fin rays 39-45 (42.3); anal fin rays 40-46 (43.2); pectoral fin rays 13-16 (14.2); pelvic fin rays 7; branchiostegal rays 7; number of oblique rows of scales 144-171 (158.6); number of gill-rakers

Table 16. Data of specimens of *Merluccius australis* used in this study

New Zealand population

Catalogue No. (FSFL)	Date	Sampling position Lat.(S)	Long.(E)	Depth (m)
B1257, B2347	July 2, 1968	43°06.8′	176°00.0′	390-400
B2342, B2346	July 13, 1968	43°05.0′	174°55.5′	380-470
B2343, B2344	July 12, 1968	42°58.0′	178°10.5′	380
B2345	July 11, 1968	43°54.5′	178°09.5′	535
EI373, EI378, EI393, EI398	Oct. 28, 1975	41°04.0′	170°43.0′	534
EI242, EI243, EI245, EI248, EI251, EI381, EI383, EI385, EI388	Nov. 1, 1975	42°05.0′	169°55.0′	956
EI189	Nov. 9, 1975	42°50.5′	177°42.5′	540
EI084	Jan. 2, 1976	51°48.5′	167°16.0′	715
EI143, EI147, EI280, EI287, EI288	Jan. 12, 1976	52°39.5′	172°39.0′	511
L944	Sept. 18, 1974	48°06.5′	168°40.5′	512
L499	Sept. 19, 1974	46°59.0′	169°40.0′	450
ED899	Nov. 8, 1975	43°06.5′	175°54.5′	419

Other specimens examined for counting of meristic characters :

Number of specimens not catalogued	Date	Sampling position Lat.(S)	Long.(E)	Depth (m)
15	Dec. 1, 1975	42°05.0′	169°55.0′	956
7	Jan. 12, 1976	52°39.0′	172°13.5′	509-511
5	Dec. 2, 1975	39°58.5′	169°50.0′	805
4	Dec. 17, 1975	47°32.0′	169°09.0′	490-572
4	Jan. 8, 1976	52°43.0′	172°54.5′	526
3	Jan. 11, 1976	52°37.2′	172°29.0′	490-520
2	Dec. 23, 1975	43°50.0′	174°21.0′	527-536

Chile-Patagonia population

Catalogue No. (FSFL)	Date	Sampling position Lat.(S)	Long.(W)	Depth (m)
EK470, EK473, EK474	May 24, 1979	44°07′	75°15′	570
EK430	May 23, 1979	43°54′	75°13′	370
EK475, EK477, EK479	May 25, 1979	44°03′	75°16′	445
EK461, EK462, EK466, EK467, EK468	May 26, 1979	44°11′	74°53′	210
EK460, EK463, EK464, EK469	May 31, 1979	45°08′	75°30′	340
EK465, EK476	June 1, 1979	45°05′	75°12′	305
EK471, EK478	June 1, 1979	45°08′	75°11′	416
EK458, EK472	June 2, 1979	45°16′	75°24′	380
EK454, EK455, EK456, EK457	June 3, 1979	45°25′	75°30′	425
EK450, EK451, EK452, EK453	June 3, 1979	45°24′	75°29′	370

Other specimens examined for counting of meristic characters :

Number of specimens not catalogued	Date	Sampling position Lat.(S)	Long.(W)	Depth (m)
20	Dec. 10, 1977	56°57′	67°51′	362
14	Dec. 6, 1977	56°19′	69°40′	330
7	June 6, 1979	45°38′	75°29′	215
6	June 5, 1979	45°29′	75°33′	405
5	June 6, 1979	45°35′	75°32′	428
5	June 4, 1979	45°25′	75°02′	117
5	May 31, 1979	45°08′	75°30′	340
2	May 23, 1979	43°54′	75°13′	370

Argentine-Patagonia population

Catalogue No. (FSFL)	Date	Sampling position Lat.(S)	Long.(W)	Depth (m)
B2373, B2374, B2375, B2376, B2377, B2378	Dec. 25, 1969	51°33′	61°52′	180
V877	Dec. 22, 1969	51°59′	57°47′	104
V887	Dec. 24, 1969	51°17′	61°42′	188
V896	Dec. 27, 1969	51°29.0′	63°32.5′	—
EJ215, EJ216, EJ218, EJ219, EJ220	Aug. 1, 1978	50°32′	57°56′	143
EJ217	Aug. 1, 1978	50°29′	56°59′	413
EJ214	July 28, 1978	48°33′	60°32′	286
EJ209-EJ213, EJ225, EJ227-EJ229	May 19, 1978	51°56′	61°55′	220
EJ221	May 3, 1978	51°01′	56°04′	730
EJ222	May 18, 1978	53°00′	60°56′	444
EJ223	May 18, 1978	52°58′	60°00′	301
EJ224	May 15, 1978	54°00′	66°02′	91
EJ226	May 15, 1978	53°55′	64°52′	118

Other specimens examined for counting of meristic characters:

Number of specimens not catalogued	Date	Sampling position Lat.(S)	Long.(W)	Depth (m)
20	May 18, 1978	52°58′	60°00′	301
19	Data from HANAMURA (1971)			
13	Apr. 30, 1978	50°58′	59°54′	133
7	May 1, 1978	48°59′	63°04′	144
7	Apr. 27, 1978	51°00′	65°09′	135
5	May 3, 1978	50°55′	56°51′	230
3	May 3, 1978	51°00′	56°59′	109
2	May 14, 1978	53°56′	63°06′	577
1	May 15, 1978	54°00′	66°02′	91

on first arch 2-4 (3.0)+8-12 (10.0)=11-15 (13.1); number of vertebrae 24-28 (26.7)+27-31 (29.3)=53-58 (55.9); number of ribs 3-4 (3.2).

Body depth in percent of standard length 13.9-20.2 (15.8); head length 24.9-28.3 (26.6); caudal peduncle depth 3.6-5.0 (4.2); length of longest first dorsal fin ray 9.9-14.9 (11.4); length of longest second dorsal fin ray (anterior lobe) 6.0-8.8 (7.2); length of longest second dorsal fin ray (posterior lobe) 9.6-12.7 (10.6); length of pectoral fin 16.7-22.5 (18.7); length of pelvic fin 11.0-15.7 (12.4); length of longest anal fin ray (anterior lobe) 6.9-10.0 (8.2); length of longest anal fin ray (posterior lobe) 8.8-12.0 (9.9); length of first dorsal fin base 8.8-11.6 (10.1); length of second dorsal fin base 43.3-47.5 (45.6); space between first dorsal and second dorsal fins 1.4-4.1 (2.8); length of anal fin base 41.1-47.0 (44.6); tip of snout to first dorsal fin origin 28.4-31.7 (29.8); tip of snout to second dorsal fin origin 40.0-45.4 (42.4); tip of snout to pectoral fin insertion 25.7-29.0 (27.2); tip of snout to pelvic fin insertion 24.4-27.6 (25.7); tip of snout to anal fin origin 42.9-48.9 (45.8); length between pelvic fin insertion to anal fin origin 18.9-25.8 (21.4). Snout length in percent of head length 33.2-39.0 (36.1);

diameter of eye 11.6-19.0 (13.8); diameter of orbit 13.8-21.9 (16.0); interorbital width 24.7-30.4 (27.3); suborbital width 5.4-9.6 (7.1); upper jaw length 48.2-55.9 (51.1); lower jaw length 62.8-68.0 (65.6).

Remarks:

In general appearance this species is more slender than other merlucciids. This species has shorter head, longer snout, smaller eye, wide gape and rather wide interorbital width. The pectoral fin is shorter and its tip reaches or extends beyond the anal fin origin in smaller fish under 500 mm SL., but in larger fish over 500 mm SL., it does not reach there. This species has also smaller scales, numerous vertebrae and fin rays. The distal margin of the caudal fin is usually truncate, but sometimes convex, especially in smaller fish. The colour of body is usually silvery white but fish living in deep waters tend to be a little blackish.

This species has two geographic populations. One is from New Zealand and the other is in southern South America, distributed both off Argentine and Chilean Patagonia through the southern tip of South America. The species was first described by HUTTON (1872) from New Zealand as *Gadus australis*. GÜNTHER (1880) suggested that the New Zealand species was *M. gayi*. Later, WAITE (1911) referred to this species and identified it as *Merluccius gayi* which had been recorded from Chile. PHILLIPPS (1927) used this name in his bibliography of New Zealand fishes. The Patagonian population was first reported by GÜNTHER (1880) from the Strait of Magellan and identified by him as *M. gayi*. NORMAN (1937) recognized that the populations from New Zealand and the Strait of Magellan were the same species, *M. australis*. BUEN (1954) recognized *M. australis* from southern Chile. MANN (1954 a and b) listed two subspecies in southern Chile, *M. gayi australis* and *M. gayi hubbsi*. He supposed that the former distributes from Subantarctic to Talcahuano and the latter is the invader from Argentine Patagonia which is distributed north to Puert Montt. In 1954, GINSBURG named the population from the Chilean Patagonia as a new species, *Merluccius polylepis* on the bases of differences in the number of second dorsal and anal fin rays from those of New Zealand species. This name was accepted by BUEN (1958) and he distinguished *M. polylepis* from *M. gayi gayi* by some meristic characters. ANGELESCU *et al.* (1958) and CABO (1965, 1966) regarded this population as *M. gayi polylepis*. WYSOKINSKI (1974) studied on the taxonomic position of the species from the Falkland Islands and Tierra del Fuego region, and identified it as *M. polylepis*. Recently, INADA (1981) studied populations from New Zealand and southern South America (Chilean and Argentine Patagonia) and concluded that two populations were the same species and the name of *M. polylepis* should be considered a synonym of *M. australis*.

This species differs from *M. paradoxus*, *M. bilinearis*, *M. productus*, *M. angustimanus* and *M. gayi* in the total number of gill-rakers, from *M. polli*, *M. bilinearis*, *M. albidus*, *M. angustimanus*, *M. gayi* and *M. hubbsi* in the number of oblique rows of scales, and from *M. angustimanus* in the total number of vertebrae. The difference in the number of anal fin rays between this species and *M. senegalensis* shows a highly statistical significant difference (Table 3). The relative length of the upper jaw shows the difference between these species (Fig. 26). The differences in the total number of vertebrae and the total number of gill-rakers between this species and *M. capensis* show highly statistical significant differences (Table 3). The relative length of pelvic fin between these species shows considerable differences (Fig. 26). The differences in the total number of vertebrae and the number of anal fin rays between this species and *M. merluccius* show highly statistical significant differences (Table 3).

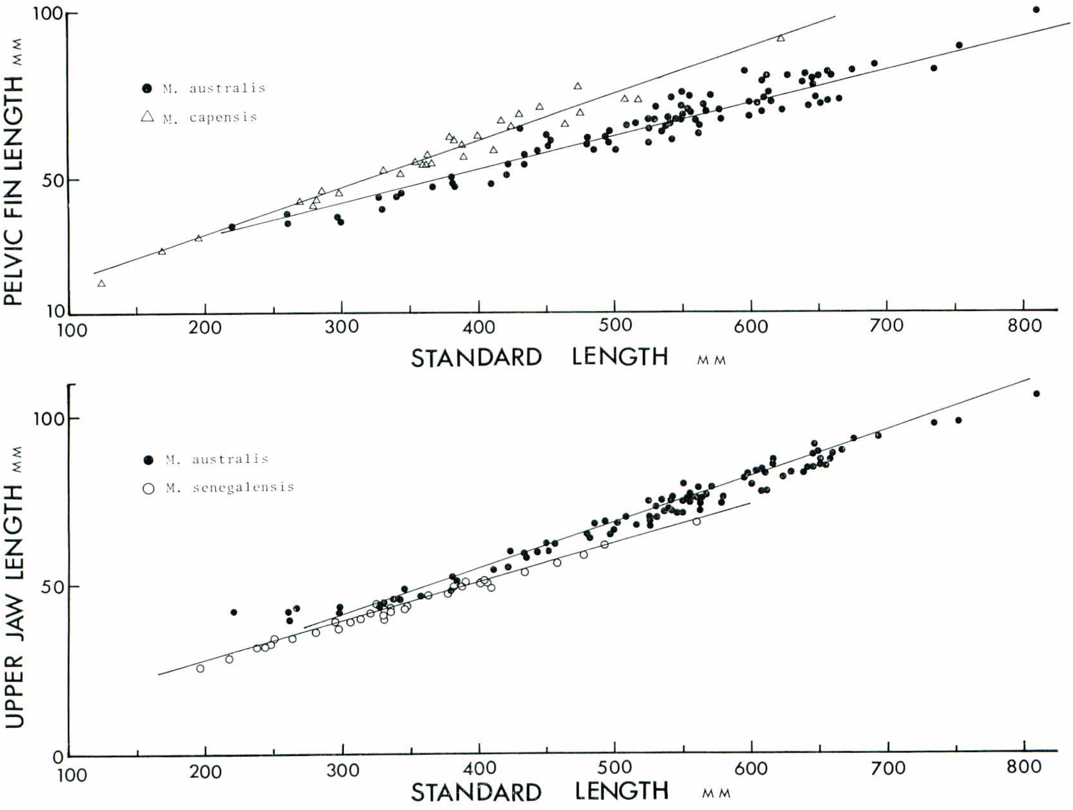

Fig. 26. Comparisons between *M. australis* and *M. capensis* on the relationship of standard length to pelvic fin length (upper) and between *M. australis* and *M. senegalensis* on the relationship of standard length to upper jaw length (lower).

This species is very different from Pacific species and from *M. hubbsi* in many characters, but closely related with eastern Atlantic species, especially with *M. merluccius*, *M. senegalensis* and *M. capensis* in general appearance.

III. Comparative anatomy

A study on the internal morphology of merlucciid fishes was made by Svetovidov (1948) in his revisional work on Gadiformes, in which he examined anatomical features mainly for comparing the genera of Gadidae. Later, Mujib (1967) described the detailed anatomy of the cranial osteology in *M. bilinearis* and compared it with other gadoid fishes (*Gadus*, *Urophysis* and *Lota*), and Soliman (1973) studied the osteology of the five species from the eastern Atlantic and *M. bilinearis*. Recently, Rojo (1976) studied the osteology of *M. hubbsi*. Chang *et al.* (1971), and De la Hoz and Arenas (1976) also studied the osteology of *M. gayi*. But there is no study on the comparative anatomy of all the merlucciid species.

The characteristics of the internal morphology of the genus *Merluccius* are as follows: Frontals paired with a large triangular mucous cavity, broadly opened in front and bordered with crests which diverge from the longitudinal crest of the posterior part of the supraoccipital. Lateral edges of frontal slightly notched or jagged. Pterotics not reaching level of posterior edge of basioccipital. Parasphenoid long and straight, widened in front and forked posteriorly. Head of prevomer protruding in front of mesethmoid. Hyomandibular elongated vertically with long lower process. Opercle wide, triangular and deeply concave at posterior edge. Preopercle significantly elongated along vertical and bent anteriorly at lower ends. All parapophyses expanded laterally, long, wide and downward curved without ribs. Cervical vertebrae possessing ribs and epipleural bones except for the first two vertebrae. The first vertebra and its neural spine firmly fused with the posterior facet of basioccipital and supraoccipital respectively. A foramen for trigemino-facial nerve on sides of skull. Olfactory bulb situated close to olfactory sac, lying in olfactory capsule, and olfactory tract composed of a single tract for its main length. Pyloric caeca absent.

An attempt has been made here to describe the skeleton for all species and to compare bones to study the differences between species and infraspecific variations. The following accounts are based on specimens of the 12 species (including 4 subspecies) of *Merluccius*, which were actually dissected. Several specimens of several species were also examined to study infraspecific variation.

Glossary of osteological terms with their synonyms and the abbreviations

act : actinost (Starks, 1901 ; Matsubara, 1955; Okamura, 1970; Uyeno, 1975 = pectoral radial of Tominaga, 1968; Weitzman, 1974; Rojo, 1976). four small dermal ossicles arranging at the base of the pectoral fin rays.

ang : angular (Harrington, 1955; Norden, 1961; Weitzman, 1974; Uyeno, 1975; Rojo, 1976 = articular of Starks, 1901 ; Gregory, 1933; de Beer, 1937 ; Berg, 1940 ; Matsubara, 1955; Mujib, 1967 ; Tominaga, 1968; Okamura, 1970 = dermarticular of Goodrich, 1930 = angular-articular of De la Hoz and Arenas, 1976). a pair of dermal bones of the lower jaw which fit into the triangular notch of the dentaries anteriorly.

bab : basibranchial (STARKS, 1901; GOODRICH, 1930; GREGORY, 1933; HARRINGTON, 1955; MATSUBARA, 1955 ; NORDEN, 1961 ; TOMINAGA, 1968 ; OKAMURA, 1970 ; WEITZMAN, 1974 ; UYENO, 1975 ; ROJO, 1976=suprabasal of CHAPMAN, 1941 a and b.). a median endochondral ossification at the base of the branchial region, to which the hypobranchials are attached.

bah : basihyal (HARRINGTON, 1955; TOMINAGA, 1968 ; WEITZMAN, 1974 ; UYENO, 1975= glossohyal of STARKS , 1901 ; MATSUBARA, 1955 ; OKAMURA, 1970). a median endochondral bone situated just in front of the first basibranchial, which is embeded in the tongue.

bao : basioccipital (All). a median endochondral bone which forms the posterior floor of the cranium and articulates posteriorly with the first vertebra.

bra : branchiostegal (All). a series of paired, flat, dermal bones which lie below the interopercular and are attached to the ceratohyal and epihyal.

cbr : ceratobranchial (All). a pair of large endochondral bones present in each of the four paired gill-arches ; each articulates with the epibranchial dorsally and hypobranchial ventrally.

ce : centrum (STARKS, 1901; MATSUBARA, 1955; OKAMURA, 1970). a cylindrical bone of each vertebra surrounding the spinal cord.

cer.v: cervical vertebrae (MAURIN, 1954b; DOUTRE, 1960; FRANCA, 1962; CHANG *et al.*, 1971; SOLIMAN, 1973; LEIBLE and MARTINEZ, 1974). the anterior five or six elements of the abdominal vertebrae lacking the parapophyses. This term is not correctly used in fishes, but adopted only for convenience sake in this study.

chy : ceratohyal (All). a pair of long and flat, endochondral bones of the hyoid arch, each of which bears six branchiostegal rays. They articulate with the hypohyals and the epihyals.

cle : cleithrum (TOMINAGA, 1968; OKAMURA, 1970; WEITZMAN, 1974; UYENO, 1975; ROJO, 1976=clavicle of STARKS, 1901; MATSUBARA, 1955). the largest pair of dermal bones of the shoulder girdles, to which the scapulas and coracoids attached.

cra : coracoid (TOMINAGA, 1968; OKAMURA, 1970; WEITZMAN, 1974; UYENO, 1975; ROJO, 1976=hypocoracoid of STARKS, 1901; MATSUBARA, 1955). a pair of thin, Y-shaped dermal bones, ventral to the scapulas of the pectoral girdles.

den : dentary (All). a large anterior toothed dermal bone of the lower jaw. It articulates posteriorly with the angular.

ecp : ectopterygoid (HARRINGTON, 1955; NORDEN, 1961; TOMINAGA, 1968; WEITZMAN, 1974 ; UYENO, 1975 ; ROJO, 1976 ; DE la HOZ and ARENAS, 1976=pterygoid of STARKS, 1901 ; GOODRICH, 1930 ; GREGORY, 1933; CHAPMAN, 1941 a and b; DINEEN and STOKELY, 1954 MATSUBARA, 1955; MUJIB, 1967; OKAMURA, 1970). a pair of flat dermal bones which lie on either side of the palate, between the palatines and the quadrates.

enp : endopterygoid (Harrington, 1955; Tominaga, 1968; Uyeno, 1975; Rojo, 1976= mesopterygoid of Starks, 1901; Goodrich, 1930; Matsubara, 1955; Norden, 1961; Okamura, 1970; Weitzman, 1974 = entopterygoid of Gregory, 1933; de Beer, 1937; Berg, 1940; Mujib, 1967; De la Hoz and Arenas, 1976). a pair of thin, triangular, dermal bones which form part of the palate and floor of the orbits.

epb : epibranchial (All). four pairs of endochondral bones which articulate dorsally with the upper pharyngeal plates and ventrally with the ceratobranchials.

eph : epihyal (Starks, 1901; Goodrich, 1930; Gregory, 1933; Harrington, 1955; Matsubara, 1955; Norden, 1961; Mujib, 1967; Tominaga, 1968; Okamura, 1970; Weitzman, 1974; Uyeno, 1975; Rojo, 1976=posterior ceratohyal of De la Hoz and Arenas, 1976). a pair of triangular endochondral bones of the hyoid arch. They articulate anteriorly with the ceratohyals, and bear the uppermost branchiostegal ray.

epo : epiotic (All). a pair of endochondral bones which form in the posterodorsal surface of the chondrocranium and enclose the posterior semicircular canals.

epp : epipleural (Starks, 1901; Svetovidov, 1948; Matsubara, 1955; Weitzman, 1974; Uyeno, 1975). an intermuscular bone attaching to the rib.

epu : epural (Monodo, 1968; Tominaga, 1968; Okamura 1970; Weitzman, 1974; Uyeno, 1975). two small bones constituting the upper part of the caudal skeleton.

eth lat : lateral ethmoid (Berg, 1940; Svetovidov, 1948; Harrington, 1955; Mujib, 1967; Tominaga, 1968; Weitzman, 1974; Uyeno, 1975; De la Hoz and Arenas, 1976; Rojo, 1976 = prefrontal of Starks, 1901; Goodrich, 1930; Matsubara, 1955; Norden, 1961; Okamura, 1970=prethmoid of Gregory, 1933). a pair of bones in the ethmoid region which are of endochondral origin and separate the olfactory capsule from the orbit.

exo : exoccipital (Starks, 1901; Goodrich, 1930; Gregory, 1933; Harrington, 1955; Matsubara, 1955; Norden, 1961; Mujib, 1967; Tominaga, 1968; Okamura, 1970; Weitzman, 1974; Uyeno, 1975; De la Hoz and Arenas, 1976; Rojo, 1976=lateral occipital of Berg, 1940; Svetovidov, 1948). a pair of endochondral bones which form in the posterior wall of the chondrocranium and lie lateral to the foramen magnum.

fro : frontal (All). a pair of dermal bones which cover most of the dorsal surface of the cranium.

hes : haemal spine (Starks, 1901; Matsubara, 1955; Weitzman, 1974; Uyeno, 1975). a spinous process projecting to the ventral side of the caudal vertebra.

hyo : hyomandibular (All). a pair of complicated-shaped endochondral bones which suspend the jaw from the cranium.

hyph: hypohyal (Goodrich, 1930; Gregory, 1933; Harrington, 1955; Okamura, 1955;

Norden, 1961 ; Mujib, 1967 ; Tominaga, 1968 ; Weitzman, 1974 ; Uyeno, 1975; Rojo, 1976=basihyal of Starks, 1901 ; Matsubara, 1955=anterior ceratohyal for lower hypohyal of De la Hoz and Arenas, 1976). a pair of upper (hyph up) and lower (hyph lo), cone-shaped, endochondral bones of the hyoid-arch that articulate with the ceratohyals and meet in a median symphysis.

hyp : hypobranchial (All). three pairs of endochondral bones in the first three gill-arches, articulating dorsally with the ceratobranchials and ventrally with the basibranchials.

hyu : hypural (Starks, 1901; Matsubara, 1955; Monodo, 1968; Tominaga, 1968 ; Okamura, 1970 ; Weitzman , 1974 ; Uyeno, 1975). a flat fan-shaped bone constituting the end of the caudal skeleton, fused with the second ural vertebra in merlucciids.

ifo : infraorbital (Matsubara, 1955; Tominaga, 1968; Uyeno, 1975=suborbital series of Starks, 1901 ; Harrington, 1955 ; Mujib, 1967 ; Okamura, 1970 ; De la Hoz and Arenas, 1976 ; Rojo, 1976=circumorbital of Goodrich, 1930 ; Gregory, 1933=postorbital of Norden, 1961). These series consist of four pairs of thin, flat dermal bones which form the posteroventral rims of the orbits.

ihs : interhaemal spine (Starks, 1901; Matubara, 1955; Okamura, 1970=proximal radial of Weitzman, 1974). a pterygiophore supporting the anal fin ray.

inca : intercalar (Tominaga, 1968 ; Weitzman, 1974 ; Uyeno, 1975 = opisthotic of Starks, 1901 ; Goodrich, 1930; Gregory, 1933 ; Harrington, 1955 ; Matsubara, 1955 ; Norden, 1961; Mujib, 1967 ; Svetovidov, 1969 ; Okamura, 1970; De la Hoz and Arenas, 1976 ; Rojo, 1976). a pair of large fan-shaped endochondral bones on the ventral side of the cranium, extending over the lateral surface of the sacculith chamber.

inh : interhyal (All). a pair of small, cylindrical endochondral bones which connect the epihyals to preopercles.

ino : interopercle (All). a pair of thin, somewhat triangular, dermal bones which compose the lower part of the opercular apparatus.

ins : interneural spine (Starks, 1901; Matsubara, 1955; Uyeno, 1975=proximal radial of Weitzman, 1974). a pterygiophore supporting the dorsal fin ray.

lac : lachrymal (Harrington, 1955; Uyeno, 1975=lacrimal of Mujib, 1967; De la Hoz and Arenas, 1976 ; Rojo, 1976=lacrymal of Goodrich, 1930 ; Gregory, 1933 ; Norden, 1961=preorbital of Starks, 1901 ; Berg, 1940 ; Okamura, 1970 = first suborbital of Vladykov, 1954). a pair of large triangular dermal bones which form the anteroventral rims of the orbits and contain the termini of the infraorbital sensory canals.

max : maxillary (All). a pair of dermal bones of the upper jaw which articulate with the premaxilaries and palatine on their anterior heads.

men : mentomeckelian (Harrington, 1955; Uyeno, 1975=Meckel's cartilage of Goodrich, 1930; Gregory, 1933; Norden, 1961; Mujib, 1967; Tominaga, 1968; De la Hoz and Arenas, 1976; Rojo, 1976). a pair of slender rods of cartilage which extend along the median surfaces of the endochondral portions of the angulars.

mes : mesethmoid (Goodrich, 1930; de Beer, 1937; Matsubara, 1955; Mujib, *1967;* Tominaga, 1968 ; Okamura, 1970 ; De la Hoz and Arenas, 1976 ; Rojo, 1976=ethmoid of Starks, 1901 ; Harrington, 1955=hypethmoid of Berg, 1940 ; Norden, 1961=dermethmoid of Gregory, 1933=supraethmoid of Uyeno, 1975). a median endochondral ossification which consists of the anterior part of the olfactory capsules.

met : metapterygoid (All). a pair of triangular endochondral bones which fit into a curved area formed by the quadrate, symplectic and hyomandibular bones.

nas : nasal (All). a pair of small spatulate dermal bones which lie on the nasal capsules of the anterior tips of the frontals.

nes : neural spine (Starks, 1901; Matsubara, 1955; Weitzman, 1974; Uyeno, 1975). a spinous process projecting to the dorsal side of the vertebra.

ope : opercle (All). a pair of dermal bones which lie at the posterior part of the skull, situated between the preopercles and subopercles.

p : pelvic bone (Matsubara 1955; Okamura, 1970). a pair of V-shaped dermal bones comprising of the pelvic girdles.

pal : palatine (Starks, 1901; Goodrich, 1930; Matsubara, 1955; Norden, 1961; Mujib, 1967; Tominaga, 1968; Okamura, 1970; Weitzman, 1974; Uyeno, 1975; De la Hoz and Arenas, 1976 ; Rojo, 1976 = autopalatine of Gregory, 1933 ; Harrington, 1955). a pair of splint-shaped, endochondral bones which lie along the margins of the palate, between the pterygoids and the maxillaries.

pap : parapophysis (Starks, 1901; Matsubara, 1955; Weitzman, 1974; Uyeno, 1975). a flattened, curved process projecting laterally from the abdominal vertebra, which are developed well in merlucciids.

para : parasphenoid (All). a long, narrow, median dermal bone which forms the floor of the cranium and extends from the prevomer to the basioccipital.

parh : parhypural (Monodo, 1968; Uyeno, 1975 = parahypural of Weitzman, 1974). a small bone situated at the lower part of the caudal skeleton in front of the first hypural.

pari : parietal (All). a pair of dermal roofing bones which lie at the center of the posterior part of the cranium on each side.

pha : pharyngeal (Starks, 1901 ; Matsubara, 1955; Tominaga, 1968; Okamura, 1970; Uyeno, 1975=pharyngobranchial for upper pharyngial and fifth ceratobranchial for lower pharyngial of Harrington, 1955 ; De la Hoz and Arenas, 1976 ; Rojo, 1976 =infrapharyngobranchial for upper pharyngeal and fifth ceratobranchial for lower pharyngeal of Weitzman, 1974). endochondral bones which consist of suspensory (sp), upper (pha up) and lower (pha lo) parts situated at the entrance of the esophagus. Some of these bear fine teeth.

poc : postcleithrum (Tominaga, 1968; Okamura, 1970; Uyeno, 1975; Rojo, 1976 = postclavicle of Starks, 1901; Matsubara, 1955). a thin, slender bone with a rounded head which is situated at the inner side of the shoulder girdle.

pot : posttemporal (Starks, 1901; Harrington, 1955; Matsubara, 1955; Tominaga, 1968 ; Okamura, 1970 ; Weitzman, 1974 ; Uyeno, 1975 ; Rojo, 1976). a pair of V-shaped dermal bones situated at the upper part of the pectoral girdle. The pectoral girdle is suspended from the cranium by this bone.

prem : premaxillary (All). a pair of curved, tooth-bearing, dermal bones which form the anterior margin of the upper jaw.

preo : preopercle (All). a pair of dermal bones which lie just behind the posterior part of the suspensorium. Posteriorly they overlie the other opercular bones.

prev : prevomer (Harrington, 1955; Tominaga, 1968; Uyeno, 1975; De la Hoz and Arenas, 1976 = vomer of Starks, 1901; Goodrich, 1930; Gregory, 1933; Harrington, 1955; Matsubara, 1955; Norden, 1961; Mujib, 1967; Okamura, 1970; Weitzman, 1974; Rojo, 1976). a median dermal bone that bears teeth and which lies at the anterior extremity of the roof of the mouth.

pro : prootic (All). a pair of large endochondral bones forming the lateral surface of the cranial cavity anterior to the intercalars.

pte : pterosphenoid (Harrington, 1955; Norden, 1961; Tominaga, 1968; Weitzman, 1974 ; Uyeno, 1975 = alisphenoid of Starks, 1901; Goodrich, 1930; Gregory, 1933 ; Chapman, 1941 a and b; Matsubara, 1955; Mujib, 1967; Okamura, 1970; Rojo, 1976 = pleurosphenoid of de Beer, 1937 ; De la Hoz and Arenas, 1976). a pair of endochondral bones which lie anterior to the prootic in the posterior region of the orbit.

pto : pterotic (Starks, 1901; Goodrich, 1930; Gregory, 1933; Matsubara, 1955; Norden, 1961; Mujib, 1967 ; Tominaga, 1968 ; Okamura, 1970 ; Weitzman, 1974; Uyeno,1975; De la Hoz and Arenas, 1976 ; Rojo, 1976 = autopterotic of Harrington, 1955 = pterotic-intertemporal of de Beer, 1937). a pair of endochondral bones which lie on the posterolateral surface of the cranium.

qua : quadrate (All). a pair of triangular endochondral bones which articulate with the angulars of the lower jaw and connect the latter with the cranium.

ret : retroarticular (de Beer, 1937; Harrington, 1955; Norden, 1961; Mujib, 1967 ; Weitzman, 1974 ; Uyeno, 1975 ; De la Hoz and Arenas, 1976 ; Rojo, 1976 = angular of Starks, 1901; Goodrich, 1930; Gregory, 1933; Berg, 1940; Matsubara, 1955; Tominaga, 1968 ; Okamura 1970). a pair of small triangular endochondral bones which are fused to the posterior corners of the angulars.

rib : rib (Starks, 1901; Matsubara, 1955; Uyeno, 1975 = ventral rib of Weitzman, 1974 = sitting rib (attached pleural) of Svetovidov, 1948). a rod-like short bone attached to the centrum of the abdominal vertebra (three or four cervical vertebrae except for the first two vertebrae).

scap : scapula (Tominaga, 1968; Okamura, 1970; Weitzman, 1974; Uyeno, 1975; Rojo, 1976=hypercoracoid of Starks, 1901 ; Matsubara, 1955). a pair of thin, fan-shaped dermal bones articulating with the cleithra of the pectoral girdles.

sph : sphenotic (Starks, 1901; Goodrich, 1930; Gregory, 1933; Matsubara, 1955; Norden, 1961 ; Mujib, 1967 ; Tominaga, 1968 ; Okamura, 1970 ; Weitzman, 1974 ; Uyeno, 1975 ; De la Hoz and Arenas, 1976 ; Rojo, 1976 = autosphenotic of Harrington, 1955). a pair of subconical endochondral bones which project anterodorsally from the otic region of the cranium.

subop : subopercle (All). a pair of thin, flat dermal bones which lie below the opercules and cover the branchiostegal rays.

supc : supracleithrum (Harrington, 1955; Tominaga, 1968; Okamura, 1970; Weitzman, 1974; Uyeno, 1975; Rojo 1976=supraclavicle of Starks, 1901; Matsubara 1955). a pair of small, plate-like short dermal bones situated at the upper part of the cleithrum of the pectoral girdle.

supo : supraoccipital (All). a median endochondral bone which comprises the posterodorsal surface of the cranium. The supraoccipital crest (soc) is of dermal origin.

supt : supratemporal (Starks, 1901; Chapman, 1941a and b ; Harrington, 1955; Matsubara, 1955; Tominaga, 1968; Uyeno, 1975=escalares of Gregory, 1933=tabular of Rojo, 1976). four small dermal ossicles at the uppermost element of each pectoral girdle, which lie on the posterodorsal surface of the skull.

sym : symplectic (All). a pair of small, short endochondral bones which form part of the jaw suspension. They act as braces between the quadrates and the hyomandibulars.

urh : urohyal (Starks, 1901; Goodrich, 1930; Gregory, 1933; Harrington, 1955; Matsubara, 1955 ; Norden, 1961 ; Mujib, 1967 ; Tominaga, 1968 ; Okamura, 1970 ; Weitzman, 1974; Uyeno, 1975; Rojo, 1976=parahyal of De la Hoz and Arenas, 1976). a median dermal bone which lies in the muscles below the ceratohyal.

v : vertebra (Matsubara, 1955; Weitzman, 1974; Uyeno, 1975). elements of the vertebral column which are abdominal (v abd) and caudal (v cau).

zyg : zygapophysis (Starks, 1901; Matsubara, 1955; Uyeno, 1975). short projecting processes upper and lower, at both sides of each centrum.

The author mainly followed Uyeno (1975) for the abbreviations of osteological terminology of skull bones, hyoid arch and branchial arch. (All) denotes that Starks (1901), Goodrich (1930), Gregory (1933), Svetovidov (1948), Harrington (1955), Matsubara (1955), Norden (1961), Mujib (1967), Tominaga (1968), Okamura (1970), Weitzman (1974), Uyeno (1975), De la Hoz and Arenas (1976) and Rojo (1976) all used this term.

1. Cranium

The cranium of merlucciid fishes is rather slender, low and wide, resembling those of gadoid fishes in general appearance (Fig. 27).

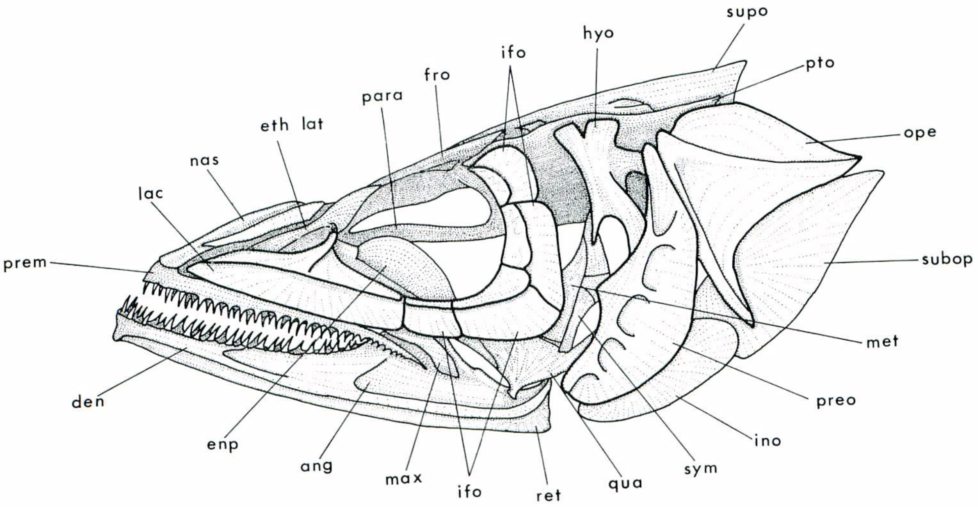

Fig. 27. General aspect of merlucciid skull bones (*Merluccius merluccius*, FSFL D1290).

In dorsal view the cranium is not very broad in the posterior region and not narrowed in the interorbital region. Its greatest width is contained more than almost 2 times in length of cranium. The edges of cranium are lightly wavy with a small projection on each side in the sphenotic part. Lateral ethmoids project to the sides in front of the frontals and form rather deep notches between the lateral ethmoids and frontals. The forward edge of the prevomer projects from beneath the forward edge of the mesethmoid. The supraccipital crest is bifurcate anteriorly and forms diverging crests on the frontals. The mucous cavity is large, deep and broadly opened in front.

In ventral view the prevomer is broad, flat and its edge is drawn out laterally with two rows of teeth into a horse shoe shape along the edge. The parasphenoid is broad and its lower surface is flat. The lateral walls of cranial box are convex.

In lateral view the dorsal contour of the cranium gradually descends forward and is almost straight for its entire length, with a small notch only above lateral ethmoid. The supraoccipital is well developed and the greatest height of cranium is almost 1/4 in the length of cranium. The lower edge of the bones at the base of the cranium presents an almost straight line. The olfactory region and the olfactory capsule are longer and prominent. The rostral end is bluntly rounded and pyramidal. The interorbital foramen (orbital cavity) is very large, elongated and its horizontal diameter is more than 1/4 times in the length of cranium. This orbit is separated by vertical membraneous septa, between the vertical ridges of the lateral ethmoids, frontals and parasphenoid.

These septa enclose the long olfactory tracts, which pass through from the brain cavity to the olfactory capsule. The foramen for the trigemino-facial nerve is not confluent with interorbital foramen.

In posterior view the cranium is almost triangular and the supraoccipital crest projects slightly above cranium. The foramen magnum is rather large, high and rhomboidal in shape. The foramina for the vagus and accessory nerves on the exoccipitals are small (Figs. 28, 29).

The components of the cranium are not heavily ossified. The cranium of merlucciids consists of 16 elements including nasal bones, that is: prevomer, mesethmoid, lateral ethmoids, pterosphenoids, parasphenoid, supraoccipital, exoccipitals, bassioccipital, sphenotics, pterotics, epiotics, intercalars, prootics, frontals and parietals. Orbitosphenoid and basisphenoid are absent. The myodome is also missing. No essential differences can be seen as to arrangement and configuration of cranial bones between species of merlucciids.

The prevomer (prev) lies towards the anteroventral side of the cranium and projects anteriorly well beyond the mesethmoid in a broadly pointed tip. The dorsal side of the prevomer slants anteroventrally and is widely separated from the ventral side of mesethmoid by an intervention of rostral cartilage. The small and short bony process projects posterodorsally on each side, which is in contact with the anterior process of the lateral ethmoid. The long and slender projection tapers to the pointed posterior end which overlies the ventral side of the parasphenoid for almost one-third the length of the parasphenoid. The lateral wings of the prevomer narrow posteriorly to a point and do not reach the level of the lateral wing of the lateral ethmoid. Ventrally the margin of the head of the prevomer bears sharp, recurved conical teeth, which lie in two rows. The inner teeth are larger and depressible to the inner side. The number of vomerine teeth are about 12 to 16 on each side. The degree of development of vomerine teeth differs by species. The species *M. merluccius*, *M. capensis*, *M. paradoxus*, *M. bilinearis*, *M. hubbsi* and *M. australis* have rather long teeth and the other species have rather short ones.

The mesethmoid (mes) is unpaired and pyramidal in shape, anterolaterally a little concaving, narrowing dorsal behind the expanded portion of the anterodorsal part of the mesethmoid. A thin bony projection protrudes posterodorsally and articulates with the frontals at the bifurcated end. Ventrally, the mesethmoid broadens into a posteriorly directed process which articulates with the anterior process of the lateral ethmoid and thus forms the anterventral margin of the olfactory capsule. A small notch anterodorsally on the mesethmoid is for the attachment of the mesethmoid-maxillary ligament.

The lateral ethmoids (eth lat) are paired and in contact with the prevomer, mesethmoid, parasphenoid and frontals. It is separated from its counterpart of the opposite side by the cartilage. It has an anterior process and lateral wing. The anterior process of the lateral ethmoid lies dorsal to the prevomer and articulates with the

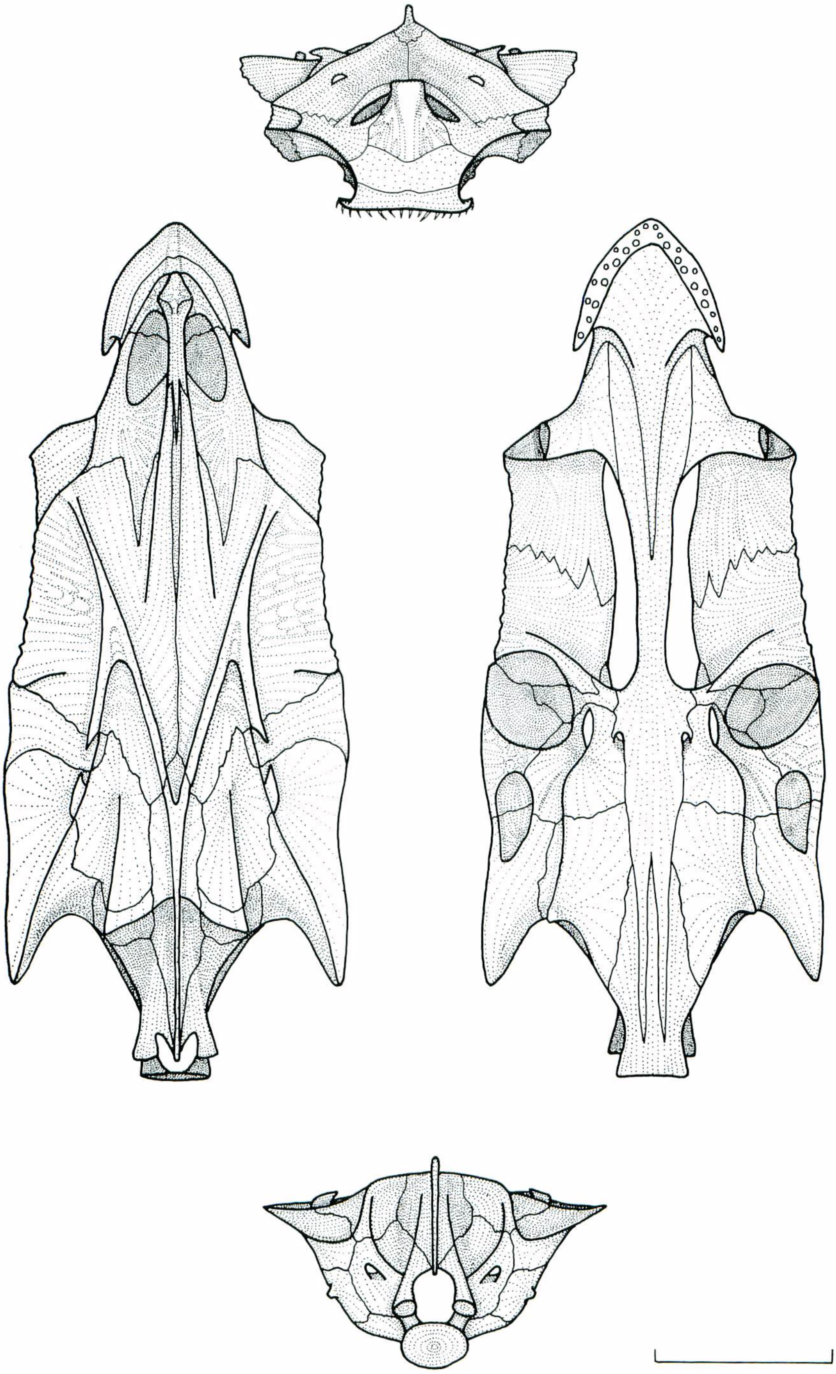

Fig. 28. General aspects of the merlucciid cranium (nasal bone excluded from this figure) (*Merluccius merluccius*, FSFL D1290). Top, anterior view ; Left, dorsal view ; Right, ventral view ; Bottom, posterior view. Scale bar indicates 20 mm.

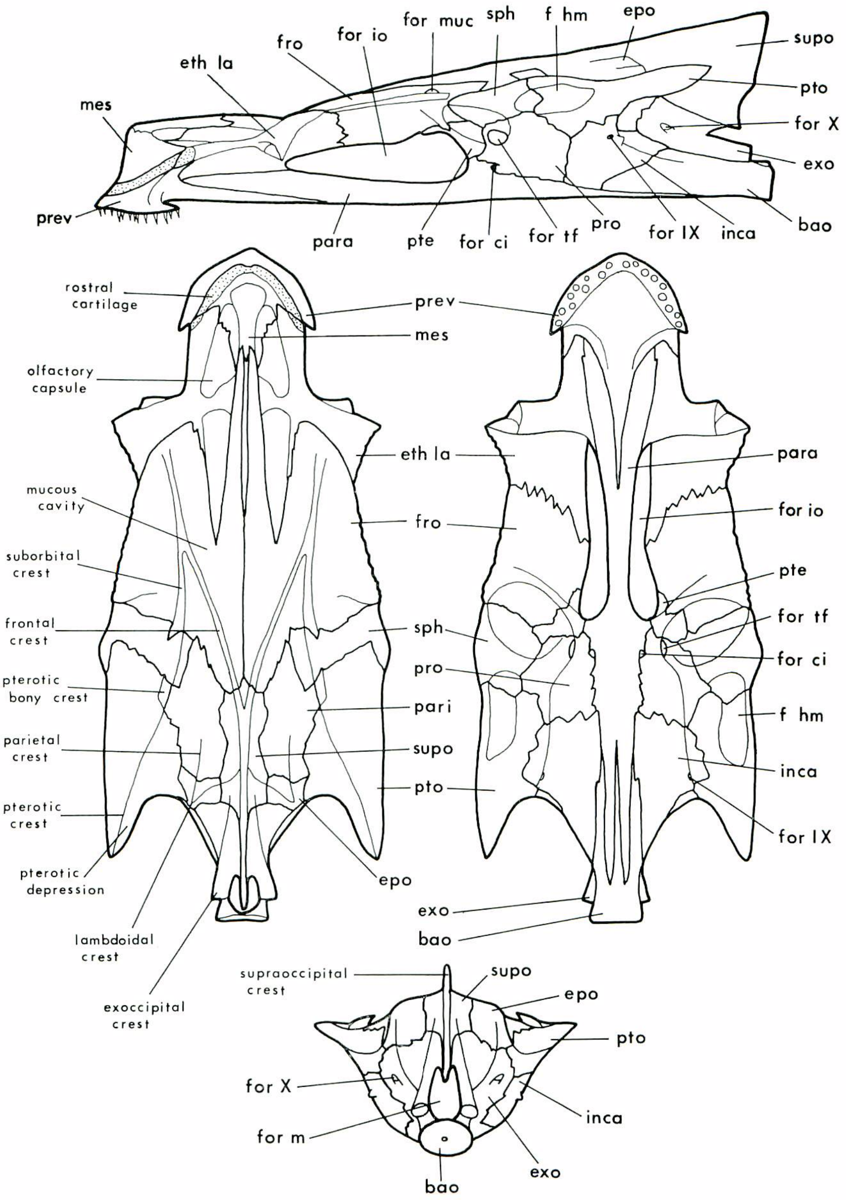

Fig. 29. Key figure of the merlucciid cranium (nasal bone is illustrated in Fig. 33). Top, lateral view ; Left, dorsal view ; Right, ventral view ; Bottom, posterior view. f hm, hyomandibular fossa ; forci, foramen for the supraorbital branch of the orbital artery ; for io, interorbital foramen ; for m, foramen magnum ; for muc, foramen of mucous ; for tf, foramen trigemino-facial nerve ; for IX, foramen for the glosso-pharyngeal nerve ; for X, foramen for the vagus and accessory nerves.

posteriorly directed process of the mesethmoid, which forms the posteroventral boundaries of the olfactory capsule. The lateral wing is prominent and extends laterally almost beyond the lateral margin of the frontal which lines less than one-third of the anterior region of the frontal. Medially, it extends up to the interorbital foramen and forms almost half the margin of this foramen. The anterior margin of the lateral wing is convex and is concave at its posterior margin, and terminates in a blunt tip, which articulates with the anterodorsal process of lachrymal. The lateral ethmoid articulates with the parasphenoid ventrally and the olfactory tract passes through the space of these bones and continues to the olfactory bulb in the capsule.

The nasals (nas) are paired, well developed thin bones on the side of mesethmoid and are a little narrowed anteriorly and broad posteriorly. Each nasal is loosely bound to the cranium by connective tissue and roofs the olfactory capsule. The lateral flange curls dorsally forming a shallow trough for the passage of the supraorbital sensory canal through the mucous cavity to the tip of snout and then jointed with the infraorbital canal through the lachrymal. The posterior end of the nasal lies anterior to the mucous cavity of the frontal.

The pterosphenoids (pte) are flat, roughly triangular bones, concave anteriorly, running dorsoventrally between the frontal and parasphenoid and form the posterior margin of interorbital foramen and the anterolateral wall of the brain case. The pterosphenoid forms a suture with frontal anterodorsally, sphenotic dorsally, prootic posteriorly and parasphenoid ventrally, but in some cases it does not form the anterior boundary of the foramen trigemino-facial nerve. The pterosphenoid is fan-shaped and is separated from its counterpart of the opposite side by the cartilage.

The parasphenoid (para), the longest bone in the skull, extends in the midline along the greater part of the ventral length of the cranium, running from prevomer to basioccipital. Its bluntly rounded anterior end is covered by the posterior projection of prevomer. It forms the ventral margin of the interorbital foramen. The posterior bifurcated end of the parasphenoid covers the ventral surface of the basioccipital for more than three-fourths the length of the latter. Between the prootic and parasphenoid it is notched for the foramen of the supraorbital branch of the orbital artery. Just behind the level of the foramina, the first upper pharyngial are attached loosely to its ventral surface. It also articulats with the pterosphenoid at the posterior boundary of interorbital foramen and with the intercalar between the prootic and basioccpital. The interorbital foramen is very large, and its length is 27.0-31.8% of the length of cranium. In the twelve merlucciids, *M. capensis* is largest, and *M. polli* and *M. hubbsi* are more than 30 % of the length of cranium, but *M. gayi* is smallest and *M. australis* is less than 28 %. The width of the anterior part of the interorbital foramen differs a littly by species as is shown in Fig. 30. As a trend, the species of *M. merluccius*, *M. senegalensis* and *M. polli* have rather narrow cranium but those of *M. bilinearis*, *M. albidus*, *M. productus*, *M. angustimauns* and *M. gayi* are wide. But this character is also variable by individuals within a species.

The supraoccipital (supo) is single and covers the posterodorsal surface of the cranium. The anteromedial surface is overlapped by the posterior pointed struts of the frontals. The supraoccipital articulates with the parietals at its anterolateral margin and with the epiotic by a posteriorly pointed process in the region of the lambdoidal

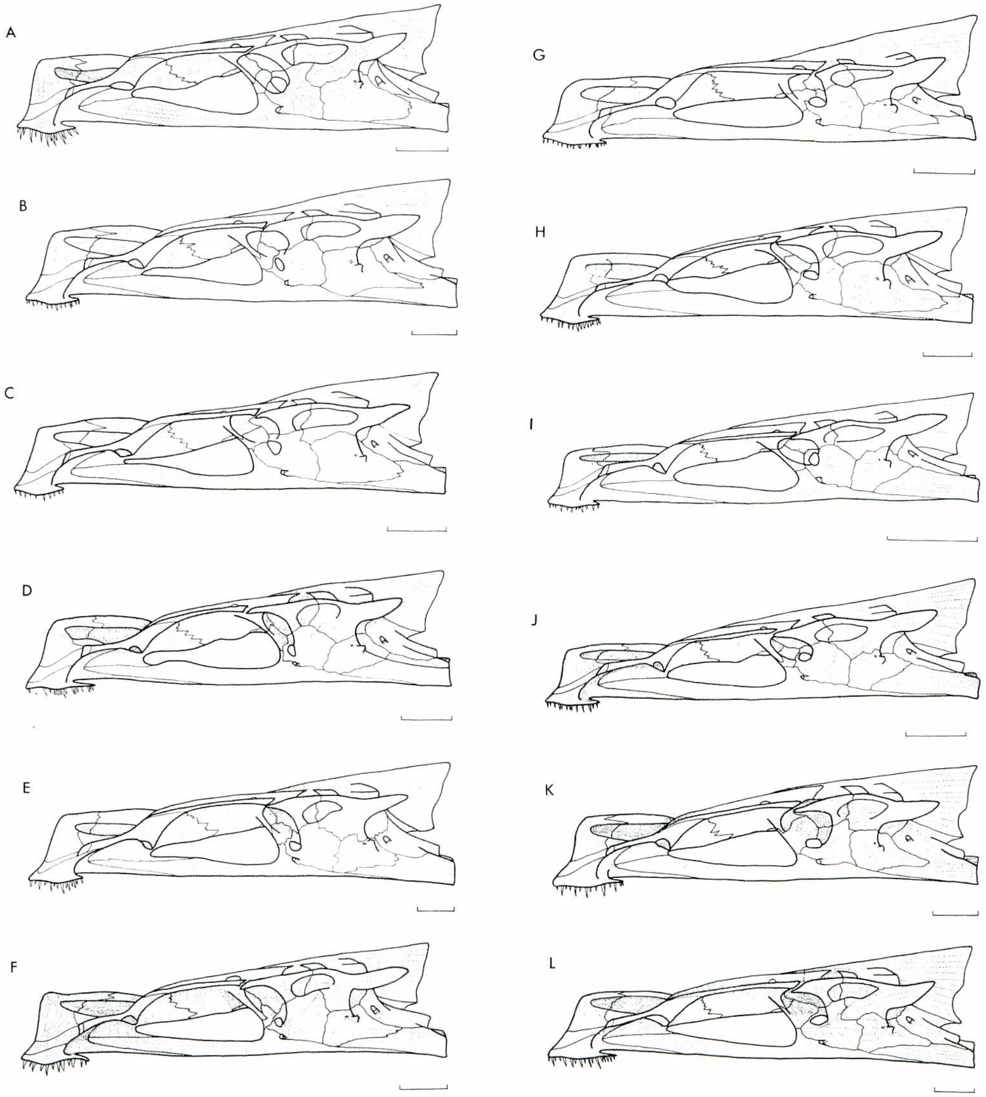

Fig. 30. Lateral aspects of merlucciid's crania. A, *Merluccius merluccius*, FSFL D1290 ; B, *M. senegalensis*, FSFL EI021 ; C, *M. polli*, FSFL EI030 ; D, *M. capensis*, FSFL S0638 ; E, *M. paradoxus*, FSFL S0354 ; F, *M. bilinearis*, FSFL D0859 ; G, *M. albidus*, FSFL EG977 ; H, *M. productus*, FSFL U0604 ; I, *M. angustimanus*, FSFL EI047 ; J, *M. gayi*, FSFL S0085 ; K, *M. hubbsi* , FSFL V0860 ; L, *M. australis*, FSFL B2375. Scale bars indicate 10 mm.

crest, which forms about one-thirds of it. The supraoccipital crest descends gradually to the anterior end of supraoccipital and runs the length of it medially, anterior to it the two branches become confluent with the paired frontal crests. Posteroventrally, the supraoccipital overlies above the exoccipitals and takes no part in the formation of the margin of the foramen magnum. The posterior end of the supraoccipital terminates at almost the same level above the posterior end of the basioccipital. The hind margin of the supraoccipital crest is slightly oblique and wavy, and is firmly connected to the neural arch of the first vertebra. The crest is higher in *M. merluccius*, *M. senegalensis* and *M. australis*, and lower in *M. angustimanus* and *M. gayi*, but this character is not so prominent as to separate species groups.

The exoccipitals (exo) form the rear wall of the brain case. Anteriorly, each exoccipital articulates medially with the supraoccipital. The anterolateral border of the exoccipital articulates with the epiotic ventral to the lambdoidal crest. Laterally, the exoccipital articulates with the pterotic and intercalar. It also articulates with the basioccipital ventrolaterally. Dorsomedially, the right and left exoccipitals meet ventral to the supraoccipital and form the dorsal margin of the foramen magnum. Within the cranial cavity, the anteroventral process of each exoccipital meets in the midline and forms the anterior floor of the foramen magnum. The large oval foramen for the vagus and accessory nerve on each side is situated just posterior to the intercalar. The exoccipital crest (condyle) is expanded posterolaterally on each side and its posterior termination forms the articulation for the haemal prezygapophysis of the first vertebra. In lateral view, its posterodorsal margin is deeply notched above the crest and the long well-developed neural prezygapophysis of the first vertebra firmly articulated with this notch.

The basioccipital (bao) is a median bone, forming the posteroventral corner of the cranium. Anteroventrally, it bears a sharp process directed forward, which inserts into the bifurcated end of the parasphenoid. It also articulats with the intercalar anterolaterally and with the exoccipital dorsally to form the ventral half of the wall of the large chamber for the sacculith. Posteriorly, it bears the projection for the articulation with the first vertebra. The dorsal surface of bassioccipital forms the posterior floor of the foramen magnum.

The sphenotics (sph) lie anterolaterally in the otic region and constitute the anterolateral corner of the brain case. It is overlapped by the pterotic posteriorly and forms nearly one quarter of the hyomandibular fossa. It articulates with the prootic posteroventrally, the pterosphenoid anteroventrally and with the frontal anteriorly. Its lateral margin is not finely serrate. The lateral margin of the sphenotic extends over the level of the margin of the frontal, but does not extend beyond the margin of the pterotic. The lateral margin articulates with the fourth infraorbital of the circumorbital series. It forms none of the boundary of the trigemino-facial foramen. The description by MUJIB (1967) that the sphenotic in *Merluccius* does not articulate with the pterosphenoid seems to be an error.

The pterotics (pto) are compressed dorsoventrally, forming the dorsolateral corner of the brain case, and fan out posteriorly to form the pterotic processes. This process is entirely formed by the pterotic and does not extend posteriorly beyond the level of the supraoccipital crest. The pterotic articulates with the intercalar and prootic ventromedially, with the sphenotic anteriorly, and forms nearly three quarters of the hyomandibular fossa. The pterotic articulates with the parietal dorsomedially and with the epiotic and exoccipital posteriorly. A low bony crest runs anteriorly from the posterior tip of the pterotic for three quarters of its length. Two supratemporals are present on this crest and form the canal for the cephalic portion of the lateral line with the pterotic process (see part of supratemporals). The statement by Mujib (1967) that the pterotic makes no contact with the prootic in *Merluccius* is an error.

The epiotics (epo) are pyramidal in shape, lying at the lateral end of the lambdoidal crest and form the posterodorsal corner of the cranium. The epiotic articulates with the lateral extension of the supraoccipital and with the parietal anteriorly. Ventral to the lambdoidal crest a process of the epiotic extends ventrally to articulate with the exoccipital and laterally with the pterotic. The process of the lambdoidal crest is the articulating surface for the upper limb of the posttemporal. One supratemporal attaches to this part and forms the supratemporal part of lateral line with the other supratemporals on the upper limb of the posttemporal.

The intercalars (inca) are thin and triangular bones, extending widely over the lateral surface of the sacculith chambers. Most of its median suface articulates with the parasphenoid. It also articulates with the basioccipital posteromedially and with the exoccipital posteriorly. Anteriorly it articulates with the prootic but not with the sphenotic. This enlarged intercalar is correlated with the size of the saccular otolith and separates the prootic and exoccipital completely. It takes no part in the formation of the hyomandibular fossa and articulates dorsolaterally with the pterotic. The small bony protuberance (intercalar process) for the articulation of the lower limb of the posttemporal is located on the ventral side of the cranium just above the sacculus chamber of this bone. The foramen for the glossopharyngeal nerve is small and situated just anterior to the intercalar process.

The prootics (pro) are rather large bones inflated outwardly, occupying a lateral surface of the brain case. It is a fan-shaped bone fitting between the sphenotic and the parasphenoid, situating anterior to the intercalar, posterior to the pterosphenoid. It also articulates with the pterotic posterolaterally. It takes no part in the formation of the hyomandibular fossa and it does not border the interorbital foramen. It meets with the counterpart of the opposite side along the ventral median line of the cranium, though its suture is concealed by the parasphenoid which is overlapped by its lateral expansion. In general, the prootic forms the posterior margin of the foramen for trigemino-facial nerve and the pterosphenoid forms the anterior one of this foramen. But in some cases, this foramen is surrorunded entirely by the prootic, and the pterosphenoid does not share the formation of this foramen. This varies by individual rather than species (Fig. 31). The size and shape of the foramen trigemino-facial nerve differs by species and is roughly divided into three groups. The first group is composed of *M. merluccius*, *M. polli*, *M. albidus*, *M. hubbsi* and *M. australis*, which have a rather large foramen. The second one has a rather small foramen which is composed of *M. bilinearis*, *M. angustimanus* and *M. gayi*. The other species have intermediate one. As far as checking infraspecific variations, the size of this foramen is a rather stable character.

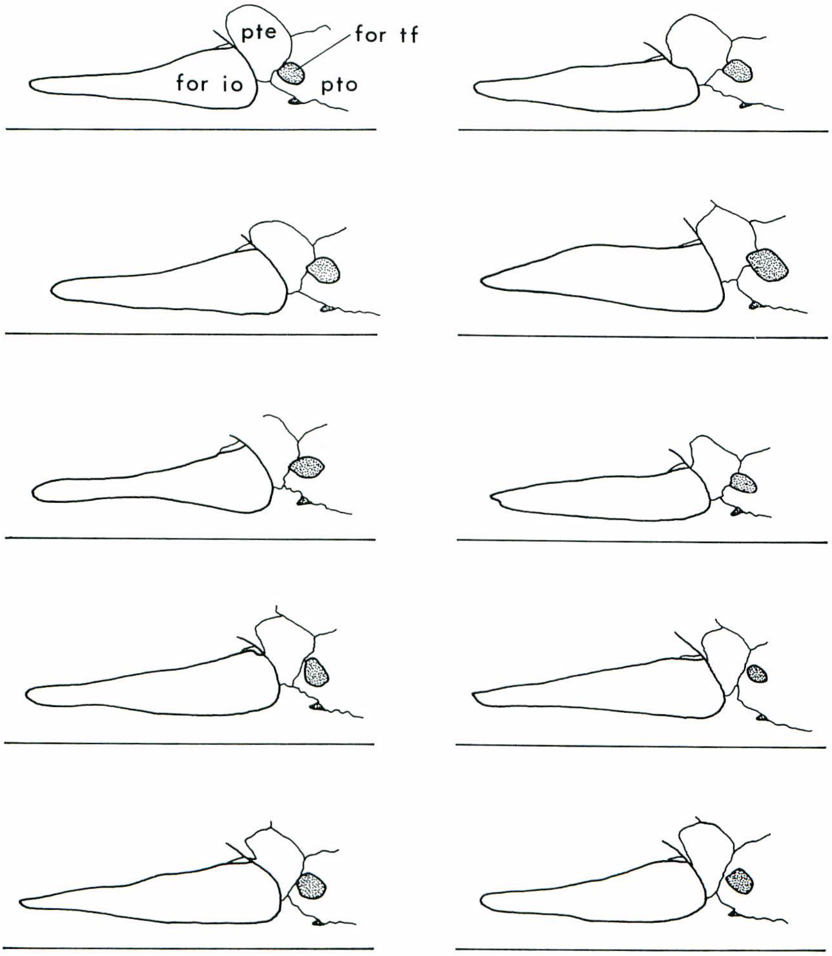

Fig. 31. Variations of size and shape of interorbital foramen (for io) and foramen trigemino-facial nerve (for tf), and connection of trigemion-facial foramen with suture between pterotic (pte) and prootic (pro) in *Merluccius australis* (Patagonian population).

The frontals (fro) are large, paired and subrectangular bones flattened horizontally. These bones form more than half of the skull roof and are connected with each other throughout their posterior half along a median suture. The serrated anteromedial margin of the frontal articulates with, and is overlapped by, the posterior end of the lateral ethmoid. The anterior long process of the frontal articulates with the bifurcated posterior process of the mesethmoid at the narrow ridge between the olfactory capsules and is covered by the nasal laterally. The weakly serrated lateral margin of the frontal forms the dorsal margin of the orbit. The lateral margin almost extends laterally as far as the level of sphenotic with which it articulates at the rear of the orbit. Posteromedially, it is pointed and articulates with the anterior end of the supraoccipital. The posterior margin of the frontal articulates with the parietal. Anteroventrally, it is lined by the lateral process of the lateral ethmoid, but ventromedially it is slightly raised into a bony ridge which protects the olfactory tract at its inside. Posteroventrally, the frontal articulates with the small anterior projecting portion of pterosphenoid which forms the posterior end of the roof for the interorbital foramen. The prominent suborbital crest (supraorbital crest) is confluent with the pterotic bony crest posteriorly after a small discontinuous interval by the sphenotic. A frontal crest is also present on each frontal. It joins posteriorly with the bifurcated end of the supraoccipital crest of each side. A prominent foramen of mucous lies below the suborbital crest where it meets the frontal crest. The mucous cavity (sometimes called as the epiphysial sinus) is very large, deep and broadly opened anteriorly.

The parietals (pari) are paired, thin, irregularly shaped bones and form a part of the roof of cranium. The parietal is separated from its counterpart of the opposite side by the intervention of the supraoccipital. Each parietal articulates with the frontal and sphenotic anteriorly, the supraoccipital and pterotic laterally, and the epiotic posteriorly. This bone forms the part of pterotic depression but does not take part in the formation of the lambdoidal crest. The parietal has well developed parietal crest and lacks a foramen for the facial nerve.

2. Upper and lower jaws

The upper jaw is long and slender, and composed of the premaxillary and maxillary. The supramaxillary (supplemental maxillary) is absent. The lower jaw is long and triangular in shape, and composed of the dentary, angular and retroarticular. The premaxillary and dentary bear long fine teeth.

The premaxillary (prem) is long, slender and a little curved; it articulates with that of the opposite side in a loose median symphysis (Figs. 32A, 33A). The anterior ascending process (asp) is large and blunt, and is separated from the articular process (arp) by a notch. The ascending process bears a strong parato-premaxillary ligament (Fig. 32D). The premaxillary becomes acutely pointed posteroventrally, where it overlies the angular to which it is connected by skin and ligaments. The posterior end of the premaxillary is slightly anterior to that of the maxillary. On the dorsal surface at about two-thirds distance from the tip a thin, high and posteriorly directed postmaxillary process (pmp) arises and is overlied by the maxillary. The shape of this process

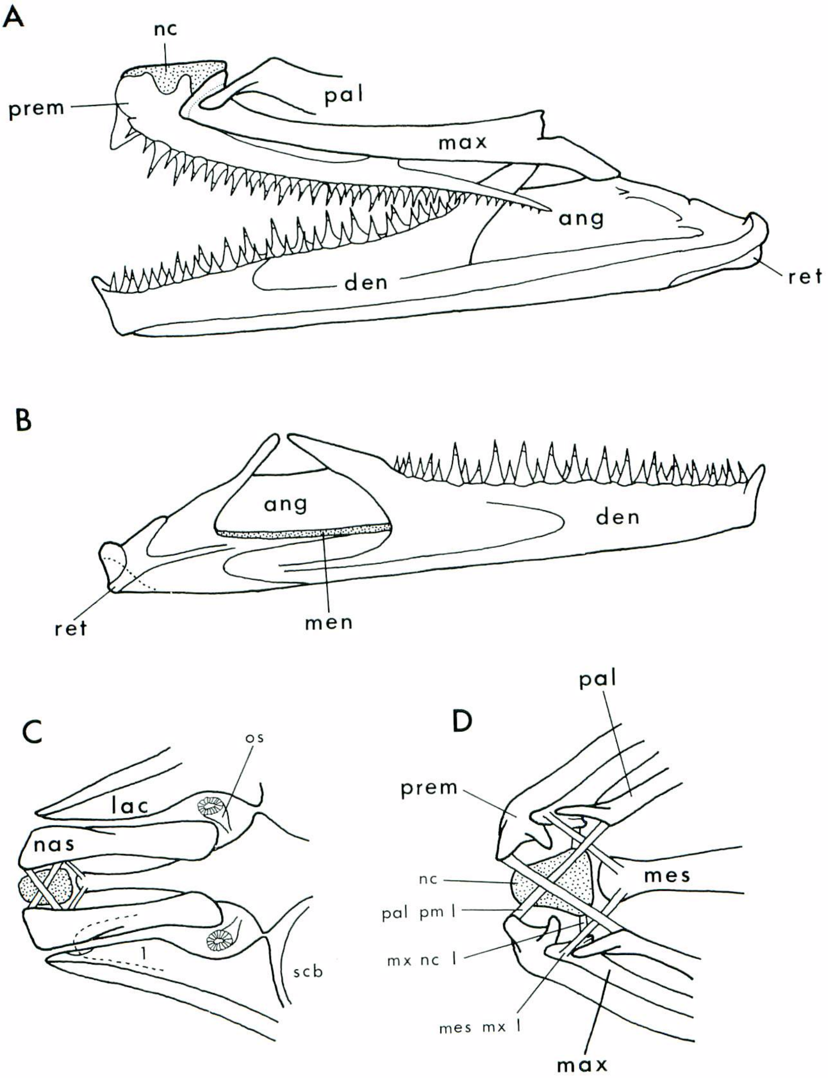

Fig. 32. Upper and lower jaws, and rostral portion of snout. A, upper and lower jaws connecting with nasal cartilage and head of palatine ; B, inner side of lower jaw of left side showing Mentomeckelian ; C, D, rostral portion of snout showing connection of ligaments (D shows after removal of nasal and lachrymal). mes mx l, mesethmoid-maxillary ligament ; mx nc l, maxilla-nasal cartilage ligament ; nc, nasal cartilage ; os, olfactory sac ; pal pm l, palato-premaxillary ligament ; scb, screrotic bone. 1, pass way of supraorbital and preorbital canals.

differs a little by species, and also varies by individuals. Along its oral border the premaxillary bears double rows of sharp and strong conical teeth which gradually decrease in length posterierly. Those of the inner row are larger and more recurved, and depressible to the inner side. The number of teeth is about 40 to 50 on each side. The size of the teeth on upper and lower jaws differs markedly by species, which are divisible into two groups. The first group is composed of *M. merluccius*, *M. capensis*, *M. paradoxus*, *M. bilinearis*, *M. hubbsi* and *M. australis* which have very long teeth on both jaws. The second group has rather short teeth and is comprised of *M. senegalensis*, *M. polli*, *M. albidus*, *M. productus*, *M. angustimanus* and *M. gayi*. There is no marked infraspecific difference by the relative size of teeth.

The maxillary (max) is rounded anteriorly and is flattened posteriorly. The maxillary has a facet on the anterior thickened head, on which the articular process of the premaxillary fits (Figs. 32A, 33A). The mesethmoid-maxillary ligament and maxilla-nasal cartilage ligament originate from this anterior head of the maxillary (Fig. 32D). Just behind the area where the ligaments attach, the anterior part of the lachrymal and the maxillary process of the palatine are attached to the maxillary (Figs. 32C, D). The maxillary increases in width posteriorly and has angle at the upper surface of the posterior end, but its lower surface bends down posterioly to form a projecting part to which the ligaments and skin connecting with the dentary are attached. Excluding the posterior projecting part the maxillary is almost entirely covered by the lachrymal.

The dentary (den) is a V-shaped bone, curved anteriorly to join with the counterpart of the opposite side in a loose symphysis. Posteriorly it is forked to receive the anterior process of the angular. The dorsal limb is raised, forming a sharp ridge and pointed posteriorly. The large ventral limb is broad and grooved for the passage of the mandibular sensory canal. The upper surface of the dentary bears double rows of long conical teeth, numbering about 30 to 40, the inner teeth are longer, pointed, recurved and depressible to the inner side (Figs. 32B, 33A).

The angular (ang) sends a long, triangular process forward into the hollow space in the dentary. The dorsal limb of the angular is short and raised. It reaches the same level as the dorsal limb of the dentary and forms a small triangular space with it. The ventral limb of the angular is short and pointed anteriorly, and overlies the ventral limb of the dentary. The posterior part of the angular is raised and receives a strong ligament from the head of the quardrate. A large hollow is present inside of the angular, where the mentomeckelian (men) runs (Figs. 32B, 33A).

The retroarticular (ret) is a small triangular bone, located at the posteroventral corner of the madible. It is firmly attached to the inside of the angular, and consequently most of it is not recognizable in lateral view. It is attached posteriorly to the anteroventral surface of the interopercle by the interopercle-retroarticular ligament (Figs. 32B, 33A).

3. Suborbital series

The suborbitals are five in number, surrounding the lower and posterior margin of the orbit. The anteroventral suborbital is called the lachrymal (lac) or preorbital and the remaining four are called infraorbitals (ifo) or suborbitals. There is no supraorbital. The infraorbital sensory canal is in an open groove and each of the suborbital series bear a flange overhanging the groove. The lachrymal is the longest in the suborbital series but not wider than the third and fourth. It extends forwards to the tip of the snout and has a small hole at the anterior end of the flange. Through this hole the infraorbital sensory canal is connected with the supraorbital canal on the nasal (Fig. 32 C). From the middle of the dorsal margin a long bony process projects, which articulates with the lateral process of the lateral ethmoid. Posteriorly, the lachrymal articulates with the first infraorbital. The first infraorbital (ifo 1) is smaller than the others. Its anterior margin is almost vertical and articulates with the lachrymal. Its posterior

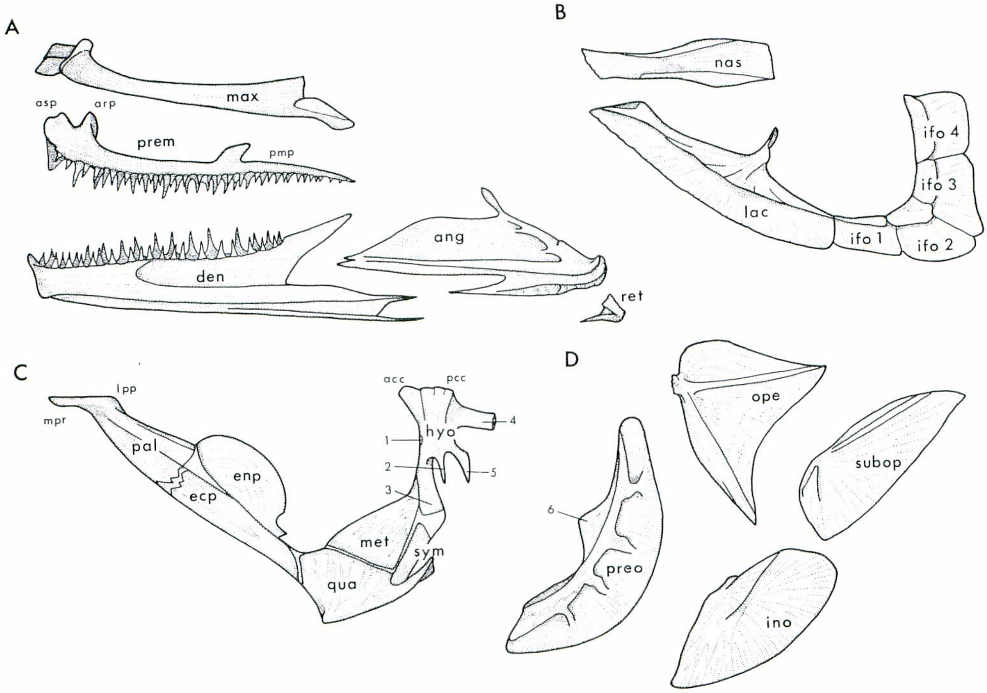

Fig. 33. Visceral skeletons of *Merluccius australis*, FSFL EI248. A, upper and lower jaws ; B, suborbital series and nasal bone ; C, suspensorium ; D, opercular bones. acc, anterior condyle ; arp, articular process ; asp, ascending process ; lpp, crooked process ; mpr, maxillary process ; pcc, posterior condyle ; pmp, postmaxillary process. 1, foramen for the hyomandibular ramus of the facial nerve ; 2, intermuscular process ; 3, lower process ; 4, opercular process ; 5, preopercular process ; 6, central protuberance of preopercle.

margin is oblique and articulates with the second infraorbital. The flange of this ossicle is very narrow. The second infraorbital (ifo 2) is situating at the posteroventral corner of the suborbital series. It is higher than long and the flange of this ossicle is well developed at the corner and somewhat overlaps the third. The third infraorbital (ifo 3) is higher than long and lies almost vertically at the rear of the orbit. Its dorsal margin articulates with the fourth. The fourth infraorbital (ifo 4) is almost square and is loosely articulated with the lateral margin of the sphenotic. It transmits the infraorbital sensory canal to the postorbital opening of the supraorbital canal (Fig. 33B).

4. Suspensorium

The suspensorium is composed of seven elements. The anterior three bones (palatine, ectopterygoid and endopterygoid) form the roof of the oral cavity and the posterior four bones (quadrate, metapterygoid, symplectic and hyomandibular) support the upper and lower jaws, and the opercular bones (Fig. 33C).

The palatine (pal) is a splint-shaped bone and bears no teeth along its oral border, located at the anteriormost part of suspensorium. The maxillary process (mpr) of the palatine is crooked and overlies the maxillary just behind its articular process (Fig. 32A). From the dorsalmost surface of the crooked process (lpp), the palato-premaxillary ligament originates (Fig. 32D). The posterodorsal portion of the palatine is thickened and rounded to a bony shaft, and articulates with the endopterygoid at its posterior surface. The posteroventral portion of it is thin and flange-like, and articulates with the ectopterygoid through the cartilage.

The ectopterygoid (ecp) is thin and slender, and meets the palatine through a cartilage anteriorly. It bends down a little at its posterior portion, where the quardrate articulates to its posterodorsal surface. It also articulates with the endopterygoid along its dorsal border.

The endopterygoid (enp) is fan-shaped and very thin bone situating the dorsal of ectopterygoid. Anteriorly it is attached to the palatine. Its dorsal edge is directed medially and lines the anterior inner part of the eyeball. It is not in contact with the metapterygoid and quardrate.

The metapterygoid (met) is a triangular, flat bone and its dorsal process articulates with the anteroventral surface of hyomandibular in a suture. The posteroventral surface of the metapterygoid articulates with the symplectic and the ventral surface is separated from the quadrate by a line of cartilage.

The quadrate (qua) is a roughly triangular or fan-shaped bone, constituting the posteroventral corner of the suspensorium. The quadrate is connected with the palatine through the ectopterygoid, with the lower jaw through a ligament, with the hyomandibular through the metapterygoid and with the opercle through the preopercle. It also articulates with the symplectic at its posterodorsal concave portion. It has a posterior directed process which overlaps the preopercle in the region of the preopercular-symplectic foramen. Through these connections, the quadrate has a roll of axis of the suspensorium.

The symplectic (sym) is a short bone, situated at posterior margin of metapterygoid. It consists of the anterior margin of preopercular-symplectic foramen. Its dorsal end is attached to the central protuberance of the preopercle and separated from the hyomandibular by cartilage. Its ventral end fits into the concave portion of the quadrate.

The hyomandibular (hyo) is a large, roughly rectangular bone, situated at the uppermost part of the suspensorium. It has two condyles for the hyomandibular fossa of the cranium at its dorsal end. The anterior condyle (acc) fits into a facet formed by the sphenotic and the posterior one (pcc) fits into a facet on the pterotic. These condyles are capped by cartilages. The hyomandibular has four processes; the opercular, preopercular, lower and intermuscular processes. The opercular process extends posteriorly and articulates with the anterodorsal facet of the opercle. The preopercular process extends posteroventrally and is overlain by a flange of the preopercle near the termination of the bony ridge. This process consists of the dorsal margin of the hyomandibular-preopercular foramen (or vacuity). The lower process is flat and broad, and articulates posteriorly with the central protuberance of the preopercle, ventrally with the symplectic through the cartilage, and anteriorly with the metapterygoid. A small foramen for the hyomandibular ramus of the facial nerve is located at its anterior margin. A short and pointed intermuscular process is present between the preopercular and lower processes and directed somewhat laterally. This process has no connection with other bones and embeded in the postorbital muscle. The length of the intermuscular process differs by species in general appearance and separates them into two groups. The group which has longer process is comprised of *M. merluccius*, *M. senegalensis*, *M. polli*, *M. paradoxus*, *M. hubbsi* and *M. australis* and the other group which has a rather short process is comprised of *M. capensis*, *M. bilinearis*, *M. albidus*, *M. productus*, *M. angustimanus* and *M. gayi* (Fig. 34). But this character also varies by individuals.

5. Opercular bones

The preopercle (preo) is a crescentic bone, concave anteriorly and convex posteriorly, situated at the anteriormost part of the opercular bones. Anterodorsally, it articulates with the preopercular process of the hyomandibular and its pointed dorsal end overlies the opercular process of the hyomandibular. The preopercle articulates with the quadrate anteroventrally and with the symplectic and the lower process of the hyomandibular at the central protuberance of the preopercle. The posterior and ventral margins of the preopercle are thin and lack any projections or spines, and partly overlies the opercle, subopercle and interopercle. The preopercle is traversed throughout its length by a groove for the preopercular sensory canal. This groove is overhung by a roof-like bony flange and the posterior edge of the flange is divided by four small bony bridges.

The opercle (ope) is a thin, smooth and triangular bone. The opercle articulates

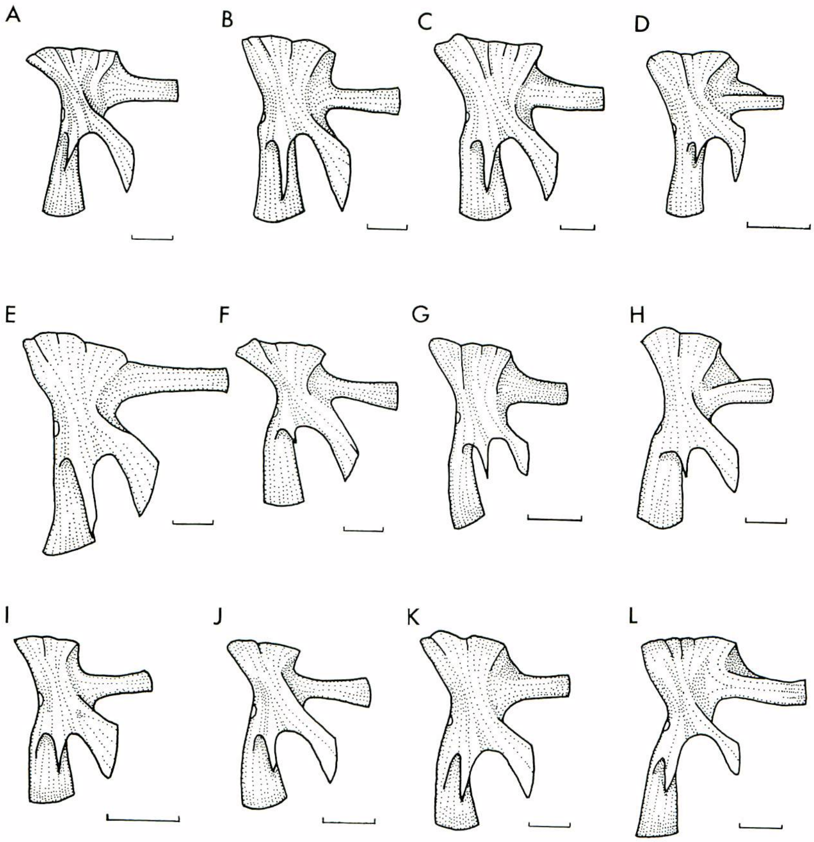

Fig. 34. Hyomandibular of merlucciids, showing the comparison of length of its intermuscular process. A, *M. merluccius* ; B, *M. senegalensis* ; C, *M. polli* ; D, *M. capensis* ; E, *M. paradoxus* ; F, *M. bilinearis* ; G, *M. albidus* ; H, *M. productus* ; I, *M. angustimanus* ; J, *M. gayi* ; K, *M. hubbsi* ; L, *M. australis*. Scale bars indicate 5 mm.

by a narrow, concave facet with the opercular process of the hyomandibular. Two divergent bony ridges start from this angle and extend to the posteriorly pointed tips. The posterior margin of the opercle is deeply concave. The dorsal and ventral margins of opercle are a little expanded and rounded.

The interopercle (ino) is thick and well ossified anterodorsally but thin ventrally, which covers most of the lower part of the branchiostegal rays. The interopercle is covered by the preopercle except for the ventral part, and slightly overlies the anteroventral part of subopercle. Anteriorly it is connected to the retroarticular by a ligament.

The subopercle (subop) is very thin and its posterior surface, which is smooth and weak, is situated at the posteriormost part of the opercular bones. It is partly overlaid by the preopercle and interopercle anteroventrally, and by the opercle anterodorsally. It covers the upper part of the branchiostegal rays.

6. Hyoid arch

The hyoid arch is attached to the inside of the marginal area of the opercular bones and supports the branchiostegal membrane. This apparatus comprises a single basihyal and urohyal, and a pair of hypohyals, ceratohyals, epihyals, interhyals and branchiostegal rays. Of these bones, the basihyal is included in the section on the branchial arch (Fig. 35).

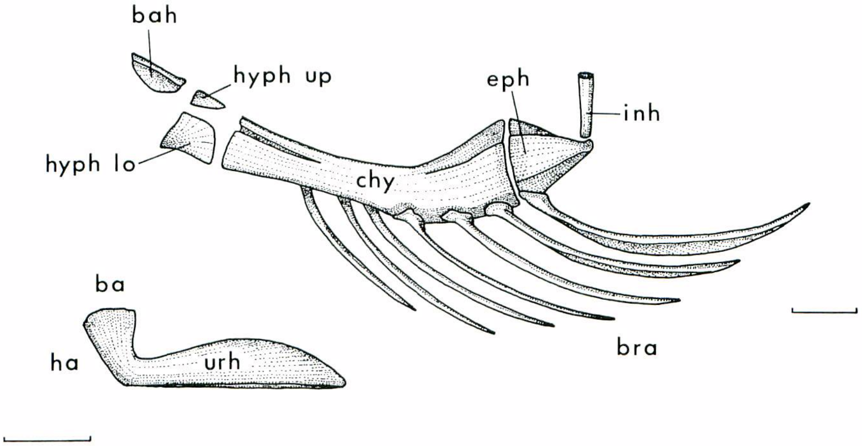

Fig. 35. Hyoid arch of *Merluccius australis*, FSFL EI248. ba, facet for the first basibranchial ; ha, articulating surface for a pair of ligaments. Scale bars indicate 10 mm.

The hypohyal is composed of two small bones situated on the anteriormost part of the hyoid arch. The upper hypohyal (hyph up) is smaller than the lower hypohyal (hyph lo) and the both hypohyals are triangular in shape. Those of the right and left sides articulate with each other at a median symphysis under the basibranchial. The upper hypohyal is bound to the lateral surface of the first basibranchial by the intervention of cartilage and also to the anterior angle of the first hypobranchial through a strong ligament. The lower hypohyal is connected with the urohyal by the ligament. Two hypohyals and ceratohyal are separated by an interspace of cartilage.

The ceratohyal (chy) is flat and slender and is a little curved. Its posterior end is expanded and is separated from the epihyal by an interspace of cartilage, but these two bones are connected by a strongly jagged suture on the middle part of the inner surface. There is no fenestra on it but it has a short groove at the posterior and anterior end of the outer surface for the ligament attachment. The axial part is thickened but the ventral edge is somewhat thin and supports six branchiostegal rays.

The epihyal (eph) lies between the ceratohyal and interhyal, and is thick and triangular in shape. The epihyal connects with the interhyal by a ligament at its posterior end which is hollowed into a shallow fossa to receive the ventral end of the interhyal, and this makes the interhyal freely movable. The epihyal bears one branchiostegal ray, at the anteroventral corner.

The interhyal (inh) is a short, cylindrical bone situated on the posteriormost part of hyoid arch. The dorsal end of interhyal fits into the inner facet of the central protuberance of preopercle.

The seven branchiostegals (bra) are curved, evenly spaced, and increase in length posteriorly. They support the branchiostegal membrane. The anterior three are attached to the ventral margin of the inner surface of the ceratohyal and the next three originate from the outer surface of the same bone. The posteriormost originates from the outer surface of the epihyal and the margin of this ray is expanded into a blade. The last four branchiostegal rays have prominent swollen heads at their bases.

The urohyal (urh) is L-shaped in lateral view and feather shaped in dorsal view (mixture of the aeroplane tail shape and large headed shape of KUSAKA (1974)), and inverted T-shaped in transverse section. At the anterodorsal end the urohyal has a facet (ba) for a cartilage which is articulated with the first basibranchial. The anteroventral part of the urohyal is an articulating surface (ha) for a pair of ligaments connecting to the lower hypohyals of the both sides. At the base the urohyal slightly projects laterally along its ventral margin. From the posterior end a strong ligament (part of the sternohyoid muscle) connects to the anteroventral tip of the cleithrum. There are no marked differences in the shapes of urohyals between species, but that of *M. hubbsi* is peculiar among the merlucciids because its thickened bone contrasts with those of other species (Fig. 36).

7. **Branchial arch**

The branchial arch supports the gills and gill-rakers, and its skeleton remains chiefly cartilaginous and is formed by the four pairs of branchial arches. It consists of the basibranchial, hypobranchials, ceratobranchials, epibranchials and upper and lower pharyngeals. The basihyal is also described here for convenience sake. The hypo-, cerato-, and epibranchials are thin, slender and grooved longitudinally and into these grooves the gill-filaments insert. The gill-rakers of the outer and inner rows are situated on their oral surfaces (Fig. 37).

The basihyal (bah) is a fan-shaped, thin and small bone situated at the anterior tip of the hyoid arch and filled with cartilage. It is slightly expanded anteriorly, toothless and embedded in the tongue. Its posterior end is truncated and articulates with the anterior basibranchial.

The basibranchial (bab) is thin and long bone composed from two ossicles, which are toothless and tightly united with each other by synchondrosis. The posterior basibranchial is expanded to the right and left and articulates with the third hypobranchials.

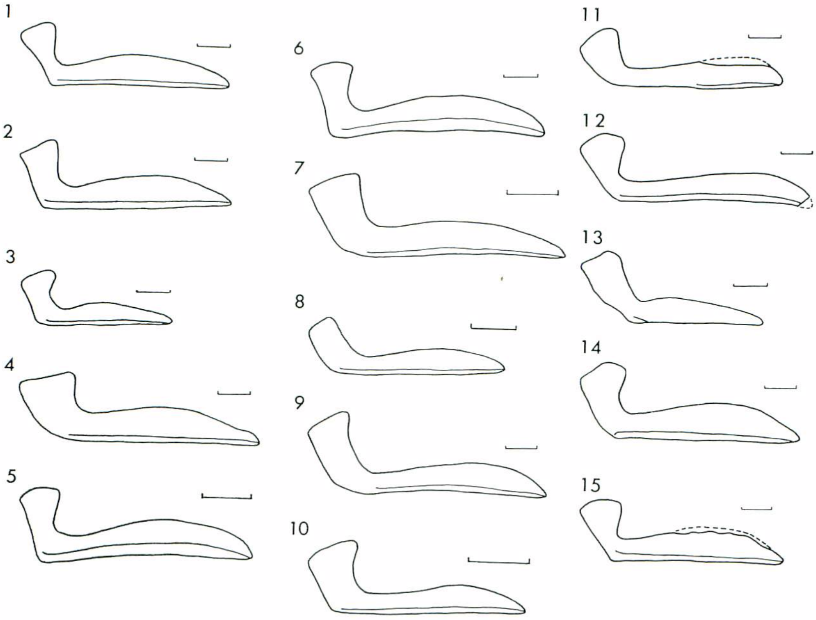

Fig. 36. Urohyal of merlucciids. 1, *M. merluccius* ; 2, *M. senegalensis* ; 3, *M. polli* (Mauritanian population) ; 4, *M. polli* (Angola population) ; 5, *M. capensis* ; 6, *M. paradoxus* ; 7, *M. bilinearis* ; 8, *M. albidus* ; 9, *M. productus* ; 10, *M. angustimanus* ; 11, *M. gayi peruanus* ; 12, *M. gayi gayi* ; 13, *M. hubbsi* ; 14, *M. australis* (Patagonian population) ; 15, *M. australis* (New Zealand population). Scale bars indicate 5 mm. The broken line shows the estimated outline of the shape.

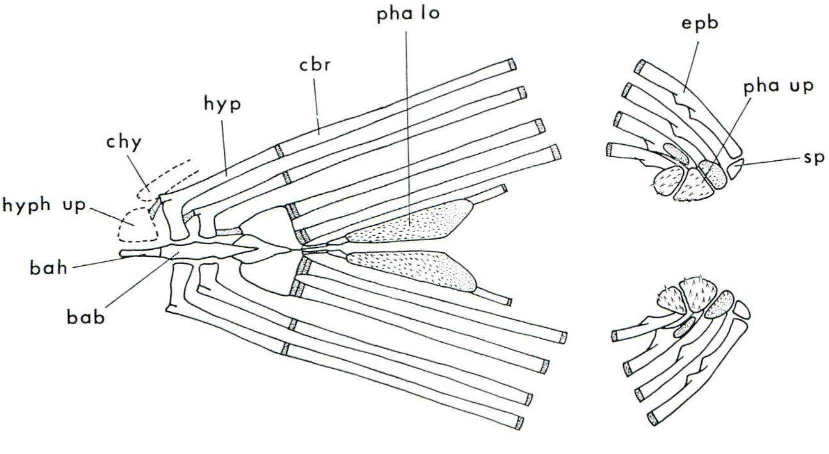

Fig. 37. Branchial arch of *Merluccius australis*, FSFL EI248.

The hypobranchials (hyp) are three on either side and decrease in length posteriorly. The proximal ends of the first and second hypobranchials fit into the cartilagenous facets under the anterior basibranchial. This proximal end of the first hypobranchial is connected with the urohyal through a cartilage. Another ligament from the anterior corner of the first hypobranchial fastens to the upper hypohyal. The third hypobranchial is flat and triangular, and articulates with the posterior basibranchial at the inner surface and with the third and fourth ceratobranchials at the posterior margin. The proximal end of the third hypobranchial is pointed and joined through a cartilage with its counterpart of the opposite side below the posterior basibranchial. The second and third hypobranchials bear ligaments from the anterior parts of their angles and are connected with each preceding hypobranchial.

The ceratobranchials (cbr) are four in number, constituting the longest bone of the branchial arch, and are of nearly the same length. The third and fourth ceratobranchials originate from the posterior margin of the third hypobranchial. The gill-slit between the fourth ceratobranchial and the lower pharyngeal is very narrow.

The epibranchials (epb) are four in number. Each bones has one (two in first epibranchial) triaugular bony wing extending dorsally, and from which the groove for the gill-filaments begins. These wings on the third and fourth epibranchials unite loosely with each other. The third epibranchial has a small tooth-plate on the oral surface. These bones articulate with ceratobranchials anteriorly and upper pharyngeals posteriorly.

The upper pharyngeals (pha up) are four in number. The right and left upper pharyngeal plates are connected with each other by a membrane. The first upper pharyngeal (suspensory pharyngeal (sp)) is rod-shaped and toothless. Its internal end attaches to the cranium through the oral membrane of upper side. Each of the upper pharyngeals of second to fourth branchial arches has an oval tooth-plate. The tooth-plates of the second to fourth upper pharyngeals form a contiguous patch of teeth. The teeth on the third and fourth upper pharyngeals are larger and stronger than those on the second. All of these teeth are directed to the inner side.

The lower pharyngeal (pha lo) is made up of a roughly triangular tooth-plate which is contiguous with that of the counterpart along the median line; the two are connected by a short anterior shaft which is attached to the pointed posterior end of the basibranchial by the pharyngeal ligament. The teeth on the anterior and median portion of the tooth-plate are larger and stronger than those on the posterior portion. The end of the posterior shaft is embedded in the muscle but is connected loosely with the fourth ceratobranchial.

8. Pectoral girdle and pelvic girdle

The pectoral girdle consists of eight well ossified elements: the posttemporal, supracleithrum, cleithrum, scapula, coracoid and postcleithrum besides the four actinosts.

The supratemporals are also included (Fig. 38).

The supratemporals (supt) are four in number. These are small, thin ossicles lying on the pterotic and epiotic region at the posterodorsal portion of the skull. The first supratemporal is on the epiotic, the second and third are on the upper limb of the posttemporal, and the fourth is on the pterotic. The second, third and fourth have small flanges on their margins. After passing through the first lateral line scale, the lateral

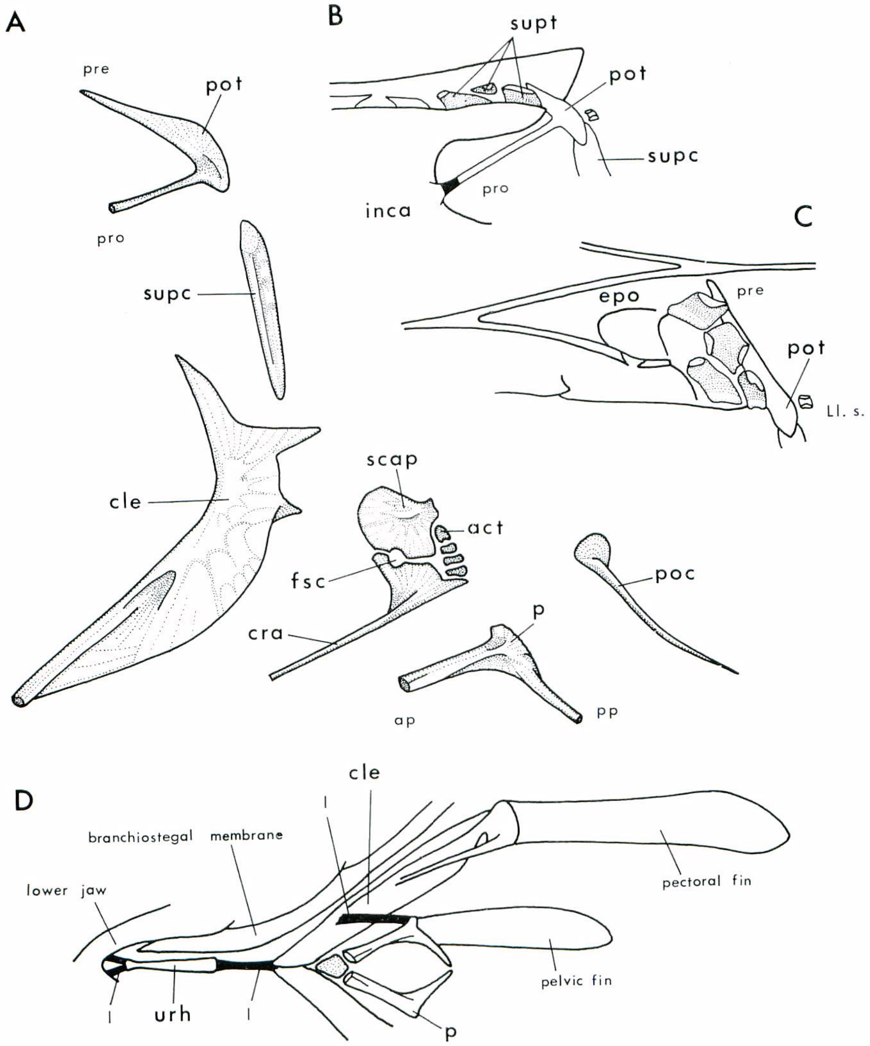

Fig. 38. Bones of the pectoral and pelvic girdles, and supratemporals of *Merluccius merluccius*, FSFL D1290. A, pectoral and pelvic girdles ; B, C, supratemporals (B, lateral view ; C, dorsal view) ; D, pelvic girdle. ap, anteriorly directed arm of pelvic bone ; fsc, scapular foramen ; l, ligament ; Ll. s, first lateral line scales ; pp, posteriorly directed arm of pelvic bone ; pre, dorsal limb of posttemporal ; pro, ventral limb of posttemporal.

canal enters the cephalic portion and is divided into two branches. One is the supratemporal portion of the lateral canal through the third, second and first supratemporals. The other is the cephalic portion of the lateral canal through the third and fourth supratemporals. The former passes through the space between the suborbital crest and pterotic crest, and joines with the supraorbital canal. The latter branches off the preopercular-mandibular canal slightly anterior to the fourth supratemporal, and bifurcates to the supraorbital canal on the frontal and the infraorbital canal on the suborbital bones at the posterodorsal corner of the orbit. The supraorbital canal enters the mucous cavity through the foramen for the mucous cavity at the bifurcated postition of the frontal crest.

The posttemporal (pot) is a V-shaped bone and has dorsal and ventral limbs, the former being longer than the latter. The dorsal limb (pre) is pointed at its anterior tip and is bound to the epiotic. The ventral limb (pro) extends forward and its tip attaches to the small bony protuberance of the intercalar by a ligament of connective tissue. On the inner surface, at the junction of the two limbs, the posttemporal has a surface for the supracleithrum. On the outer surface of the base of dorsal limb, the lateral line canal enters the supratemporals from the first lateral line scale.

The supracleithrum (supc) is thickend along the anterior margin but thin posteriorly. The rounded condyle at the dorsal end of supracleithrum articulates with a flattened surface on the inner side of the posttemporal. The ventral end of the supracleithrum is attached to the outer surface of the dorsal process of the cleithrum.

The cleithrum (cle) is a large bone of rather complex shape, comprising a considerable part of the pectoral girdle. It is thickened along the anterior margin and thin posteriorly. Dorsally it tapers into a sharp process and is overlapped by the supracleithrum. A strong ligament connects the inner side of this process of the cleithrum with the first vertebra, and allows the pectoral girdle flexibility. Two other processes are present on the posterior margin. The upper one is triangular and embedded in muscle. The lower one articulates with the scapula at its inner surface. The ventral end of the cleithrum meets its counterpart of the opposite side on the median line and the anterior part of the ventral end is connected with the urohyal by a strong sternohyoid muscle. At the posterior side of the ventral end the cleithrum connects with the pelvic girdle through a cartilagenous bone. The groove is present on the anteroventral margin of cleithrum in most species, but those of *M. productus*, *M. gayi* and *M. hubbsi* are shallow.

The scapula (scap) is thin bone and articulates with the cleithrm at the internal surface of its lower process. The ventral margin of the scapula borders the upper margin of the scapular foramen (fsc) between the dorsal margins of the coracoid. The ventral edge of this bone is separated from the coracoid by a line of cartilage. At the posterodorsal corner of the bone there is a saddle-shaped facet for the dorsalmost ray of the pectoral fin. At the posteroventral corner there is a right angle depression for the uppermost actinost.

The coracoid (cra) is gingko leaf-shaped and located ventral to the scapula. The posterodorsal wing is fan-shaped and its dorsal margin is connected with the vetral margin of the scapula through a cartilage. It borders the lower margin of the scapular foramen. The anterior tip of this wing fits solidly to the inner surface of the cleithrum. The posterodorsal process is short and pointed. Its upper margin borders the lowermost actinost. The ventral process is long and slender, and extends anteroventrally, where it is connected with the anterior inner margin of the cleithrum.

The four actinosts (act) are bony ossicles which increase in length downward. The first is slightly rounded, the other three are rather longer. These four bones articulate proximally with the scapula and coracoid, and connect distally with the pectoral fin rays. Two small interosseous spaces are present between the first and second, and third and fourth.

The postcleithrum (poc) is thin and slender and its anterior head is swollen and slightly rounded. The head of the postcleithrum is attached loosely to the muscle on the inner surface of the upper process of the cleithrum. The shape of this bone, especially the size of its rounded head, varies markedly by species. The heads of postcleithra of *M. bilinearis*, *M. albidus*, *M. productus* and *M. australis* are small compared with the lengths of their shafts, and those of the eastern Atlantic species (*M. merluccius*, *M. senegalensis*, *M. polli*, *M. capensis* and *M. paradoxus*) are very large. Those of other species (*M. angustimanus*, *M. gayi* and *M. hubbsi*) are rather intermediate in size (Fig.

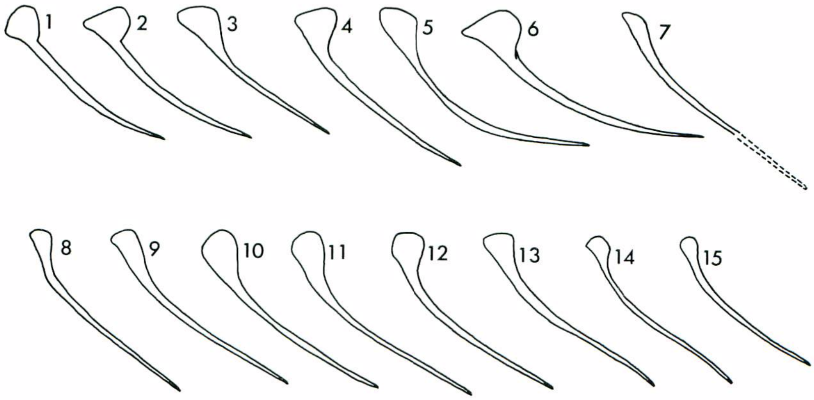

Fig. 39. Postcleithra of merlucciids. 1, *Merluccius merluccius* ; 2, *M. senegalensis* ; 3, *M. polli* (Mauritanian population) ; 4, *M. polli* (Angola population) ; 5, *M. capensis* ; 6, *M. paradoxus* ; 7, *M. bilinearis* ; 8, *M. albidus* ; 9, *M. productus* ; 10, *M. angustimanus* ; 11, *M. gayi peruanus* ; 12, *M. gayi gayi* ; 13, *M. hubbsi* ; 14, *M. australis* (Patagonian population) ; 15, *M. australis* (New Zealand population).

39). As far as the variation of shape by individual are concerned, this character is rather stable within a species (Fig. 40).

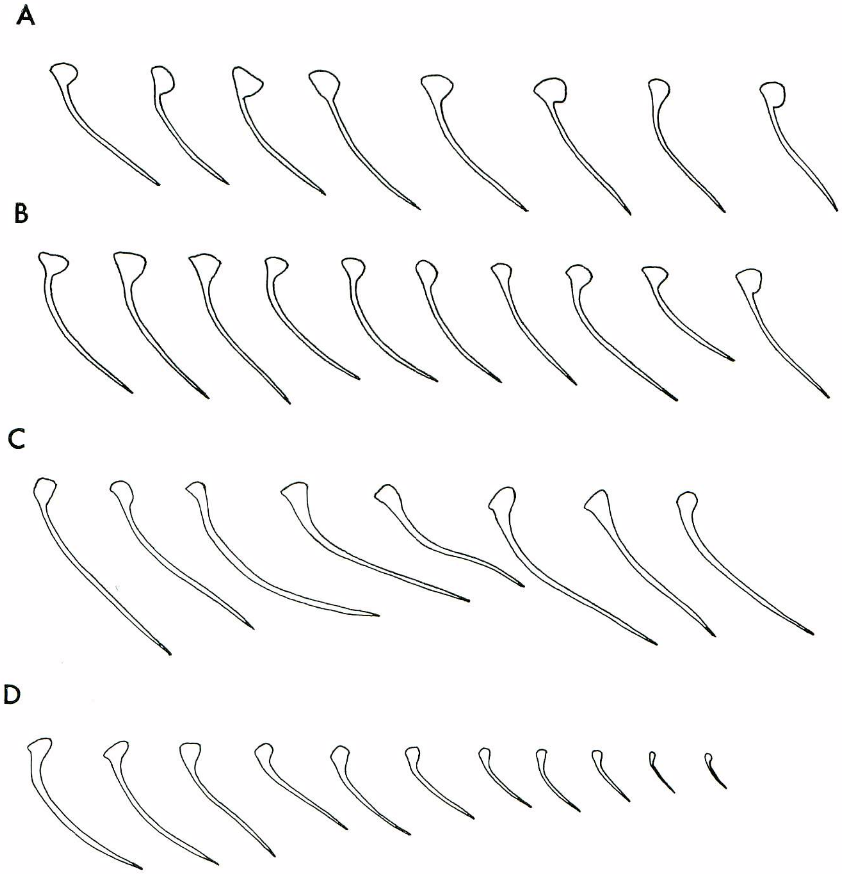

Fig. 40. Infraspecific variations of the shapes of postcleithra of *Merluccius capensis* (A), *M. paradoxus* (B), *M. australis* (C) and *M. hubbsi* (D). Relative size of each postcleithrum corresponds with each size of specimen.

The pelvic girdle is situated at the thoracic region and is composed of a V-shaped pelvic bone (p). The posteriorly directed process (postpelvic process (pp)) is slender and connected with that of the opposite side at the median line. The anteriorly directed process (ap) is rod-like and meets its opposite mate at the midline near the thoracic region. Thus a large rhombic interosseous space is left between the paired bones. The pelvic girdle is connected with the lower tip of the cleithrum through a knob of cartilage. A strong ligament is attached to the lateral projection of the pelvic bone at the one end and to the inner surface of the lower wing of the cleithrum at the other. There is a facet for the pelvic fin rays at the posterior surface of this bone.

9. Vertebrae

The vertebral column is composed of well ossified centra. The total number of vertebrae ranges from 48 to 58 in merlucciids. The vertebrae consisted of the anterior abdominal vertebrae that do not have haemal spines and the posterior caudal vertebrae that do have haemal spines. The abdominal vertebrae are divided into the two parts. One is called cervical vertebrae, the anterior five or six vertebrae that do not have parapophyses, and the other is composed of the posterior vertebrae that have well developed parapophyses (or lateral processes).

The first vertebra is firmly attached to the posterior projection of the basioccipital. A pair of neural prezygapophyses of the first vertebra project anteriorly and connect firmly with the posterior surface of the exoccipital condyles. The neural spine of the first vertebra is thin and well developed, and its anterior margin is inclined anteriorly and firmly fused to the posterior margin of the supraoccipital crest. A small rounded space is present at the base of these sutures. The anteroventral part of this neural spine projects anteriorly and fits into the notch formed by the lower margin of the supraoccipital and exoccipital condyles, and almost fuses with them. The centrum of the second vertebra is the smallest; the succeeding three or four centra gradually increase in size and each has a pair of ribs. These ribs are short and rod-like, attaching to the lateral surfaces of the centra (Fig. 41A).

The number of ribs varies by species and by individual, moreover, even in the same individual the number of ribs differs on each side. Nevertheless, there are some trends for mean values. The Atlantic species except *M. polli* have 4 ribs and the Pacific species including *M. hubbsi* have 3 ribs in most individuals (Table 17). This character seems to suggest a phylogenetic relationship between these two groups, leaving some question as to the status of *M. polli*.

Table 17. Number of ribs of merlucciids

species	Number of specimens	Number of ribs	Mean	species	Number of specimens	Number of ribs	Mean
(Atlantic species)				(Pacific species)			
M. merluccius	23	3-4	4.0	*M. productus*	20	3	3.0
M. senegalensis	20	3-4	3.9	*M. angustimanus*	20	3	3.0
M. polli	31	3	3.0	*M. gayi*	45	3-4	3.1
M. capensis	20	4	4.0	*M. hubbsi*	24	3-4	3.1
M. paradoxus	20	4	4.0	*M. australis*	41	3-4	3.2
M. bilinearis	20	4	4.0				
M. albidus	14	3-4	3.9				

Eight to eleven epipleural bones are present, extending lateral between the muscle layers and placed on the anterior part of the abdominal vertebrae. These bones are short and slender; the last one is very small. The head of the first epipleural is loosely attached to the tip of the first rib by a membrane. These epipleurals decrease in lengh posteriorly. The rudimental last epipleural is embedded in the muscle above the tip of the porapophysis. Other intermuscular bones are entirely absent (Fig. 41B).

Parapophyses are well developed on the abdominal vertebrae (except cervical

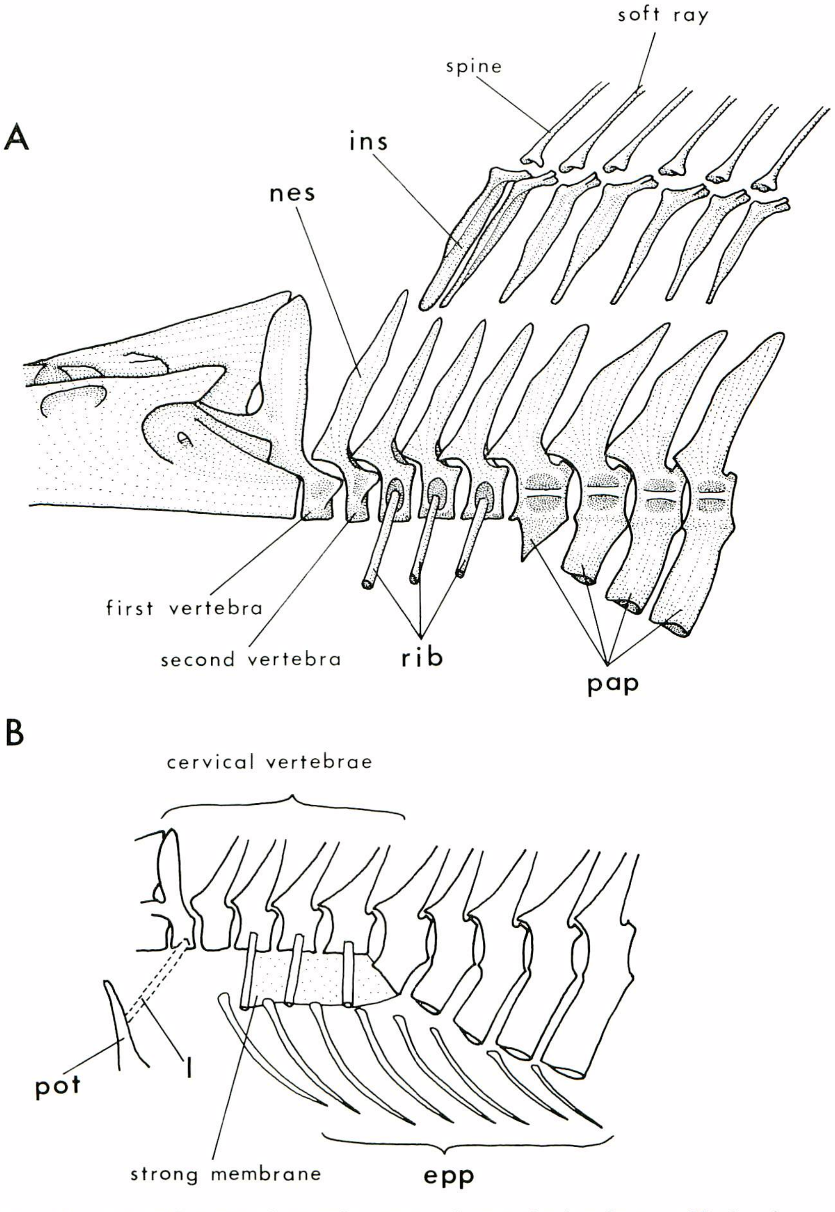

Fig. 41. Lateral view of anterior part of vertebral column (*Merluccius australis*, FSFL D2375). A, relations of skull, vertebrae and interneural spines ; B, relationship between ribs and epipleural bones.

vertebrae) and expand laterally into bony wings. These begin from the sixth or seventh vertebra. The shape and degree of development of these parapophyses differ a little by species or by individuals. The parapophyses of *M. bilinearis* are strongly inclined anteriorly at their tips and those of other species are rather straight (Fig. 42). But this character varies in individuals. The ratio (b/a; percent) of the width of the widest parapophysis (b) to the length of abdominal vertebrae which have parapophyses (a) is shown in Table 18. The degree of development of parapophyses is subject to wide infraspecific variations as can be seen in *M. hubbsi*.

Table 18. Ratio of width of parapophysis (b) to length of abdominal vertebrae (a) of merlucciids. (see Fig. 42A).

species	Ratio (b/a ; %)	species	Ratio (b/a ; %)
M. merluccius	38.5	*M. albidus*	34.5
M. senegalensis	32.3	*M. productus*	27.8
M. polli	31.1-35.6	*M. angustimanus*	37.6
M. capensis	31.0	*M. gayi*	28.8-31.4
M. paradoxus	24.4	*M. hubbsi*	29.4-35.7
M. bilinearis	27.6	*M. australis*	25.0-28.6

The parapophyses on the abdominal vertebrae would have developed together with the development of swim-bladder historically. Instead of parapophyses, on the cervical vertebrae short stout ribs developed which protect the abdominal cavity with intervening membranes between each rib, and this makes the pectoral girdle flexible. This mechanism allows large items to pass easily through the esophagus (Fig. 43A). A pair of thick and long muscle bands run along the ventral surface of the cervical vertebrae from the vertebra just before the swim-bladder to the outer wall of the upper pharyngeal. This seems to have the function of conveying sound from the swim-bladder to the auditory apparatus of inner ear or vibrating the swim-bladder to create sound (Fig. 43B).

The neural spines of the abdominal vertebrae are rather short and wide and bluntly pointed at their tips. Those of the caudal vertebrae are long and slender, and decrease in length posteriorly. The haemal spines are almost the same in shape and length as the neural spines on the caudal vertebrae (Fig. 44).

10. Fins

In the merlucciids, all the fins are composed almost of soft rays. Two dorsal fins and one anal fin are present and each of the second dorsal and the anal fin has a deep notch in the rear part. The caudal fin is usually truncate and is separated from the second dorsal and anal fins.

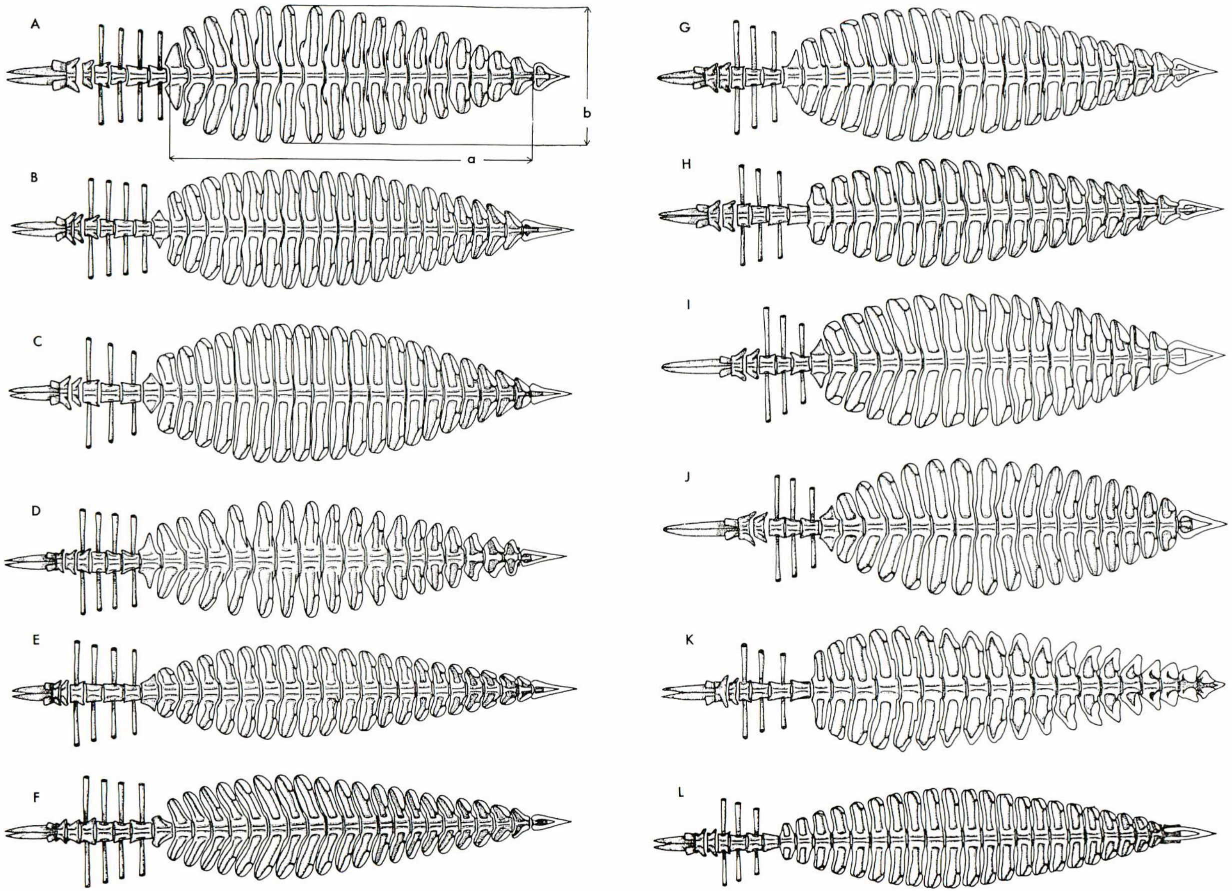

Fig. 42. Ventral view of abdominal vertebrae and parapophyses of merlucciids. A, *Merluccius merluccius*, FSFL D1290 ; B, *M. senegalensis*, FSFL E1021 ; C, *M. polli*, FSFL E1030 ; D, *M. capensis*, FSFL S0638 ; E, *M. paradoxus*, FSFL S0354 ; F, *M. bilinearis*, FSFL D0859 ; G, *M. albidus*, FSFL EG977 ; H, *M. productus*, FSFL U0604 ; I, *M. angustimanus*, FSFL E1047 ; J, *M. gayi*, FSFL S0085 ; K, *M. hubbsi*, FSFL V0860 ; L, *M. australis*, FSFL B2375.

The first dorsal fin is triangular in shape, high and short based. It consists of 8 to 13 soft rays; the second or third ray is the longest. The first interneural spine (ins) is inserted just above between the second and third neural spines. A predorsal rayless interneural spine is absent. The length of the interneural spines decrease posteriorly and in some individuals the last one or two is rudimental and lacks a ray. The first and second interneural spines are developed and close to each other. All rays are segmented and branched except for the first ray. The first ray is spiny; the anterior margin is entirely smooth and rounded, the posterior margin is deeply notched as if the spine was formed by the fusion of a pair of soft rays (a kind of pseudospine of OKAMURA (1970)). The base of each ray is slightly expanded and articulated with each interneural spine through the small cartilage.

The second dorsal fin is long and has 34 to 45 soft rays. There is a narrow space between the first and second dorsal fins. The second dorsal fin begins approximately above the 13th or 14 th vertebra, gradually decreases in length until the 17th to 21st ray and then rapidly increases in length posteriorly. There is no rayless interneural spine

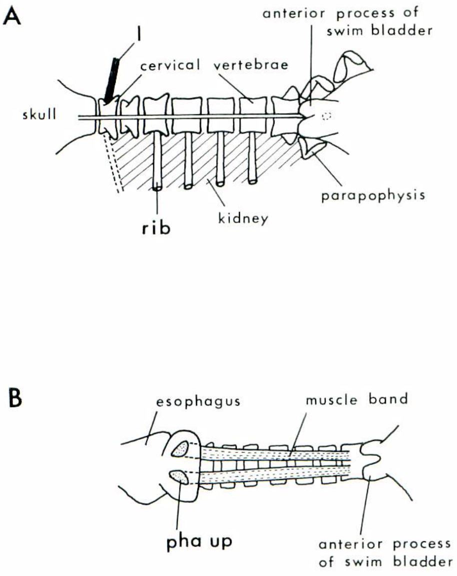

Fig. 43. Ventral view of anterior part of abdomen. A, ventral view of the cervical vertebrae ; B, showing the muscle bands of the ventral part of the cervical vertebrae.

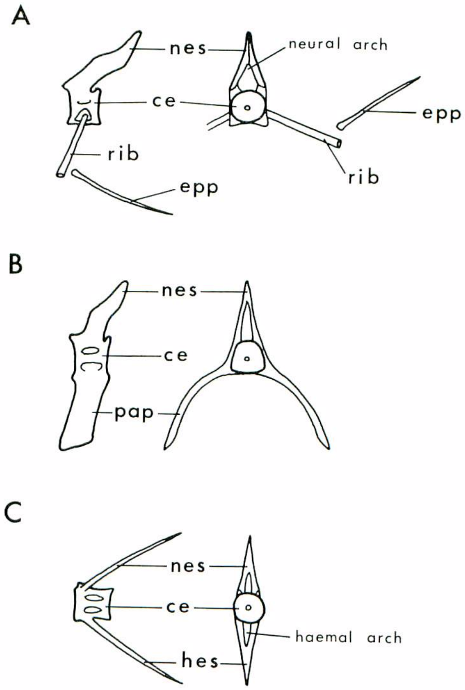

Fig. 44. Lateral (left) and frontal (right) aspects of the vertebra and its accessory bones. A, cervical vertebra with ribs and epipleural ; B, abdominal vertebra with parapophyses ; C, caudal vertebra.

before the first ray. The first interneural spine of the second dorsal fin is pointed at its tip and lies more obliquely. Subsequent ones gradually decrease in length posteriorly. There is no postdorsal rayless interneural spine at the end.

The anal fin consists of 35 to 46 soft rays. It begins near the 15th or 16th vertebra and is almost the same shape as the second dorsal fin. The first anal fin ray is sometimes very short. The first interhaemal spine is rather short but from the second onward, they are long until about the 18th ray and then decrease in length posteriorly. There is no postdorsal rayless interhaemal spine at the end.

The pectoral fin usually consists of 12 to 18 soft rays. It is comparatively high in position and long. The uppermost ray is short and attached the second one. These two rays do not branch at their tips but all the other rays branch at their tips except for the last short ray.

The pelvic fin is thoracic in position and consists always of soft rays, which are branched at their tips. The third ray from the outer is the longest and the innermost ray is the shortest. These rays have the segments, including the first.

The caudal fin is supported by the last 9 or 10 vertebrae and consists of 41 to 46 soft rays. The upper and lower 10 to 12 rays are short. The middle rays are branched and segmented at their tips. As a rule, the shape of the posterior margin of caudal fin is truncate or slightly concave in adults, but young individuals have rather convex or truncate caudal fins. The young of *M. australis* usually has a slightly convex caudal fin but this changes to the truncate form through growth. On the other hand, the young of *M. gayi* usually has a concave caudal fin and the adult has a more deeply concave one. The degree of emargination of the caudal margin differs slightly by species but it also differs by individual and by growth (Fig. 45). In general, the species *M. productus*, *M. angustimanus* and *M. gayi* have rather strongly concave caudal fins.

The merlucciid caudal fin has been called isocercal or pseudocaudal as in other gadoids by many authors. It has been pointed out that these fishes have fundamentally a true caudal skeleton as in other teleosts by WHITEHOUSE (1935) for *Gadus*, AHLSTROM and COUNTS (1955) for *Merluccius*, OKAMURA (1970) for macrouroids, and GOSLINE (1963), ROSEN and PATTERSON (1969) and MARSHALL and COHEN (1973) for gadoids in general. The terminology for the caudal skeleton in this study follows MONOD (1968). The merlucciid caudal skeleton consists of two vertebrae, two epurals and four hypurals, and there is no urostyle. The terminal vertebra of merlucciids consists of the fused second ural vertebra with the third and fourth hypurals (Following GOSLINE(1961, 1963), this bone is formed by the fusion of two postterminal vertebrae and the fourth hypural). Two epurals on the upper side and two hypurals on the lower side are present. Following ROSEN and PATTERSON (1969). the structure interpreted by MONOD as the first hypural is the parhypural, his second hypural is the first and second hypurals fused, his first ural vertebra is the first pre-ural and the first ural vertebrae fused, and the terminal vertebra consists of the second ural vertebra and three hypurals fused. Various authors have commented on the presence of an extra set of bones in the caudal skeleton of all gadoids. These are called "X" and "Y" and are located anterior to the neural spine of the first pre-ural vertebra and the parhypural (MONOD, 1968). The terminal vertebra supports 6 caudal rays, two epurals support 3 rays and two hypurals support 4 rays. The haemal spine of the first pre-ural vertebra is not jointed but connected through a cartilage, called "parhypural bone" by MONOD (1968) (Fig. 46).

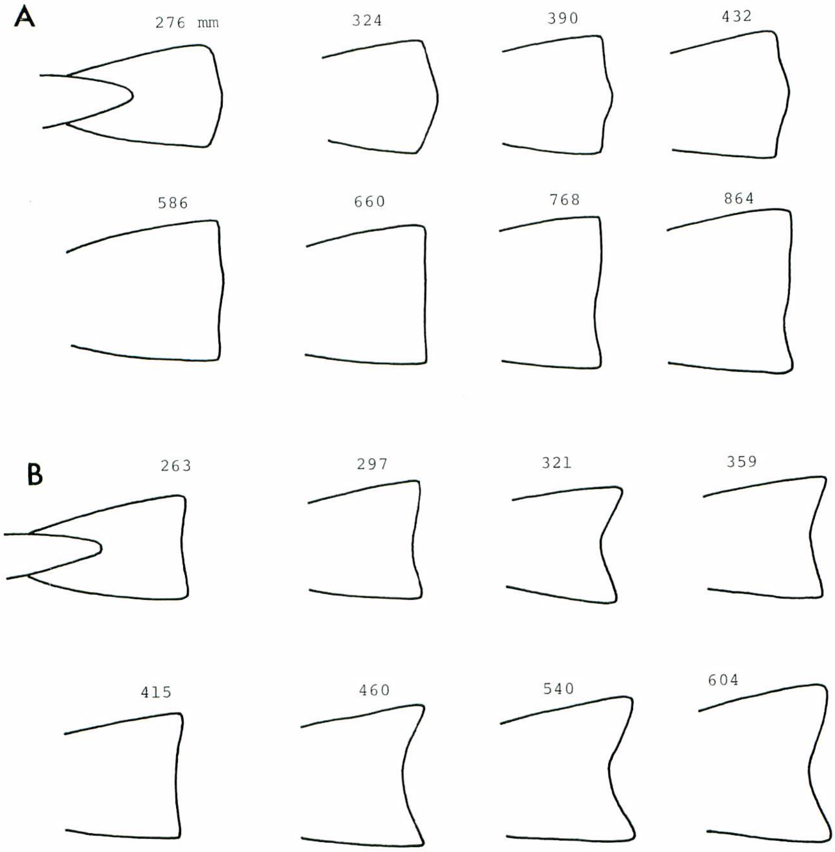

Fig. 45. Shape of the posterior margin of the caudal fin of *Merluccius australis* (Patagonian population) (A), and *M. gayi gayi* (B), showing their change of the shape by growth. Numerals show the standard length of each individual.

11. Gill-rakers

The gill-rakers of merlucciids are attached in double (outer and inner) rows to the hypo-, cerato- and epibranchials except for the third hypobranchial and the inner row of the fourth branchial arch. The gill-rakers on the outer row of the first gill arch are comparatively long, and are equipped with fine, minute teeth along the edge of their oral sides on each gill-raker. Those on the posterior (distal) half of the ceratobranchial are the longest. The gill-rakers on the inner rows of the first, second and third, and the outer rows of the second, third and fourth branchial arches are small tubercular or granular, with fine teeth on their surfaces. The fourth branchial arch is attached to the esophagus by a membrane but has a small slit between the fourth ceratobranchial and the lower pharyngeal. The first branchial arch has some tubercles (=low spinulose tubercles of GINSBURG (1954)) at both ends. Those on the upper one are none to three but those on the lower one, which are on the hypobranchial, are three to ten or more. All of these tubercles have small fine teeth on their surfaces.

The size and shape of the gill-rakers on the first branchial arch differs by species (Fig. 47). They can be roughly classified into three types. The first type is represented by five species, *M. paradoxus*, *M. bilinearis*, *M. productus*, *M. angustimanus* and *M. gayi*. In these species the gill-rakers are long, slender and numerous (16 to 25 in number), and have pointed tips. The second type comprises five species, *M. merluccius*, *M. polli*, *M. albidus*, *M. hubbsi* and *M. australis*, which are marked by having comparatively fewer short, thick gill-rakers (8 to 16 in number), with blunt tips. The last type is assigned to two other species, *M. senegalensis* and *M. capensis*, which show an intermndiate shape between the first and second types. In *M. australis* and *M. hubbsi*, there was a little remarkable variation in shape by individual, population, and growth (Fig. 48). Regarding this character, *M. capensis* has tubercles of uniformly white colour, whereas those of

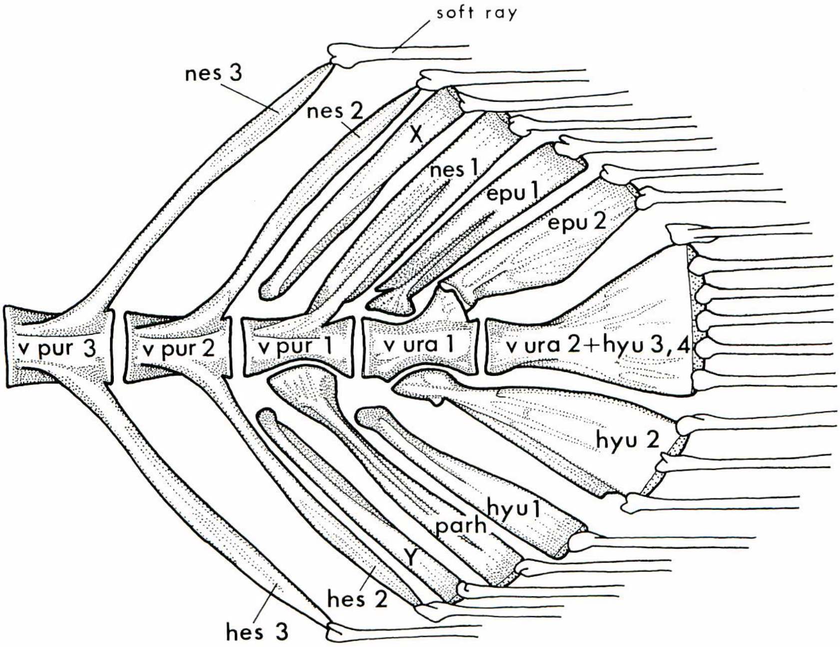

Fig. 46. Lateral aspect of caudal skeleton of *Merluccius australis*, FSFL EI248. v pur, preural vertebra ; v ura, ural vertebra ; X, dorsal accessory bone ; Y, ventral accessory bone.

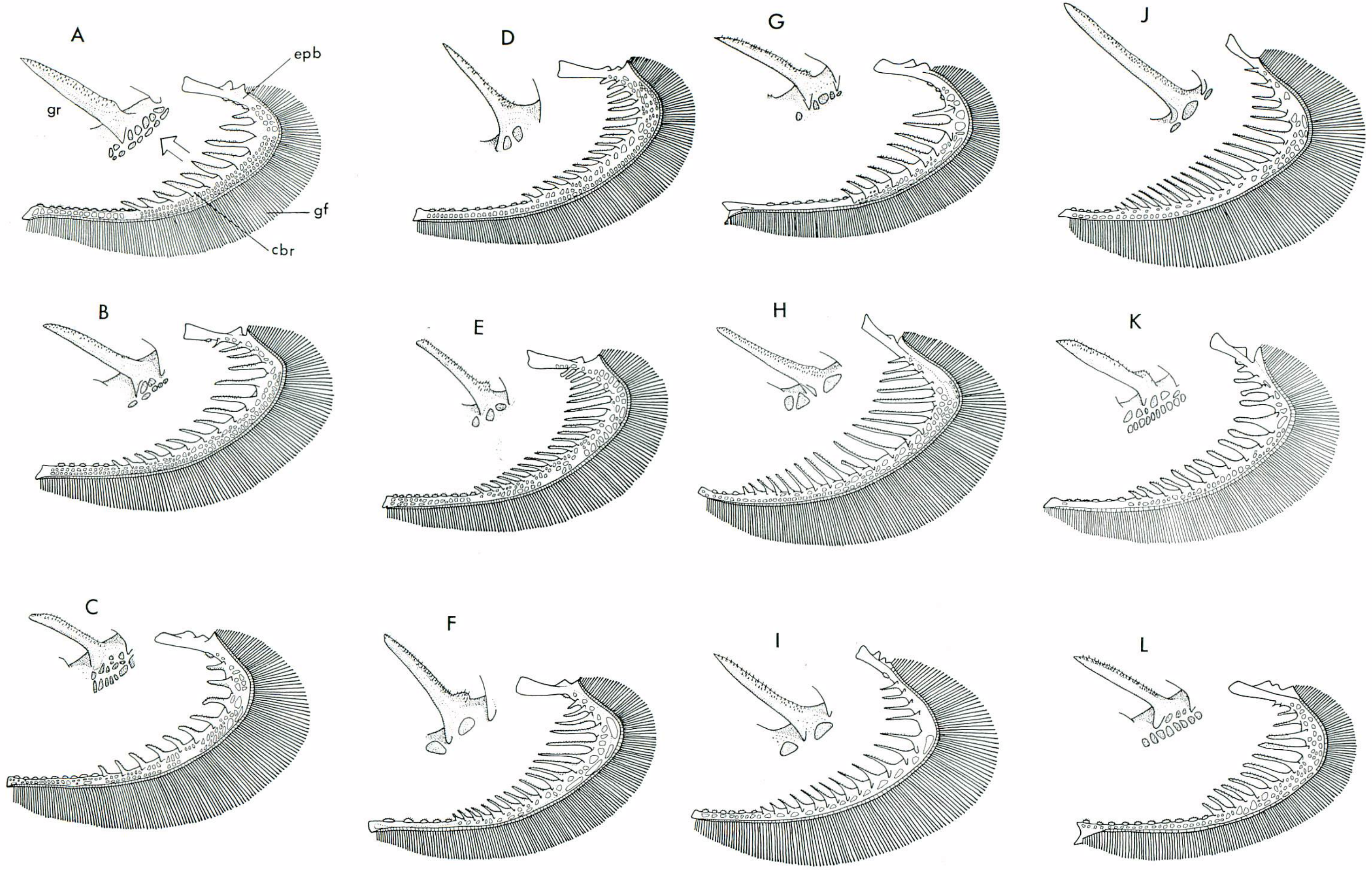

Fig. 47. Outer view of the first gill-arch and gill-raker of each merlucciid species. A, *Merluccius merluccius*; B, *M. senegalensis*; C, *M. polli*; D, *M. capensis*; E, *M. paradoxus*; F, *M. bilinearis*; G, *M. albidus*; H, *M. productus*; I, *M. angustimanus*; J, *M. gayi*; K, *M. hubbsi*; L, *M. australis*. gr, gill-raker; gf, gill-filament.

M. paradoxus have a small black area approximately at the center. The tubercles of the latter species also seem more square than those of *M. capensis* (van Eck, 1969). The number of gill-rakers on the first arch does not change with growth. The number of gill-filaments are about 150.

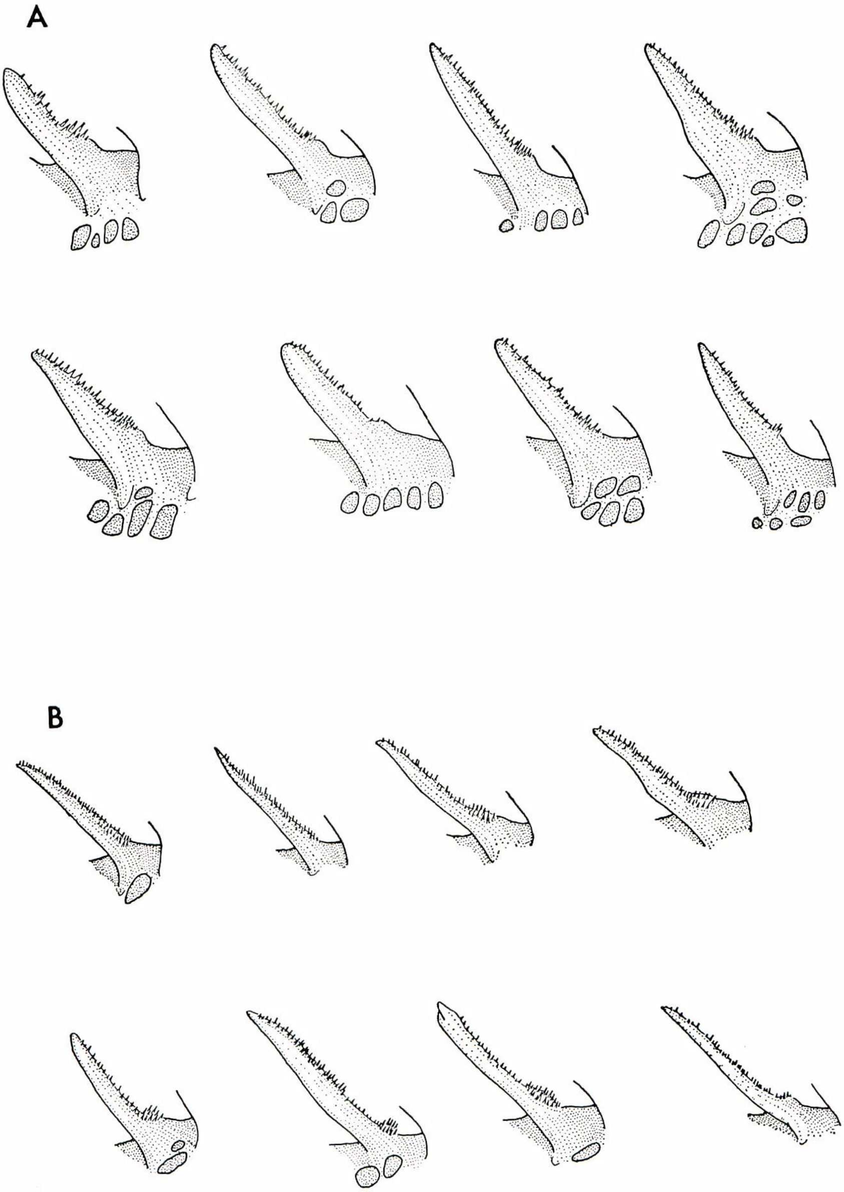

Fig. 48. Infraspecific variations of the shape of gill-rakers of the first gill arch in *M. australis* (A) and *M. hubbsi* (B).

12. Swim-bladder

The swim-bladder (air-bladder) is of the long oval type and is well developed under the abdominal vertebrae, which have laterally projecting parapophyses. It is firmly attached to the lower side of these vertebrae and parapophyses, and is closed, lacking a pneumatic duct. The wall of the swim-bladder is formed of a thick, tenacious membrane of connective tissues. Its cavity is not divided by membrane, but is filled with gases. The retia mirabilia is located on the inside of the ventral wall of the swim-bladder and is well developed along almost the entire length of the swim-bladder. It is likely that

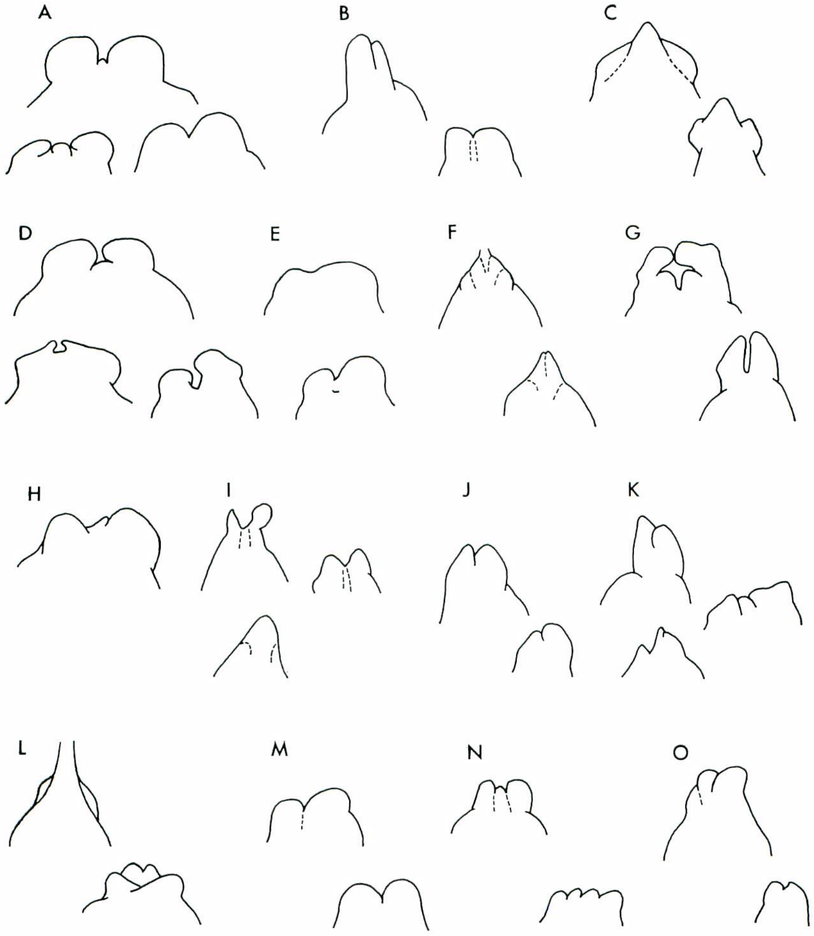

Fig. 49. Shape of anterior appendage of swim-bladder of each merlucciid species. A, *M. merluccius* ; B, *M. senegalensis* ; C, *M. polli* (Mauritanian population) ; D, *M. polli* (Angola population) ; E, *M. capensis* ; F, *M. paradoxus* ; G, *M. bilinearis* ; H, *M. albidus* ; I, *M. productus* ; J, *M. angustimanus* ; K, *M. gayi peruanus* ; L, *M. gayi gayi* ; M, *M. hubbsi* ; N, *M. australis* (Patagonian population) O, *M. australis* (New Zealand population).

this development aids the acitive vertical movement of merlucciids (Marshall, 1966). Anterior to the swim-bladder, a pair of muscle bands are extended from just under the vertebra of the anterior tip of the swim-bladder. These bands extend forward below the cervical vertebrae anteriorly and reach the outer wall of the upper pharyngeal. This apparatus may have the function of sound producing by conveying the movement of oral muscles to the swim-bladder, as well as the function of sound receiving as already noted in section 9. The swim-bladder usually possesses a pair of horn-like processes at the anterior end (=anterior extensions of the swim-bladder of Lagler *et al.* (1962), horn-like appendage of the air bladder of Svetovidov (1948)).

The shape of the anterior process of the swim-bladder differs by species and by individuals (Figs. 49, 50). This process is fundamentally composed of two pairs of

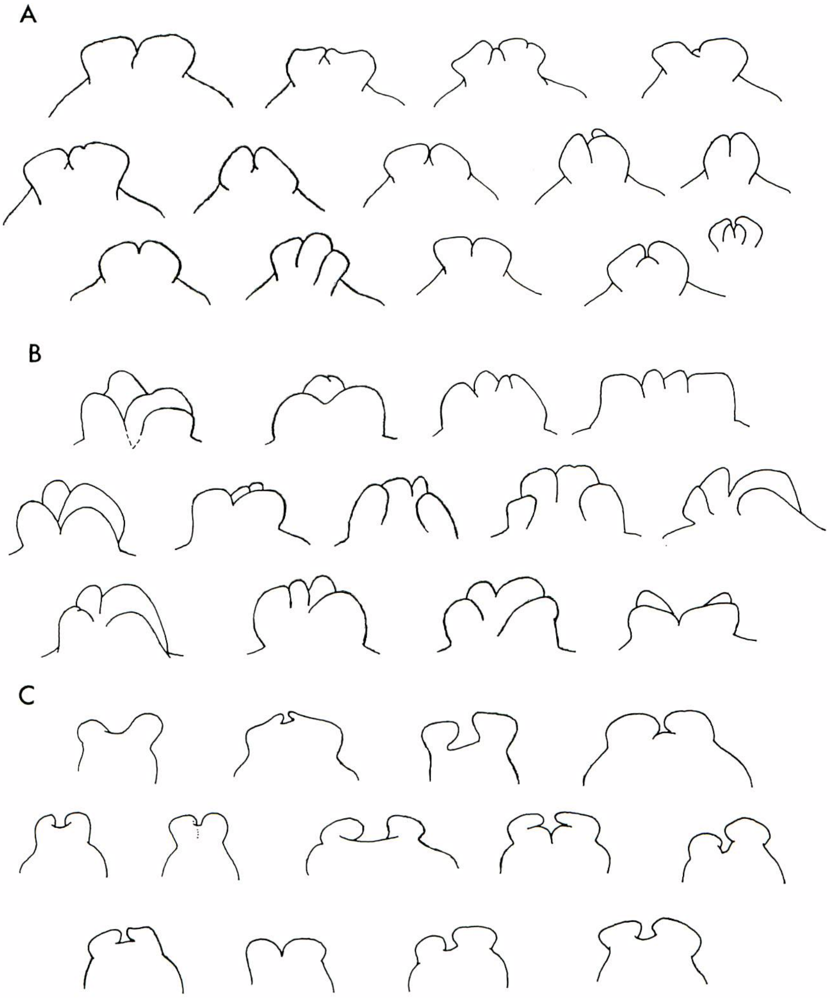

Fig. 50. Infraspecific variation of the shape of anterior appendage of swim-bladder of *M. hubbsi* (A), *M. australis* (B) and *M. polli* (C).

appendages ; one is situated in the outer side and the other is in the inner side. SVETOVIDOV (1948) noted that the size and form of these processes are variable by species and individual in the case of the species of *Gadus*, but each horn-like process has its own definite structure, and the structure of the process is most closely associated with the habitat of the cod. It is clear that this character will of use as a key character in Gadiformes at the level of genus or family, but it will not be suitable to use for a species character in merlucciids.

13. Brain

The merlucciid brain in general appearance is comparatively large and high (Fig. 51). The olfactory bulbs (ob) are advanced from the cranial cavity to the olfactory capsule and situated close to the olfactory sacs (os) at the posterior end of the capsule. Associated with this, the olfactory nerves (oln) as a single tract can hardly be observed between the bulbs and the sacs. Posteriorly each olfactory bulb is connected with the olfactory lobe (oll) by a long olfactory tract (ot) which enters into the orbit through the pit formed by the bones between the both sides of the lateral ethmoid. In the orbit, the olfactory tract runs between the groove which is formed by the ventral

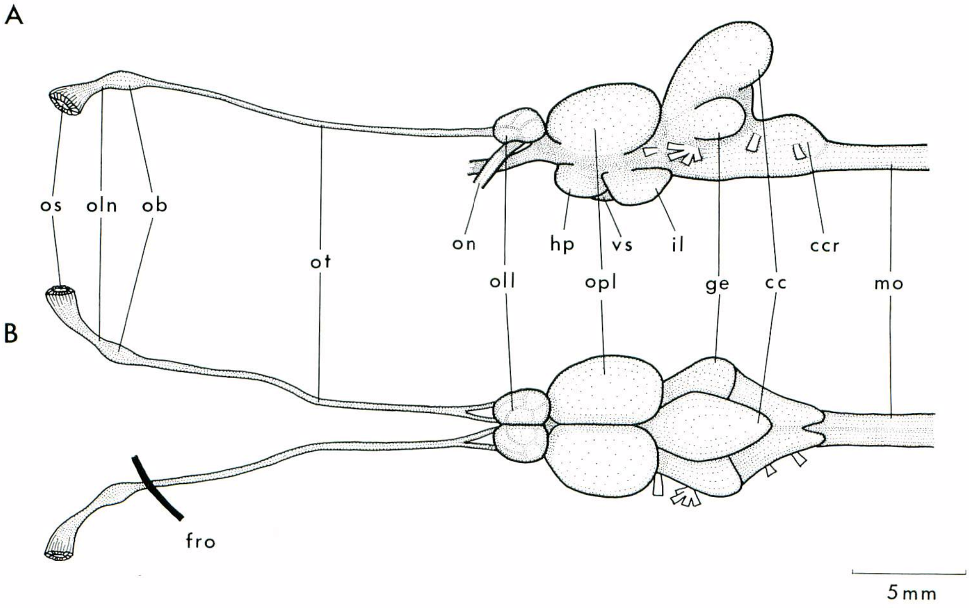

Fig. 51. Lateral (A) and dorsal (B) aspects of the brain of *Merluccius merluccius*, FSFL D1290. cc, cerebellar corpus ; ccr, cerebellar crest ; ge, granular eminence ; hp, hypophysis ; il, inferior lobe ; mo, medula oblongata ; ob, olfactory bulb ; oll, olfactory lobe ; oln, olfactory nerve ; on, optic nerve ; opl, optic lobe ; os, olfactory sac ; ot, olfactory tract ; vs, vascular sac.

margins of the lateral ethmoids and frontals of the both sides and the membraneous interorbital septum. After entering into the cranial cavity the olfactory tract is divided into two branches just before the olfactory lobe. The olfactory lobes are spherical and a little depressed in shape. It is quite well developed but smaller than the optic lobe (opl). The surface is provided with several small swellings. The optic lobes consist of a pair of ovoid bodies and are better doveloped than those in morids and macrouroids (OKAMURA, 1966). The optic nerves (on) are comparatively large in diameter. The chiasma is a simple crossing. The infundibulum, inferior lobes (il), hypophysis (hp), vascular sac (vs) and pineal body comprise the diencephalon. The infundibulum is not so developed and is hidden by the enlarged hypophysis. A pair of inferior lobes are a flattened ovoidal shape and situated on the ventral side of the brain. The inferior lobes are not so well developed as those of the macrouroids. The hypophysis is ovoidal but flattened on its ventral surface and hangs downward from the infundibular region of the brain. Immediately behind the hypophysis, the vascular sac is visible but is very small between the inferior lobes. The pineal body is clearly perceptible between the olfactory and optic lobes. The cerebellum is as well developed as those of other gadoids. It consists of a large cerebellar corpus (cc) which extends posterodorsally. The granular eminence (ge) is spherical or ovoidal on each side of the corpus. The myelencephalon consists of four parts: cerebellar crest (ccr), facial lobe, vagus lobe and medulla oblongata (mo). Behind the cerebellar corpus, the medulla oblongata gives rise to a pair of cerebellar crest. The merlucciid brain is characterized by the shift forward of the olfactory bulbs and the resultant elongation of the olfactory tracts, as is the case with the other gadoids (OKAMURA, 1970). Such a feature has often been used as an important character at the ordinal and family level in the taxonomy of the gadiforms (SVETOVIDOV, 1948; MATSUBARA, 1963; GOSLINE, 1963 ; OKAMURA, 1966).

The characteristics of the merlucciid brain are as follows. The olfactory bulb is very close to the olfactory sac and lies in the olfactory capsule, and the olfactory tract is composed of a single tract for most of its length. These two features are different from those of gadoids. In Gadidae, the olfactory bulb is situated in the olfactory capsule (precranial cavity of OKAMURA (1970)) and the olfactory tract is double (SVETOVIDOV, 1948). MARSHALL (1966) noted that the olfactory bulb of merlucciids is in an intermediate position between the olfactory sac and olfactory lobe. However, the olfactory bulbs are situated near the olfactory capsules in adult specimens of *M. merluccius* (SVETOVIDOV, 1953). It should be noted that the olfactory bulbs of gadoids shift toward the olfactory capsules with growth (SVETOVIDOV, 1969). Following BURNE (1909) and MARSHALL and COHEN (1973), the olfactory capsule extended forward to the olfactoy sac as in *Merluccius*, is not found in the rattailed merlucciids, *Lyconus* and *Macruronus*. Regarding the phylogenic relationships of the merlucciids with other gadoids in light of the position of the olfactory bulb, it may still remain an open question until a through study of this character for all sizes of the fishes.

GEIGER (1954) studied the brains of *M. merluccius* and *M. senegalensis* in detail and compared the number of olfactory lamellae and the relative weight of the brain in the two species. FRANCA (1960a) also compared the number of lamellae in the merlucciids of the west coast of of Africa.

14. Otolith

Of the three otoliths of the merlucciids, the utriculith and the lagenalith are small, and the sacculith is very large. The sacculith is an elongated oval shape and

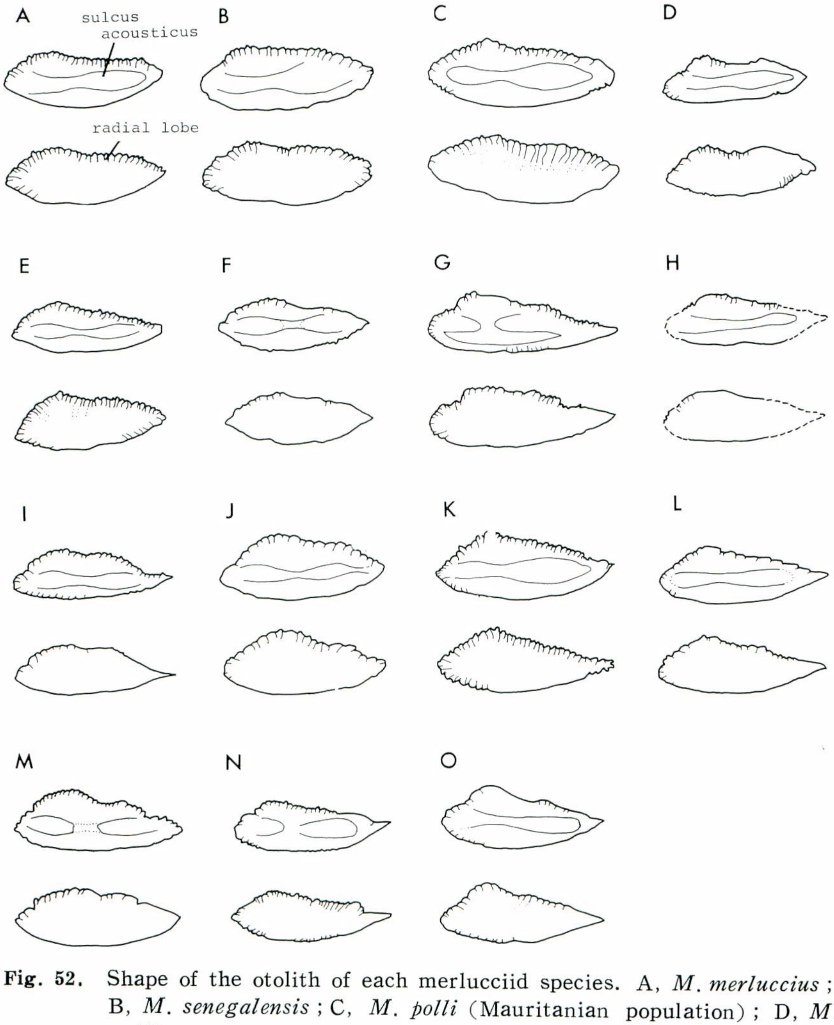

Fig. 52. Shape of the otolith of each merlucciid species. A, *M. merluccius*; B, *M. senegalensis*; C, *M. polli* (Mauritanian population); D, *M. polli* (Angola population); E, *M. capensis*; F, *M. paradoxus*; G, *M. bilinearis*; H, *M. albidus*; I, *M. productus*; J. *M. angustimanus*; K, *M. gayi peruanus*; L, *M. gayi gayi*; M, *M. hubbsi*; N, *M. australis* (Patagonian population); O, *M. australis* (New Zealand population). upper, median surface of right side otolith; lower, lateral surface of left side otolith. The broken line shows the estimated outline of the shape.

strongly compressed laterally. The anterior end is bluntly rounded and the posterior end tapers to a point which may be sharp or blunt. The median surface is smooth and marked by a prominent sulcus acousticus but the lateral surface is marked to a greater or lesser extent by radial lobes. The ventral border is smoothly curved while the dorsal surface usually has a distinct indentation. The sacclith length/height ratio shows that those of *M. paradoxus*, *M. bilinearis* and *M. productus* are very low but those of *M. angustimanus*, *M. hubbsi* and *M. australis* are rather high. The length/width ratio of the sacculith of *M. senegalensis* is highest and the size of the sacculith of *M. bilinearis* is largest compared with head length (Fig. 52). But it is clear that all these proportional characters change with growth. An attempt has been made to compare the sacculiths of *M. hubbsi* and *M. australis*. It is very difficult to separate the two species by the shape of the sacculith, especially in small fishes. But the slight differences between the species are more apparent in larger sized fishes. The sacculith of *M. hubbsi* is rather rounded until total body lengths of 340-400 mm, after that length the dorsal surface is a little convex. At a length of 800 mm, the posterior tip is prolonged and sharply pointed. On the other hand, that of *M. australis* is rather slender, and its posterior end is rather more prominent than *M. hubbsi* (Fig. 53). A comparison of the sacculiths of *M. capensis* and *M. paradoxus* is shown by BOTHA (1971). According to him there are differences in the sacculith growth pattern of these species and above fish lengths of 40 cm the more elongated sacculith can without doubt be identified with *M. paradoxus*. But he also stated that in fishes less than 40 cm the two sacculith types resemble each other more closely and become accordingly more difficult to distinguish, and also in fishes less than 20 cm the sacculiths are virtually identical and identification by sacculith morphology becomes very difficult.

A similar study was made by MOMBECK (1970b and c) on the differences of otolith shape between *M. polli*, *M. capensis* and *M. paradoxus*, and between *M. albidus* and *M. bilinearis*.

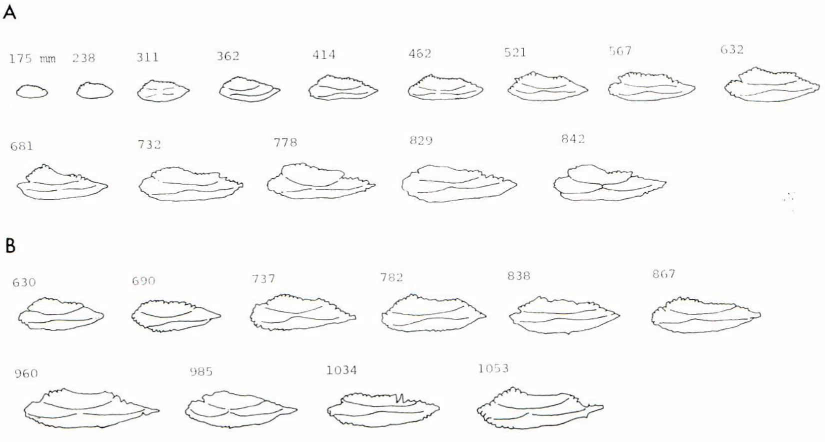

Fig. 53. Shape of otolith of *M. hubbsi* (A) and *M. australis* (B) by size of specimen. Numerals attached with each otolith show the total length in mm of each fish.

IV. Distribution, biology and fishery

The species belonging to the genus *Merluccius* are commonly called Hake (or sometimes called Whiting) in English, Merlu in French and Merluza in Spanish. Hakes are distributed in the waters of both sides of the Atlantic Ocean, the eastern Pacific Ocean and around New Zealand (Fig. 54). HART (1948) pointed out that the distribution of all the known species seems clearly to be determined by the major hydrological features along the coasts of the continents (the two most critical isotherms, 7°C and 23°C are given as August and February values for each in Fig. 54). Hakes mainly inhabit the continental shelf and the upper part of the slope, but some hakes in some seasons enter estuary regions and/or very deep waters over the lower continental slope.

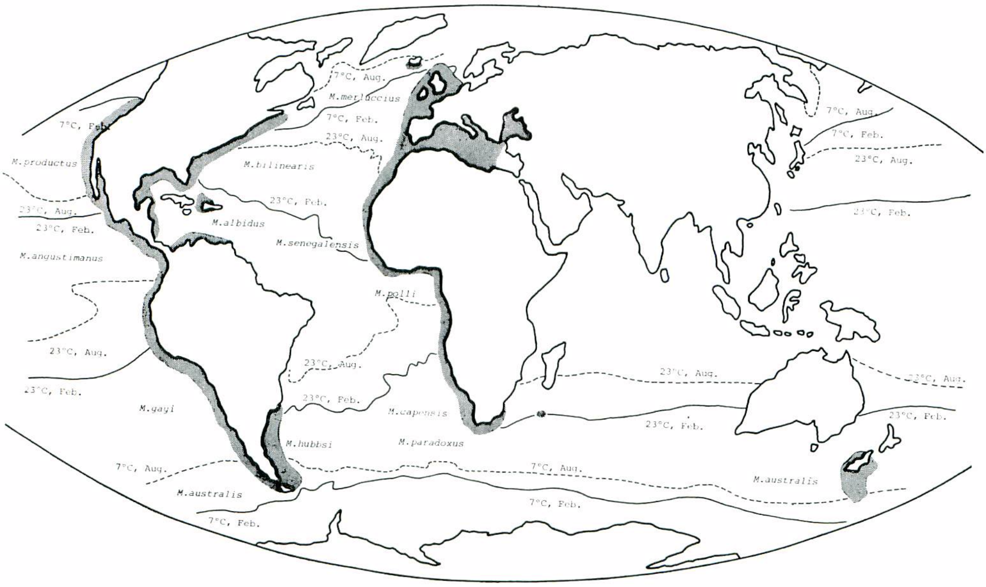

Fig. 54. Distribution of merlucciid fishes in the world. (isothermal lines after HART, 1948).

In general, hakes produce transparent, spherical pelagic eggs containing an oil globule. After hatching the larvae have a pelagic life (There are considerable variations in the amount of time of the pelagic larval stage by species) and then descend to the bottom in shallow coastal waters. Almost all hakes undertake diurnal vertical movements, during which they move away from the seabed at night to feed. They also exhibit seasonal migrations. Generally, they move northward (or southward in the Southern Hemisphere) in warm seasons (spring to summer) into inshore areas, and in cold seasons (autumn to winter) they move back southward (or northward in the Southern Hemisphere) into deep waters. Males grow more slowly than females, which live longer than males. The growth rate and the age at maturity differ by species. Generally, cold water species grow larger (exceeding 1 m) than do tropical species (Panama hake grows up to 32 cm). The main spawning season is spring to summer in most species, but some species which have wide distributional ranges spawn in other seasons. It is supposed that hakes spawn in places where the larvae may easily drift shoreward by means of surface currents. Where there is a narrow continental shelf they spawn in rather deep waters, but where the continental shelf is very wide they spawn in shallow waters. The fecundity of hake is estimated to be around 300,000 to 600,000. Hakes are carnivorous in general, but their food preferences changes during growth. Juvenile hakes feed on planktonic organisms such as small crustaceans and small fishes. Adults feed chiefly on small hakes, other fishes and squids.

Most hake fisheries have developed recently and eight species are now being exploited heavily. Other species are also being exploited but to a lesser extent. Worldwide catches of hakes amounted to 1.8 million tons in 1978. Hakes were the third most important species among the gadoids in the world fish catch. Cape hakes are now producing the largest quantities (520,000 tons in 1978) and the USSR catches the most hake (745,000 tons in 1978). The total standing stock of hakes in the world is not known exactly, but it is estimated to be at least 10 million tons.

The data used in this section are mainly based on the studies of SVETOVIDOV (1948) and GINSBURG (1954) for distribution, HART (1948), and GRINOLS and TILLMAN (1970) for biology and fishery, JONES (1974) and BOEREMA (1977) for fisheries and stocks. And some data for some species are based on the results of research activities by Japanese vessels.

1. European hake (*Merluccius merluccius*)

Distribution :

European hake is distributed in the Atlantic Ocean along the coast of Europe and off western north Africa (Fig. 55). To the north this hake is occasionally caught off the Lofoten Islands and south western shores of Iceland, and east of Kiel harbour and Skagerrak. To the south this hake is caught off Western Sahara and Mauritania. Specimens reported from Cape Verde as a local population may be another species. The southern limit of this hake is normally defined by the limit of influence of the Canary Current, which is cold relative to the tropical surface waters. This hake is also distributed in the Mediterranean and Adriatic Seas, to the Bosphoras and shores of Egypt, Syria and Palestine, the Marmora Sea and the southeastern coast of the Black Sea along the coast of the Caucasus (NORMAN, 1937 ; HART, 1948 ; SVETOVIDOV, 1948, 1973b ; CABO 1965, 1966).

From the fisheries standpoint, the resources northern limit is approximately 62°N, and greatest abundance is off the western seaboard of central and southern Europe, to as far south as the Morocco coast. The limits of the fisheries are the Skagerrak in the north-west, where it is fished principally in the summer months, and off Alexandria and

Port Said in the east (GRAHAM, 1956). Indications of its occurence along the coasts of Greenland (JORDAN and EVERMAN, 1898) are doubtful. Due to the warming of the Arctic observed in recent years, occasional specimens may penetrate into the Barents Sea. This hake is usually found at depths between 100 m to 400 m, but may occur within a wider depth range, from 20-25 m to 1,000 m within the limit of the continental slope (SVETOVIDOV, 1948).

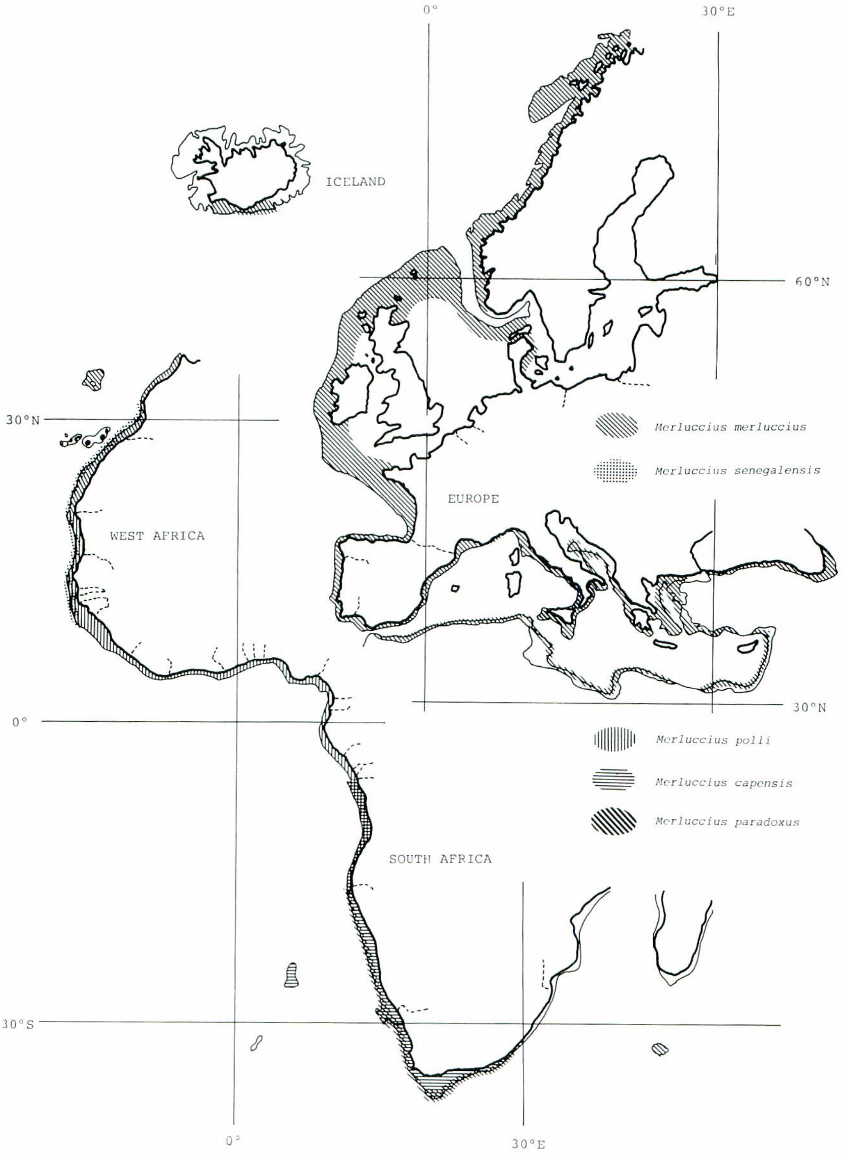

Fig. 55. Distribution of merlucciids in European and west African waters

Fig. 56 shows the distribution of this hake surveyed by Japanese vessels (Anon., 1973). This hake was caught around Great Britain including Porcupine Bank and Great

Sole Bank, and the North Sea around Shetland Islands and the Bay of Biscay. But there was no record from the northern part of Norway, around Iceland, Rockall Bank and the Faeroes. The depths and bottom temperatures at which this hake was recorded were between 52 m and 450 m, and between 7.0°C (off southern Norway) and 16.0°C (off Western Sahara) respectively.

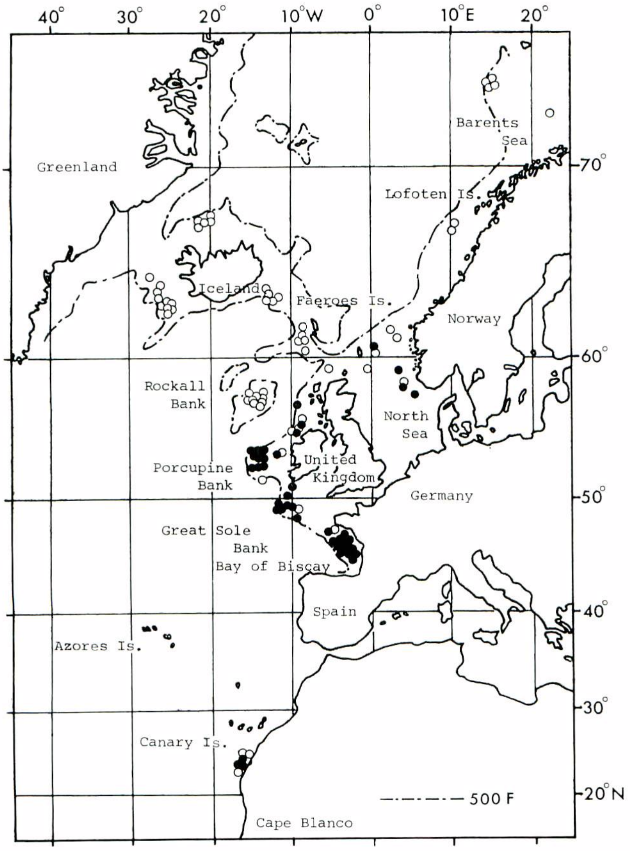

Fig. 56. Distribution of European hake (*M. merluccius merluccius*) surveyed by Japanese exploratory research vessel in 1972. solid circle, station collecting this hake ; open circle, station not recording this hake.

Biology :

European hake produces transparent, spherical pelagic eggs that hatch into pelagic larvae. Diameter of this egg ranges from 0.94 mm to 1.03 mm and that of the oil globule is 0.27 mm. The incubation period of the eggs is from 60 hours to 70 hours. The eggs are subject to surface drift caused by prevailing winds and carried to rich inshore feeding grounds. The newly hatched larvae (about 3 mm length) generally are undeveloped. The time between hatching and the development of a functional mouth is 7-14 days.

During the early stages of their postembryonic existence, this hake is apparently sustained by nutrients from their large yolk-sac. The eggs and larvae have a prolonged pelagic existence. During their first year of life, juveniles live mainly on the surface or in midwater, and settle to the bottom at the end of their second year of life when they are about 20 cm long (HICKLING, 1933; GRAHAM, 1956; WHEELER, 1969 ; GRINOLS and TILLMAN, 1970).

Growth parallels with the changes in the stage of maturity and falls into three periods : 1) period of raplid growth (up to 2 years in femaes, to 3 years in males), during the juvenile stage, 2) period of medium growth (to 7 years), corresponding to attainment of sexual maturity, and 3) period of delayed growth or slowed growth (after 7 years), after attainment of full sexual maturity (SVETOVIDOV, 1948). The rate of growth within the limits of distribution is unequal. In the Mediterranean fish living off the coast of north Africa attains an average length of 30.0 cm in 8 years. On the other hand, fish living off Spain attains 75.0 cm in 7 years. In the Atlantic, fish near Ireland, Scotland, Bay of Biscay and Morocco attains 65-67.9 cm, 68 cm, 61-71 cm and 78 cm in 8 years respectively (FIGUERAS, 1964). HICKLING (1933) distinguished small regional differences in the mean lengths of two and three years old hake, there being a "northern group" occupying the grounds to the west and north of Ireland with mean lengths of 19 cm and 25 cm at two and three years of age, respectively, and a "southern group" - to the south of Ireland - with approximate mean lengths of 22 cm and 26 cm. An approximate average growth rate is: in the 1st year up to 16 cm, in the 2nd up to 20 cm, followed by an annual growth increment of 8-9 cm until 9th year, when they are on averages 73cm in length (WHEELER, 1969). The hake of the Spanish Mediterranean increase 3.5 cm during the first three years of life, but during the following six years this increase is only of 2.3 cm a year. Three-year-olds have a modal size of 21.5 cm (FIGUERAS, 1955). Females commonly reach larger sizes than males, which grow more slowly after maturing in their 3rd or 4th year of life. Females become sexually mature in their 8th year, and grow to 99 cm (HART, 1948). The maximum recorded length is 1.3 m, and weight 15 kg (CASTRO, 1955). The differential growth rate between sexes does not become readily apparent until the 3rd year of life (BAGENAL, 1954).

This hake tends to form large schools over the continental shelf. This habit may be related to the distribution of the euphausiid (*Meganyctiphanes norwegica*). Feeding hakes move off the bottom at night in apparent pursuit of euphausiids and other food organisms, which themselves undertake nocturnal migrations (HICKLING, 1927). Generally, adults and juveniles move inshore during the spring, adults for spawning and juveniles for feeding. After spawning, the adults move back into deep water (165-550 m depth) and are later joined by the juveniles in the wintering area (HICKLING, 1927). The timing of seasonal movement of this hake varies by latitude and local populations (HART, 1948). Spawning takes place off the northern and western shores of Great Britain and Ireland, the western part of the English Channel, the Bay of Biscay and the

Mediterranean Sea. This hake spawns in some years in the Skaggerak and the most northeastern section of the North Sea. The period of spawning is very long but mainly extends from spring to fall (SVETOVIDOV, 1948). Spawning time of geographically distinct populations of this hake varies clinally by latitude, the more northern populations spawning later in the year than the southern. Spawning occurs from April to July off Ireland, from May to August off Scotland, and from March to April in the Bay of Biscay. In the Mediterranean they spawn from January to June but the population in the Adriatic spawns at the end of fall and the beginning of winter (HICKLING, 1927 ; BASIOLI, 1965). The earliest spawning takes place in winter, in depths greater than 200 m, but as the season progresses, spawning takes place in shallow water (WHEELER, 1969). Temperature requirements for spawning are quite high, no lower than 9-10°C, and for salinity, not less than 35.2‰ (SVETOVIDOV, 1948; CASTRO, 1955). Eggs do not ripen simultaneously in this species. It may be assumed that spawning takes place several times during the season, because the ovaries cannot accumulate a great quantity of ripe eggs (ANDREU, 1956). The fecundity of this hake is reported as 2-7 million (CASTRO, 1955). Hermaphroditic individual has been observed (BREDER and ROSEN, 1966).

This hake is mainly carnivorous. Large hake in deep water eats blue whitings, small hakes and squids. During the summer their shoreward migration brings other species such as whitings, norway pouts, mackerels, herrings and garfishes into their diet. Nineteen percent of stomach contents of the Adriatic population consisted of sardines, 8% of anchovies and 7% of mackerels (BASIOLI, 1965). During the breeding migration this hake feeds less greedily than at the other times, but after spawning this hake recuperates rapidly at the expense of mackerels, clupeoids and other shoaling fishes (HART, 1948). Young hake feeds largely upon krills (euphausiids) and other macroplanktonic crustaceans such as amphipods and post-larval *Munida*. Soon after hatching and before reaching a length of 1 cm, larval hake appears to feed upon nauplii and small calanoid copepods and eats larger calanoids (LEBOUR, 1919; WHEELER, 1969). A marked change in diet seems to occur at about the age when the males reach maturity during their third year of life. However, the females also begin to eat more fishes at about this age and size. Thus the marked change in feeding habits at a certain age is not so closely linked with the onset of sexual maturity as it seems to be in so many other fishes of widely diverse habit (HART, 1946; 1948). This hake is mainly fed upon by several carnivorous sharks (CASTRO, 1955).

Fishery :

European hake has been an important constituent of food for western European peoples throughout historic times. This hake has been mentioned in the scientific literature from the time of Aristotle, and has been intensively fished over its whole range of distribution for many years. The development of otter trawling, especially steam trawling at the turn of century, caused the rapid decline in the proportion of prime fish landed, but the development of friedfish shops greatly stimulated hake trawling. The cycle of depletion and recovery was repeated up to and during World War I and II. Since then hake landings have decreased in the United Kingdom, Italy, Spain, Portugal and France, and their fishing ground shifted from traditional grounds to areas off the coast of Africa and adjacent Mediterranean countries (HART, 1948). This hake is caught primarily by bottom trawl but also by longline, bottom set gill-net and Danish seine. The total catch for northern European waters amounted to about 96,000 tons (1969), and in the Mediterranean countries of Spain, Cyprus, France, Greece, Israel, Italy, Malta, Algeria, Turkey and Yugoslavia 17,800 tons (1970) were landed (SVETOVIDOV, 1973 b). In recent years, the total catch of this hake has dropped from about 130,000 tons to 75,000 tons in 1978 (Table 19). The main fisheries are in the areas north and west of Scotland, west and south of Ireland, the Bay of Biscay, the Portuguese coast and off the coast of western north Africa (GRAHAM, 1956; WHEELER, 1969; JONES, 1974).

Table 19. Catch in thousand tons, of European hake (FAO, 1979)

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Catch	141	90	138	130	132	135	119	99	75

For management of this hake, a minimum mesh size was adopted and was required for boats fishing since 1946. In 1959, the North-eastern Atlantic Fisheries Convention was created to manage European hake stocks and other fish resources, and the traditional European hake fishing grounds are now regulated by the international convention (ENGHOLM, 1961; GRINOLS and TILLMAN, 1970).

The potential yield of this hake from the north east Altantic is estimated at around 150,000 tons (GULLAND, 1971).

2. Senegalese hake (*Merluccius senegalensis*)

Distribution :

Senegalese hake is distributed along the coast of western north Africa (Fig. 55). It ranges from "Cape Cantin" (33°N) to "Cape Roxo" (10°N) (CABO, 1965, 1966 ; QUERO, personal communication). According to FRANCA (1956a), it ranges from 30°N to 14°N. This hake was caught by Japanese research vessel cruises off Western Sahara and Mauritania, mainly off Cape Blanco (Fig. 57). The range of depths at which this hake was recorded was from 50 m to 404 m (Fisheries Agency of Japan, 1972; Anon., 1975).

Biology :

The maximum recorded total length of this hake is 81.1 cm and the relationships between age and length determined from otoliths (DOUTRE, 1960) are given in table 20.

About four percent of fishes between 24 cm and 28 cm total length, but 100 percent

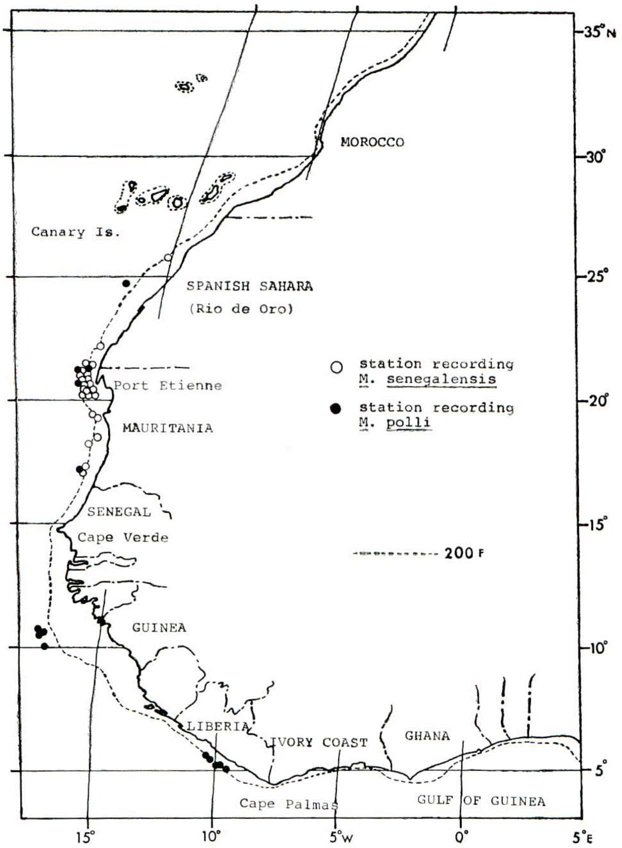

Fig. 57. Distribution of Senegalese hake (*M. senegalensis*) and Mauritanian population of Benguela hake (*M. polli*) surveyed by Japanese research vessels in 1971 and 1974.

Table 20. Relationship between age and length (cm) of Senegalese hake (DOUTRE, 1960)

Age	0 +	1 +	2 +	3 +	4 +	5 +	6 +	7 +
Total length	12.6 -13.7	18.6 -22.9	23.6 -30.2	29.7 -39.4	39.1 -50.3	46.0 -59.2	53.4 -65.1	66.5 -73.1
Mean	13.00	19.90	26.85	33.48	44.95	52.90	58.47	70.05

of fishes over 42 cm total length are mature. The spawning season is probably from January to March and the spawning depth, temperature, and salinity is about 300 m, 12°C and 35.4‰, respectively (DOUTRE, 1960).

Food components are as follows : fishes (*Synagrops microlepis*, *Chlorophthalmus agassizi*, myctophids, *Paracubiceps ledanois*, *Lionurus* sp., *Malacocephalus laevis*, *Trachurus trecae*, *Scomber colias*, *Caranx ronchus*, *Merluccius* sp.) ; crustaceans (*Munida iris*, *Para-*

penaeus longirostris, Plesionika edwardsi, Plesionika heterocarpus) ; and cephalopods (DOUTRE, 1960).

The habitats and migrations are as follows: individuals smaller than 40 cm TL are found in depths around 180 m, those over 40 cm TL migrate to deeper (more than 200 m) areas, and those of 50-70 cm TL inhabit depths of 250-350 m (DOUTRE, 1960).

Fishery :

Compared with other hake fisheries, the fishery is small and the estimated sustainable catch is low (JONES, 1974). Senegalese hake is caught mainly by USSR bottom trawlers in assosiation with European hake and Benguela hake off Western Sahara and Mauritania. Catches were around 100,000 tons from 1973 to 1976 but declined in 1977, because of extension of fishing zones to 200 miles by the coastal countries (Table 21).

The stock size of this hake is not known.

Table 21. Catch in thousand tons, of Senegalese hake, in part including Benguela hake (FAO, 1979)

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Catch	11	11	37	102	103	90	102	65	33

3. Benguela hake (*Merluccius polli*)

Distribution :

Benguela hake is distributed along the west coast of equatorial Africa from Mauritania to Angola (Fig. 55). Its northern limit is around Cape Blanco (20°N) and the southern limit Baie des Tigres (16°36′S) (POLL, 1953).

BLACHE *et al.* (1967) included this species in their faunal list for the eastern Atlantic (from 20°N to 15°S). Research cruises by Japanese vessels found this hake was also present West Sahara (24°49′N) and northern South-West Africa (18°30′S) (Figs. 57, 58). The northern population of this hake (called the Mauritanian population) was caught at depths of 132-910 m off Mauritania, 193-398 m off Liberia (Anon., 1975) and the southern population (called the Angola population) was caught at depths of 50-450 m off Congo and Angola, and 310-550 m off South-West Africa (POLL, 1953; Anon., 1978b). This hake is continuously distributed from Mauritania to Angola through the Gulf of Guinea. In the equatorial region from Guinea to Gabon, it was recorded mainly at the depths of 400-600 m (WILLIAMS, 1968). The distribution of this hake overlaps with that of Senegalese hake off Mauritania and Senegal but Benguela hake inhabits deeper waters. This hake also occurs off Gabon, Congo and Angola as does the Shallow-water Cape hake but inhabits deeper waters (WILLIAMS, 1968; Anon., 1978b).

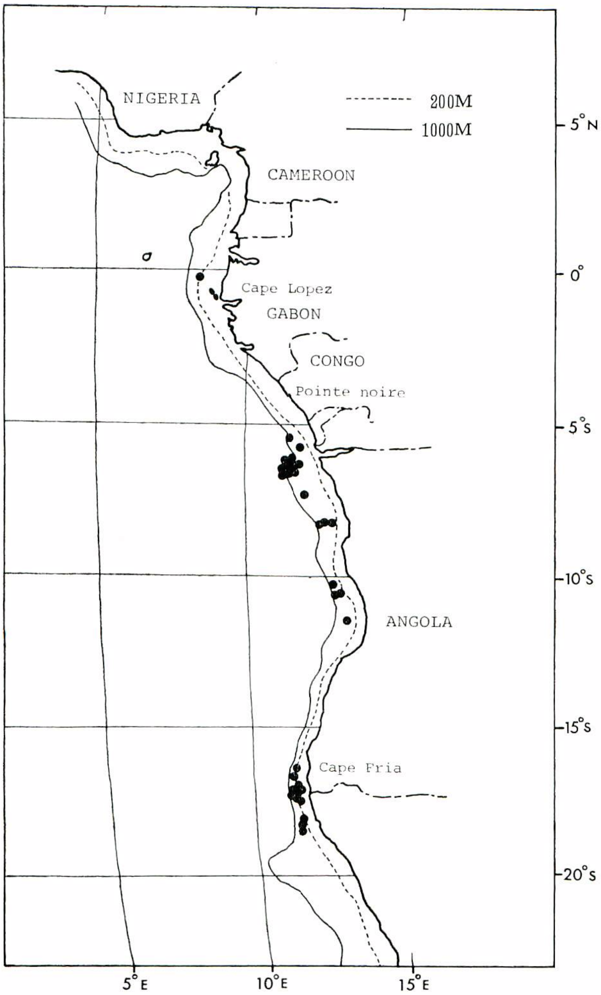

Fig. 58. Distribution of Angola population of Benguela hake (*M. polli*) collected by POLL (1953) and Japanese research vessel in 1977. solid circle ; station recording this hake.

Biology :

The maximum total length recorded for the Mauritanian population of this hake is 61.3 cm and the relationships between age and length as determined from otoliths (DOUTRE, 1960), are given in table 22.

Table 22. Relationship between age and length (cm) of Benguela hake (DOUTRE, 1960)

Age	1	2	3	4	5
Total length	17.1-23.2	20.2-29.1	33.1-35.6	40.9-50.4	54.0-61.3
Mean	20.27	24.18	34.63	47.22	54.97

The largest mode in the length frequency curve is at 21 cm (1-2 years) and smaller ones occur at 26, 34, 40 and 61 cm. Fifteen percent of fish of 34-38 cm TL and all over 38 cm are mature. The spawning season and spawning depth of the Mauritanian population are thought to be almost the same as those for Senegalese hake (DOUTRE, 1960). Reproduction of the Angola population is not known well. The gonad condition was half mature and almost maturing in August and maturing and spent in February for individuals from the northern part of South-West Africa. Those of Rio Muni were mainly ripening females with some ripe running males in late April and spent males in May (WILLIAMS, 1968; Anon., 1978b). The maximum size recorded was from a 65 cm specimen taken off the northern part of South-West Africa (Anon.,1978b).

The habitats and migrations of this species are also similar to those of Senegalese hake (DOUTRE, 1960) and the stomach contents of the Angola population are mainly fishes (*Engraulis* sp., *Hoplostethus* sp.), squids, and shrimps (Anon., 1978b). This hake off the west coast of Africa (4°-12°S) is a single population judging from morphological characters (PCHENITCHNY, 1979).

Fishery :

This hake was not exploited commercially until recently. Some parts of the Mauritanian population have been caught with Senegalese hake off Mauritania (total catch in 1978: 36,000 tons). Small quantities of the Angola population were also caught by Spain and Cuba in 1975 and 1976 and amounted about 60,000 tons in 1978 (FAO, 1979).

Stock size has not been estimated. Results of Guinean Trawling Survey (GTS) show that this hake in the equatorial regions (from Liberia to Cameroun) is considered to be of little economic importance because of low catch rates, the deep habitat, and the relatively small size, under 40 cm TL. (WILLIAMS, 1968).

4. Shallow-water Cape hake (*Merluccius capensis*)

Distribution :

Shallow-water Cape hake is distributed off southern and south-western Africa (Figs. 55, 59). It ranges from Baie Farte (12.5°S) or a little more north (10°S), over the Agulhas Bank in the south, to Port Elizabeth and East London (SMITH, 1949). or Natal (28°S) in the Indian Ocean (NORMAN, 1937; HART, 1948; SVETOVIDOV, 1948; CABO, 1965, 1966; JONES and van ECK, 1967). It is supposed that the northern limit of this hake is further north to near the equator (off Rio Muni and Gabon) (WILLIAMS, 1968). This hake also occurs on the Valdivia Bank (26°18′S, 6°20′E) at depths of 228-283 m (Anon., 1978b). The distribution range of this hake is influenced by the cold, northward flowing Benguela Current along the west coast and is limited by the warm, southward flowing Mozambique Current along the east coast. The area greatest abundance is in the region between Cape Frio (18°S) and East London (QUERO, 1973).

This hake occurs on the continental shelf and the upper part of the slope to 440 m in the Agulhas Bank and mixes with Deep-water Cape hake (*M. paradoxus*) at depths between 200 m and 400 m. In the area north of 28°S (off Lüderitz) this hake occurs in depths to 460 m. It overlaps with Benguela hake north of 18°S. It inhabits waters of between 4°C and 12°C but mainly higher than 8°C (Botha, 1973).

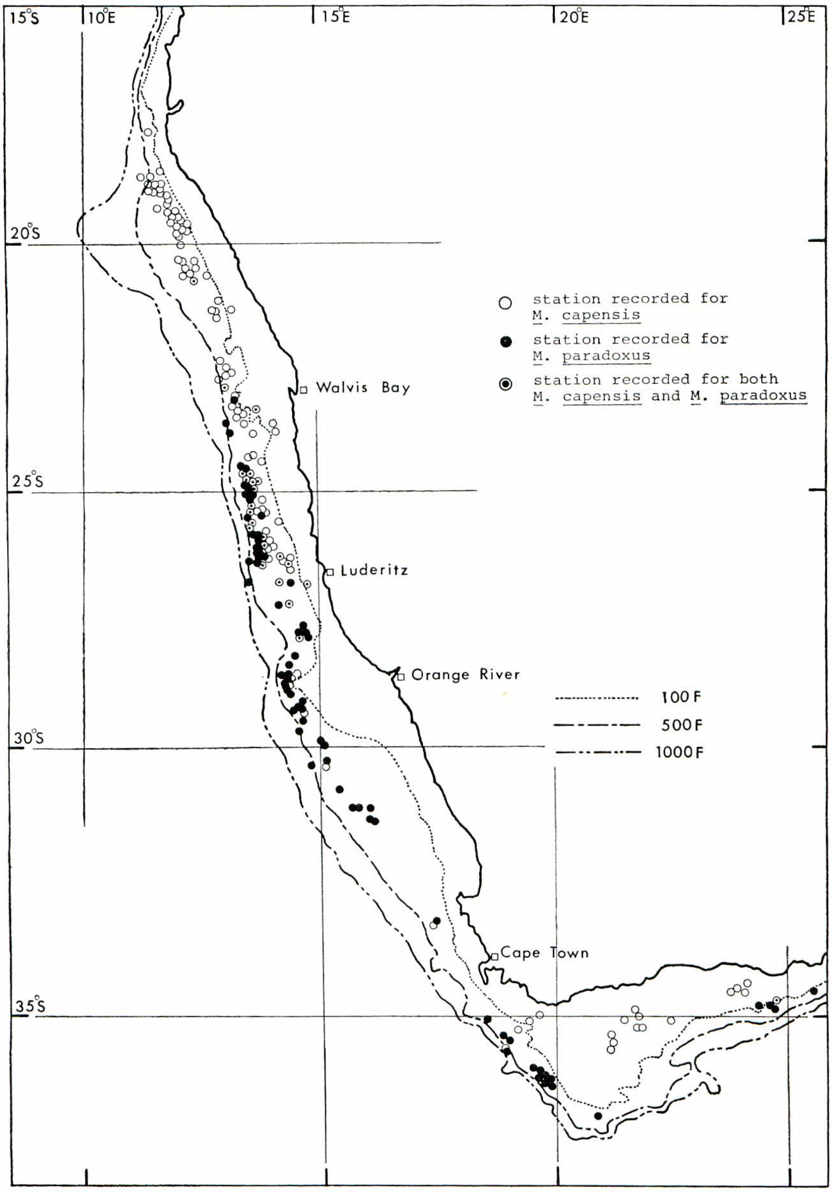

Fig. 59. Distribution of Cape hakes caught by Japanese research vessels in 1971, 1973, 1976 and 1977.

Biology :

The eggs of this hake are spherical with a smooth (unsculptured) membrane, a narrow perivitelline space and a single oil globule. The diameter of eggs range from 0.85 mm to 1.06 mm (mean 0.94 mm) and that of the oil globule from 0.15 mm to 0.26 mm (0.22 mm) (O'TOOLE, 1978). The artificially fertilized and reared eggs hatched after 2 days or 60 hours of incubation. The time between hatching and the development of a functional mouth is 36 hours. The average length of the larva after hatching is 2.35 mm (MATTEWS and de JAGAR, 1951). The eggs and larvae have rather prolonged pelagic existence and the juveniles settle to the bottom at the end of the second year of life (GRINOLS and TILLMAN, 1970).

The relationships between age and length (Table 23) are from BOTHA (1971). Females grow faster than males and this hake grows faster than Deep-water Cape hake (JONES, 1967). The maximum length recorded is about 120 cm (POSTEL, 1966; QUERO, 1973). The sexual maturity of this hake occurs at lengths of 45-60 cm in the Cape region (JONES, 1967), 43.7-50.2 cm off Lüderitz and 33.5-40.9 cm in the vicinity of Cape Peninsula (MOMBECK, 1970a), Fifty percent of males of 45 cm are mature and 50% of females are mature at 60 cm length (JONES and van ECK, 1967).

Table 23. Relationship between age and length (cm) of Shallow-water Cape hake (BOTHA, 1971)

Age	3	4	5	6	7	8	9	10	11
Mean length	29.05	38.81	47.72	55.95	63.41	70.18	76.37	82.01	87.18

This species spawns offshore in deep water from September to November (RATTRAY, 1947; ROUX, 1949; BOTHA, 1973). On the other hand, JONES and van ECK (1967) stated that the main spawning season appears to be from August to September and PCHENITCHNY and ASSOROV (1969) stated that this hake spawns from September to February in depths between 200 m and 300 m north of 25°S.

An extensive study on the distribution of the eggs and larvae off South-West Africa by O'TOOLE (1978), showed the area between Henties Bay and Hollams Bird Island to be an important spawning ground. The occurrence of newly hatched larvae suggests that spawning was continuous from September to April. However, the majority of fish apparently spawned between October and December (midspring to early summer). Newly hatched larvae predominated off Walvis Bay, 50-100 km off the coast.

The size of this hake increases with depth. Fishes larger than 50 cm inhabit in depths between 220 m and 440 m and fishes between 20 cm and 40 cm inhabit depths shallower than 220 m. BOTHA (1973) found that this hake does not exhibit the extensive seasonal horizontal movements at any size class, but tends to be found more often in mid-water during the spawning season. On the other hand, ROUX (1949) pointed out that this hake moves inshore in spring and summer and offshore in autumn and winter. The populations of this hake off South-West Africa (Namibia) show seasonal migrations (KRUGLOV and TRUNOV, 1966). In the southern spring, these populations move to the south and in autumn they move northward. These migrations correspond with the movement north and south of the boundaries between the warm Southern Equatorial Current and the cold Benguela Current. The concentrations of this hake coincide with the northern and southern boundaries of the mixed water zone (17°-24°S) formed by these currents. This hake undertakes diel vertical movements, moving away from the seabed at night and returning to the bottom near dawn. This migration is associated with feeding behavior (RATTRAY, 1947; JONES, 1967).

This hake shows a certain amount of selectivity in its food, and the size of the fish seems to have an important bearing on the type of food eaten. Thus fishes from 25 cm up to about 64 cm eat mainly small crustaceans (Mysidacea, Euphausiacea) and small deep-sea fishes (*Myctophum* sp., *Maurolicus* sp.), while fishes above 76 cm feed chiefly on small hakes, jack mackerels (*Trachurus trachurus*) and to a lesser extent on large-scaled rattails (*Coelorhynchus fasciatus*). Fishes between 64 cm and 76 cm appear to feed fairly evenly on all the major constituents of the diet. Cephalopods (mostly *Loligo* sp.) and prawns (*Solenocera* sp., *Funchalia* sp.) may possibly form minor constituents of the diet (RATTRAY, 1947; DAVIES, 1949).

Fishery:

Shallow-water Cape hake, which is known in South Africa as Stock fish, has been the primary target of the modern trawling industry which has been developed in that country. The fishery for this hake began in South Africa at the end of the 19th century, but statistics of early commercial landings are not available. In the period 1929-1932, the catch of this hake, some 7850 tons, was more than one-third of the weight of all fish landed (HART, 1948). This hake was processed for smoking, quick-freezing, salting and drying, fish liver oils, white fishmeal and in part for canning by the South African fish industry (DREOSTI, 1961).

A new inland market created through technological advances in cold storage facilities and improved railway transportation led to the importation of steam trawlers from the United Kingdom, and the landings of this hake increased steadily in the early 20th century (DREOSTI, 1961). Until 1962 this hake was exploited only by South African vessels working mainly on the Cape Grounds. As the South African trawling industry expanded and fishing effort increased, the catch per unit of effort declined and by 1962 had become reduced to 70 percent of the 1940-1947 level (ROUX, 1949; JONES and van ECK, 1967; JONES, 1974).

In 1962 trawlers from Spain and Japan started fishing in this area. Since then, a number of foreign countries including USSR, Germany, Greece, Israel, Belgium, Portugal, Poland and Korea have sent long-distance freezer-trawlers to this area. As a result, the total catch of this hake increased rapidly from 100,000 tons in 1961 to 300,000 tons in 1965, and the area fished has expanded to the north, particularly off the Orange River and Lüderitz. Fishing depth has also increased to 1,000m (GULLAND, 1971). After 1965, the tatal landings of this hake kept increasing to a peak of over 1 million tons in 1972. Thereafter, the catch declined somewhat to 520,000 tons in 1978 (Table 24). The catch of this hake is still the largest of all the hake catches in the world and constitutes about 90% of the total ground fish caught in the area (NEWMAN, 1977). Landing statistics seldom distinguish between two species (Shallow-water and Deep-water Cape hakes) which are very similar in appearance.

Table 24. Catch in thousand tons, of Shallow-water Cape hake, in part including Deep-water Cape hake (FAO, 1979)

Year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Catch	698	614	762	798	1111	906	738	656	804	598	520

In 1970, the International Commission for the Southeast Atlantic Fisheries (ICSEAF) was created for the management of the fisheries of this area. A 110 mm minimum mesh size for trawl nets was introduced in 1975 and annual quotas were established (NEWMAN, 1977). After the establishment of a 200 mile fishing zone, the resource off South Africa fell under the regulation of that country.

GULLAND (1971) noted that the potential catch of Cape hake stocks off South-West Africa and South Africa is around 620,000 tons. The maximum potential yield in the ICSEAF area in 1975 is estimated 815,000 tons (NEWMAN, 1977).

5. Deep-water Cape hake (*Merluccius paradoxus*)

Distribution:

Deep-water Cape hake is distributed along the continental slope off the southern and south-western Africa (Fig. 55). It ranges from Cape Frio (18°S) to the eastern part of Agulhas Bank to East London or Port Elizabeth (van ECK, 1969; QUERO, 1973). FRANCA (1971) suggested that this hake occurs as far north as 15°S off the coast of Angola (200-300 m depth or more). It is also recorded from the Madagascar Ridge (33°07′S, 44°05′E) in the Indian Ocean, but is not known from the Crozet and Kerguelen Islands (Anon., 1978a).

Its distribution is more offshore than that of Shallow-water Cape hake (Fig. 59). It occurs on the continental slope deeper than 200 m to at least 850 m of the Agulhas Bank and mixes with Shallow-water Cape hake in depths between 200 m and 400 m. In the area north of 28-30°S, this hake occurs at depths greater than 400 m and mixes with

Shallow-water Cape hake between depths of 375 m and 460 m. Depth distribution of this hake tends to be deeper in northern areas (deeper than 450 m) than in southern areas (deeper than 300-350 m) (KAWAHARA and NAGAI, 1980). This hake prefers temperatures between 4°C and 8°C, and is a colder water species than in the Shallow-water Cape hake.

Biology:

BOTHA (1971) described the growth of this hake (Table 25). It is clear that females grow faster than males.

Table 25. Relationship between age and length (cm) of Deep-water Cape hake (BOTHA, 1971)

Female

Age	3	4	5	6	7	8	9	10	11
Mean length	32.58	41.73	49.77	57.34	63.26	68.90	73.90	78.30	82.23

Male

Age	3	4	5	6	7
Mean length	31.28	39.43	45.38	49.73	52.93

The probable spawning season is from September to November based on the following evidence: (a) gonad activity increases to a peak in August, (b) the greatest percentage of ripe gonads were obtained during September, (c) no ripe and running fishes were found in any other months of the year, and (d) spent gonads were found in increasing numbers from October onwards and reached a peak in February (BOTHA, 1973). PCHENITCHNY and ASSOROV (1969) stated that this species spawns from October to May in deep water south of 25°S.

Size increases with depth. Fishes larger than 50 cm (mode, 56-62 cm) inhabit waters deeper than about 500 m and comprise maturing schools. Fishes between 20 cm and 40 cm (mode, 37 cm) inhabit range between 260 m and 400 m and form schools of males and immature females (BOTHA, 1973). No marked horizontal movement is shown by this hake throughout the year (BOTHA, 1973).

Food consists of fishes (Myctophids, Stomiatids, Merlucciids, etc.), mysids, euphausiids, and squids. In the younger stages this hake feeds mainly on euphausiids, but the diet changes to polyphagous with growth.

Fishery:

Catch statistics of this species are not separated from Shallow-water Cape hake because of their similar appearances. Deep-water Cape hake has probably been a significant catch component in foreign catches since 1962.

The stock size has not been estimated.

6. Silver hake (*Merluccius bilinearis*)

Distribution:

Silver hake is distributed along the Atlantic coast of Canada and the United States (Fig. 60). It ranges from the southern and eastern part of the Gulf of St. Lawrence and southern Newfoundland to off South Carolina (GINSBURG, 1954; MCKENZIE, 1956; LEIM and SCOTT, 1966). Some authors recorded this hake from the Bell Isle Channel (52°N) and deep water off the Bahamas (24°N) (NORMAN, 1937; SVETOVIDOV, 1948). HART (1948) linked the northern, abundant part of the distribution (between Nova Scotia and New York) with a hydrographic feature caused by the Labrador Current.

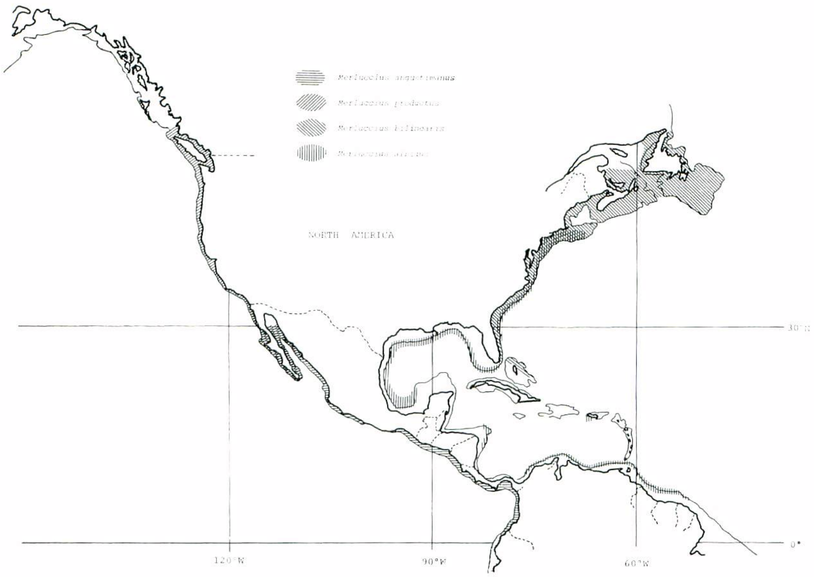

Fig. 60. Distribution of merlucciids in the both sides of North American waters

Silver hake are found in both shoal and deep water within a wide temperature range, usually over bottom of sand or sand-silt mixtures (FRITZ, 1965). This hake is found near shoals, where it sometimes strays (TYLER, 1971), to depths of over 920 m (LEIM and SCOTT, 1966). But the deeper records for this species may actually be *M. albidus*. It is especially abundant at depths of 80 m to 300 m on the sandy grounds of the continental shelf (LEIM and SCOTT, 1966).

Biology:

Silver hake produces buoyant, transparent and spherical eggs, whose diameter ranges from 0.70 mm to 1.11 mm. It has a small yellowish or brownish oil globule about 0.19 mm to 0.26 mm in diameter (KUNZ and RADCLIFFE, 1918; SAUSKAN and SEREBRYAKOV, 1970). The incubation period is 2 days (at 7.0°-13.0°C). The length of larvae just hatched is 2.8 mm. The length of pelagic life is about 2 months and larvae descend to the bottom after they attain 17.0-20.0 mm, near the end of summer or early autumn (BIGELOW and SCHROEDER, 1953). The larvae are apparently concentrate near the thermocline during summer (FAHAY, 1974). The development of eggs and larvae is similar to the development observed for other hake species (SAUSKAN and SEREBRYAKOV, 1970). After they shift their habitat to the bottom, they undertake diel vertical migration. Those living in deeper water pursue food in a pelagic fashion, coming near the surface, chiefly at night (LEIM and SCOTT, 1966; VINOGRADOV, 1971). On the other hand, RIKHTER (1968) noted that the high night catches with bottom trawl indicate an absence of nocturnal upward migration.

This hake grows to 3-8 cm by the first fall, to 6-17cm by the next April and to 24-28 cm at 2 years of age. It reaches a maximum length of 76 cm and 2.3 kg (LEIM and SCOTT, 1966; POSTEL, 1966). NICHY (1969) noted that fish reached 8-9 cm off southern New England and 12 cm in the Gulf of Main in the first winter. Females grow faster than males.

Spawning takes place in the slope regions of Georges Bank from May to September, and in the shelf regions of Nova Scotia from Halifax to the Sable Islands from July to October. The most intensive spawning is in the regions of the southeastern and southern slope of Georges Bank from June to July and on the Sable Island Bank in August-September (SAUSKAN and SEREBRYAKOV, 1970; FAHAY, 1974). North of Cape Cod spawning is most prevalent from July to August, at depths from 100 m to 550 m, temperatures from 5°-7°C to 12°-15°C, and salinity from 31.5‰ to 32.5‰ (FAHAY, 1974).

Distribution is related to life stage and annual and seasonal variations in hydrological conditions. Depending upon their biological state, Silver hake requires definite hydrographic conditions which are largely affected, directly or indirectly, by water temperatures (SARTINS and SAUSKAN, 1967). The species exhibits a seasonal onshore-offshore migration. Spawning adults and feeding juveniles move inshore during the spring and when winter cooling occurs on the shelf, they migrate to warmer water on the continental edge and slope. It is suggested that they also undertake a latitudinal seasonal movement (LEIM and SCOTT, 1966). During the fall they move toward the south and then return to more northerly waters during late spring.

Silver hake consists of two morphologically separable and nonmingling populations roughly separated by the 41.5°N parallel. One population is found in the Gulf of Maine and the northern edge of Georges Bank, while the other is located at the southern slope of Geoges Bank and the continental shelf south and west of Cape Cod (CONOVER *et al.*, 1961; NICHY, 1969).

LANGTON and BOWMAN (1980) studied the food habits of this hake. Silver hake is voracious and cannibalistic. Fishes are the major prey for larger Silver hake over 40 cm FL. The primary food is gadids, including Silver hakes. Atlantic herrings (*Clupea harengus harengus*), Atlantic mackerels (*Scomber scombrus*), alewives (*Alosa pseudoharengus*), butterfishes (*Peprilus triacanthus*), horned lanternfishes (*Cetraoscopelus maderensis*), sand lances (*Ammodytes*), snake blennies (*Lumpenus lampetraeformis*), smelts (*Osmerus mordax*) and silversides (Atherinidae) are also eaten. Smaller Silver hake preys on crustaceans, with Euphausiacea (*Meganyctiphanes norvegica* etc.) and Pandalidae (*Dichelopandalus leptocerus* etc.) being the most important. Shrimps (*Crangon septemspinosa* and *Pasiphaea*), cephalopods (*Loligo* and *Rossia*) and molluscs are eaten in small quantities.

Fishery:

In early days Silver hake was regarded as a trash fish by New England fishermen, and also as a great nuisance when large numbers were caught in herring and mackerel pound nets (GOODE, 1884; HART, 1948; JENSEN, 1967). Silver hake did not salt well, and the flesh became soft and tastless unless refrigerated or eaten very soon after capture (JENSEN, 1967; GRINOLS and TILLMAN, 1970). Around 1840 New England fishermen began catching Silver hake for the local fresh markets. Later, it was also used for manure or as bait in the hook-and-line fishery for spiny dogfish. During this period most hake were still caught in pound and trap nets. The price was too low for offshore fishermen to bring in those they caught (GOODE, 1884; BIGELOW and WELSH, 1925).

A limited fishery for hake continued during the 1920's, mostly to supply fried-fish shops in north-central United States. An active food fishery began in the 1930's when a market for frozen hake was developed (JENSEN, 1967; GRINOLS and TILLMAN, 1970). This market continued to grow, and by 1940 nearly half of the annual catch was being frozen, and amounted to as much as 11 percent of all frozen fish produced in the United States, becoming the most important single species of the frozen fish trade. This rapid development of the market was realized by a big change in fishing methods, with more being taken in otter trawls than in pound nets (HART, 1948). In recent years, Silver hake has been made into meal for the animal food and other industrial markets, but human consumption still accounts for the greatest proporton of the U.S. catch. Silver hake are frozen in the round, headed and gutted or filleted (FRITZ, 1960; JENSEN, 1967; GRINOLS and TILLMAN, 1970). Product diversification provided the basis for the expansion of the fishery into the second most important industrial species on the east coast (FRITZ, 1960; GRINOLS and TILLMAN, 1970).

After 1962 a large USSR high-seas fleet entered the Siver hake fishery and the catch exceeded 300,000 tons in 1964 and over 400,000 tons in 1973, but then the catch decreased suddenly (Table 26). The main fishery for this hake takes place off the coast of Nova Scotia, in the Gulf of Maine, and on Georges Bank, in depths up to 220 m

(JONES, 1974; L'HERROU, 1972).

The International Commission for the Northwest Atlantic Fisheries (ICNAF) was formed in 1950 because of concern over the stocks of fishes in the area. ICNAF had the authority to apply regulatory measures to conserve the demersal fish resources including Silver hake stocks until the establishment of the 200 mile limit by the U. S. A. in 1977 (ENGHOLM, 1961; MÖCKLINGHOFF, 1973).

Table 26. Catch in thousand tons of Silver hake (GULLAND, 1971 ; FAO, 1979)

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969
Catch	48	98	272	309	370	268	126	102	144

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Catch	222	236	233	435	225	232	178	113	86

Preliminary assessment of Silver hake in the New England area (sub-area 5 of ICNAF) suggests that by 1965 fishing effort had reached a level beyond which no substantial increase in average catch could be expected, and that the greatest average catch from this area would be 300,000-400,000 tons (GULLAND, 1968). The estimated catch potential of this hake in the Northwest Atlantic is 350,000-500,000 tons (GULLAND, 1971).

7. Offshore hake (*Merluccius albidus*)

Distrbution:

The Offshore hake is distributed along the Atlantic coast of the United States, Gulf of Mexico and Caribbean Sea (Fig. 60). It ranges from the Georges Bank, New England (40°46′ N) to the Orinoco Delta, Venezuela (8°N) (KARNELLA, 1973). This hake inhabits the outer part of the continental shelf and upper part of the continental slope. In this zone (beyond the 80 m isobath) this hake intermingles with the offshore fringe of the population of Silver hake, but does not range northward beyond Georges Bank (CABO, 1965, 1966; BIGELOW and SCHROEDER, 1955). Offshore hake overlaps with Argentine hake, *M. hubbsi* at the southern end of its distribution (vicinity of Rio de Janeiro, Brazil) (RIBEIRO, 1915; CERVIGON, 1966; VERGARA, 1978). But the specimens recorded from the coast of Brazil are the northerly stragglers of *M. hubbsi* (CARVALHO, 1950; MATSUURA, personal communication).

It inhabits depths between 92 m and 1,170 m on the New England slope, between 142 m and 1,100 m in the Gulf of Mexico, between 200 m and 795 m in the Caribbean Sea including the insular slope of the Antilles (GINSBURG, 1954; ROHR and GUTHERZ, 1977) and between 250 m and 550 m off Surinam and French Guiana. The center of abundance for this hake lies between 185 m and 550 m on the New England slope. The temperature at which the species was taken in 1953 ranged from 11.7°C down to 3.3-3.9°C, with the greatest majority of the catch made at 4.7-111.°C (BIGELOW and SCHROEDER, 1955).

Biology:

The fertilized egg is pelagic, spherical, transparent, and has a narrow perivitelline space. The average diameter is 1.10 mm. The single oil globule averages 0.32 mm. The egg and developing embryo are colorless until after the tail has partially separated from the yolk mass. Pigmentation is found on the body, yolk mass and oil globule. All larvae hatch in a relatively undeveloped condition between 6 and 8 days after fertilization. At hatching, the length of prolarvae averages 3.54 mm and ranges from 3.05 mm to 3.75 mm. The prolarvae have a group of melanophores in the jaw region and on the posterior part of the head (MARAK, 1967).

The length and age relations presented for the northern Gulf of Mexico population (Table 27) were based on length frequency data tentatively. Juvenile males and females are about the same size, but males are slightly larger than females at age 1^+. However, females become significantly larger by age 2^+ and the difference becomes more evident as the fish get older (ROHR and GUTHERZ, 1977).

Table 27. Preliminary figures of length (in cm) at age by sexes on the northern Gulf of Mexico population of *Merluccius albidus* (ROHR and GUTHERZ, 1977)

Age (yr)	0^+	1^+	2^+	3^+	4^+	5^+
Males	10.5	21.5	26.5	29.5	—	—
Females	10.5	20.5	31.5	36.5	40.5	44.5

The largest male and female were 404 mm SL and 680 mm SL respectively. Length frequency data imply that males rarely live longer than 3 years whereas a large number of females live at least 5 years. The exact life-span of this species is unknown (ROHR and GUTHERZ, 1977).

There is a total absence of male in trawl catches from depths greater than 550 m. Gonad maturation data suggest that spawning occurs near the bottom in depths of 330 m to 550 m. Spawning occurs in New England from April to July and in the Gulf of Mexico and Caribbean Sea from late spring to early autumn. The Caribbean population may spawn later than that of the Gulf of Mexico.

Fecundity of this hake is estimated 340,000 eggs by a 680 mm SL specimen. Since the estimated number of eggs is somewhat similar to that of *M. productus*, the fecundity of the two species may be similar (BIGELOW and SCHROEDER, 1955; ROHR and GUTHERZ, 1977).

Offshore hake is segregated by size and sex along a depth gradient. The juvenile of both sexes, younger adult females and adult males occur on the upper slope in less than 550 m. The large, mature females occur in depths greater than 550 m.

Prey species exhibit diel movement, but the similarity between day and night catch rates of this hake suggests that Offshore hake does not move far off the bottom in persuit of prey. These prey species apparently move to the bottom where they become available to *M. albidus* (ROHR and GUTHERZ, 1977).

Offshore hake preys most heavily on fish. The Gadidae contribute more than half of the diet. In the Gulf of Mexico, fishes are made up about 75% of their diet, with species of *Steindachneria argentea* (Merlucciidae) and Myctophidae are consumed most frequently. About 20% of the specimens examined had been feeding on juvenile *M. albidus* indicating some degree of cannibalism. Crustaceans are of secondary importance, consisting of pandalid shrimps (*Dichelopandalus leptocerus* and *Panalus*), euphausiids (*Meganyctiphanes norvegica*) and the pelagic shrimps (Pasiphaea). *Penaeopsis megalops* (Penaeidae) was the dominant shrimp found in stomachs of Offshore hake in the Gulf of Mexico (LANGTON and BOWMAN, 1980). The type and size of prey change by growth of hake as follows; juveniles contained primarily shrimps with a few fragments of fishes and squids; maturing adults contained a variety of fishes especially trichiurids, crustaceans and squids; adults contained primarily stomiatoidei fishes, macrourids, trichiurids, caridean shrimps and squids (ROHR and GUTHERZ, 1977).

Fishery:

It seems that there is no fishery for this species except as a by-catch in the Silver hake fishery in the northern area of the Atlantic coast of the U.S.A. and minor local fishing in the southern area. Catch statistics for this species are reported only by Cuba and the U.S.A. (negligible quantities in 1975) (VERGARA, 1978).

GULLAND (1971) pointed that this hake occurs in commercial quantities in the western Gulf, off southern Texas in deep water (100-500 m). Density estimates of a maximum 11 kg/hectare, average 3 kg/ha and minimum 0.5 kg/ha imply a small overall population of Offshore hake in the northern Gulf of Mexico (biomass: 3.30×10^6 kg). However, these estimates must be considered minimum as they are based on catches taken with bottom trawls with small vertical openings. Other species of hake are reported to form large dense schools within a few fathoms above the bottom, suggesting that, if Offshore hake behave similarly, mid-water trawling as well as bottom trawling must be used to obtain accurate assessment data (KLIMA, 1976; ROHR and GUTHERZ, 1977).

8. **Pacific hake (*Merluccius productus*)**

Distribution:

Pacific hake is distributed off the west coast of North America (Fig. 60). It ranges from the Gulf of Alaska to the Gulf of California (GOODE, 1884; STARKS and MORRIS, 1907; WILIMOVSKY, 1954; NELSON and LARKINS, 1970). It mixes with Panama hake throughout the southern extent (northern part of Mexico) of its distribution (CABO, 1965, 1966; GRINOLS and TILLMAN, 1970). In the northern part of its range this hake is seldom taken and throughout much of the Gulf of Alaska it is apparently replaced by Pacific cod (*Gadus macrocephalus*) and walleye pollack (*Theragra chalcogrammus*) (ALVERSON *et al.*, 1964). It is common along the whole British Columbia coast. The major concentrations of this hake appear to be associated with the areas influenced by the California Current, which lies between lat. 23°N and 48°N, of the Pacific coast of North America (SVERDRUP *et al.*, 1961; ALVERSON *et al.*, 1964). Although most adults are caught on the continental shelf, this hake occurs from shallow shelf waters (or surface and estuarine waters) to depths of 900-1,000 m (CLEMENTS and WILBY, 1961; BEST, 1963; ERMAKOV and POLUTOV, 1967).

Biology:

Pacific hake produces pelagic, spherical, clear and smooth eggs which are found mostly near the thermocline at depths of about 45 m to 100 m. It has a tough, transparent, unsculptured shell membrane and contains a single, large oil globule in the unsegmented yolk. The average diameter of egg is 1.12 mm (range 1.07-1.18 mm) and the average diameter of oil globule is 0.30 mm (0.27-0.34 mm) (AHLSTROM and COUNTS, 1955). Under usual conditions, hatching takes place in about 3 days or less. Larvae emerge before a functional mouth develops and before the ocular pigment appears. During the early stages of their postembryonic existence larvae are sustained by nutrients from the large yolk-sacs. Juveniles apparently have a pelagic existence for at least 1 or 2 years (AHLSTROM and COUNTS, 1955). One-year old hake are found in inshore waters off southern California, associated at times with schools of northern anchovy, *Engraulis mordax* (DARK *et al.*, 1970).

The growth of this hake is rapid during the first three-year after which it slows and approaches an asymptoto in the oldest ages, 10-13 years. This hake exhibits sex-specific rates of growth in which females ultimately become larger than the male and tends to survive 2 or 3 years longer, to age 13 (GRINOLS and TILLMAN, 1970; DARK, 1975). or may live to age 16 (FISCUS, 1979). The relationship between age and length (BEST, 1963) is shown in Table 28. Recently, BEAMISH (1979) described the new methods to determine the age of Pacific hake from otoliths.

This hake begins to mature by age 3 and most are mature by age 4 at about 35-42 cm in length. Average length of mature fish varies with locality, e.g., mature fish off Washington averages 52 cm, but mature fish off northern California averages about 47 cm (NELSON and LARKINS, 1970; FISCUS, 1979). MACGREGOR (1971) noted a marked cline in size at first maturity for female hake; from 140 mm standard length off southern Baja California to about 340 mm off northern Baja California and southern California. He considers the populations off southern and central Baja California to be *M. productus*. The differences in size at maturity between areas were thought to be a geographic cline by latitude, similar to the distribution and growth patterns of European hake. He acknowledged the possibility that these populations might be composed of a different species, *M. angustimanus* (MACGREGOR, 1971).

Table 28. Relationship between age and length (cm) of Pacific hake (Best, 1963)

Age	1	2	3	4	5	6	7	8	9	10	11	12	13
Average length	15.5	27.4	35.4	38.7	39.8	48.1	50.8	54.4	54.5	57.9	58.6	61.6	61.3
Size range	8-23	21-37	31-42	33-46	36-49	40-52	43-56	46-62	47-61	50-61	52-63	52-68	53-69

The maximum size for males was 66 cm and for females it was 76 cm (Best, 1963) and the maximum length recorded for a fish which was not sexed was 91 cm (Postel, 1966; Hart, 1973). Males attain an average weight of about 1.2 kg by age 11 and females reach an average weight of about 1.4 kg by age 13 (Dark, 1975).

Spawning occurs mainly in the southern part of the range, off southern California and Baja California, in deep waters. The effective northern limit of spawning is probably near the latitude of San Francisco, California. It appears that the adults migrate farthest northward, and as a result there are relatively more juveniles in the south in summer. The available evidence seems to indicate that Pacific hake in Mexican waters belong to the same stocks as the hake further north (Nelson and Larkins, 1970). In spawning schools sex ratios favor males. The parcentage of males in spawning populations may be twice that of inshore, feeding coastal populations. Similar sex ratios are found for spawning schools in Puget Sound. Mature Pacific hake is only found at the northern end of their distribution whereas mature as well as younger and smaller specimens appear in more southerly areas (Grinols and Tillman, 1970). Males are recorded as being ripe in May in Puget Sound. Off northern Mexico and southern California spawning takes place in winter and spring (from January to April or June) at intermediate depths where the bottm is 1,000 m deep or more (Ahlstrom and Counts, 1955; Shippen and Alton, 1967; MacGregor, 1971). The spawning time of geographically distinct populations varies by latitude - the more northern populations spawn later in the year than the southern (Grinols and Tillman, 1970). According to Kramer and Smith (1970), the larvae appear first in December just south of Point Conception. In January and February, the major centers of larvae abundance extend from Point Conception to Magdelena Bay in a widening band. The distribution of larvae spreads offshore and northward during March and April but disappears from these areas in May and June. Fecundity in California is reported as 3,400 for 13 cm females and 496,000 at 69 cm. Although two sizes of yolked eggs are present in the ovaries, the peculiarities of the distribution and the relatively short spawning season indicate that the species spawns only once a year (MacGregor, 1966, 1971).

Temporal and areal distribution of the various life history stages suggests that adult Pacific hake undertakes extensive annual migrations along the west coast of North America (Alverson and Larkins, 1969; Nelson and Larkins, 1970). Adult hake appears on the continental shelf and slope in April and early May off central and northern California and southern Oregon. They first occur off northern Oregon and Washington in April; however, they are most abundant from June through September in 37-274 m. From July into September new incursions of adult hake appear from southern Oregon northward to the Vancouver Island area. In late September this hake begins to move off the continental shelf into the deeper waters of the slope and by December most adults are gone from the area - presumably moving southward to the spawning area. Feeding groups of adult hake undertake pronounced diel vertical movement. During the day, These fishes are found on the continental shelf in characteristical school of long, dense, relatively narrow bands. Rather than being completely continuous, these bands are usually composed of distinct clusters. The long axis of a school is nearly always parallel to the isobaths. Hake schools near the edge of the continental shelf or over the continental slope show more variation in their schooling characteristics than those found on the shelf. Over the slope, hake schools are well off the bottom without definite orientation to bottom contours. Schools over the edge of the continental shelf are often at a constant depth from the surface. These schools rise and disperse in the water column during the evening. During darkness hakes are scattered throughout the water column. By dawn, schools have regrouped near the seabed but necessarily near the areas from which they had dispersed (Nelson and Larkins, 1970). These diel movements probably are related to the movement of their euphausiid prey. During their spawning period mature hakes are more pelagic in behavior than during the rest of the year and demonstrate little diel movement. It is observed that this hake stops feeding before spawning and feeds ravenously afterward in Puget Sound (Nelson, 1969).

Pacific hake feeds on a large variety of fishes and invertebrates. Juvenile hake feeds on pelagic red crabs (*Pleuroncodes planipes*), euphausiids (*Thysanoessa spinifera*, *Euphausia pacifica*) and small squids (*Loligo opalescens*). Stomach contents of adult hakes consist of anchovies (*Engraulis mordax*), small hakes, queenfishes (*Seriphus politus*), sanddabs (*Citharichthys* spp.), slender soles (*Lyopsetta exilus*), curlfin turbots (*Pleuronichthys decurrens*), pink seaperches (*Zalembius rosaceus*), euphausiids, clams (*Solemya panamensis*) and large squids. The food of adult hake off the British Colombia coast consists primarily of euphausiids and sand lances (*Ammodytes hexapterus*), and to lesser extent herrings (*Clupea harengus pallasii*), smelts (Osmeridae), sablefishes (*Anoplopoma fimbria*), anchovies and shrimps. In northern California hake eats ocean shrimps (*Pandalus jordani*), brills (*Eopsetta* sp.), slender soles (*Lyopsetta exilis*), eulachons (*Thaleichtys pacificus*), tomcods (*Microgadus proximus*) and other fishes. Evidence suggests that this hake is mainly a nocturnal feeder. The feeding behavior clearly demonstrates their opportunistic habits. The availability of this hake is related to the species of forage organisms. The predominance of a single food organism in the stomach of this hake reflects more on the availabilty of that organism than selection of any particular species (Gotshall, 1969; Alton and Nelson, 1970; Fiscus, 1979).

This hake in turn is a handy food item for larger predatory fishes. Young hakes often are food for several species of rockfishes and albacore tunas (*Thunnus alalunga*), arrowtooth flounders (*Atheresthes stomias*) and bigmouth soles (*Hippoglossina stomata*). Adult hakes are eaten by Pacific lancetfishes (*Alepisaurus richardsoni*), bluefin tunas (*Thunnus thunnus*), sablefishes (*Anoplopoma fimbria*), lingcods (*Ophiodon elongatus*), soupfin sharks (*Galeorhinus zyopterus*), great white sharks (*Carcharodon carcharias*), electric rays (*Torpedo californicus*) and dogfishes (*Squalus acanthias*). Otoliths of this hake have been found in the stomach of several marine mammals including sea lions (*Zalophus californianus*), elephant seals (*Mirounga augustirotris*) and porpoises (*Lagenorhynchus obliquindes, Phocoenoides dalli*) (Best, 1963; Shippen and Alton, 1967; Nelson and Larkins, 1970).

Fishery:

In 19th century, Pacific hake was scarcely saleable in the San Francisco market and its value as a food-fish was nil (Goode, 1884). The commercial exploitation of this hake was limited to a small fishery for animal food in northern California and to incidental catches taken mainly in fisheries for groundfish (Best, 1963). Despite the existence of this large resource, the fishery on this hake has for a long time remained at a very low level (Nelson, 1969). In 1965, USSR started to exploit these stocks at a substantial level. By 1967 the catch had reached about 170,000 tons and thereafter it remained at about this level until 1973 (Table 29), except for some sudden drops in 1968, 1970 and 1972. The catch rose to over 200,000 tons in 1974 and remained at that level up to 1976. Under the Fishery Conservation and Management Act of 1976, it was recommended that the total allowable catch in 1977 off the U.S. west coast (California to Washington) be set at 130,000 tons. Of the foreign fleets, only the USSR and Poland fished for this hake in 1977 (Anon., 1977; Fiscus, 1979).

Table 29. Catch in thousand tons, of Pacific hake (FAO, 1979)

Year	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Total	108	172	117	183	119	164	207	230	238	126	101

Following Boerema (1977), standing stock estimates have been made using data from eggs and larvae surveys. Ahlstrom (1968) compared hake and jack mackerel larval numbers and estimated the standing stock of Pacific hake at 2-4 million tons. The figure modified by Gulland (1971) to 1.3 million tons by comparing hake and sardine larval numbers and using available independent estimates of the sardine biomass. In 1969, the size of the adult hake stock over the entire range of distribution was estimated to be

2.6 million tons from egg and larvae surveys (KRAMER and SMITH, 1970). ALVERSON (1968) gave a original standing stock estimate of 0.68 million tons north of 42°N, based on trawl and acoustic surveys, which is in agreement with the figure of 1.3 million tons for the whole area. From the estimate of total standing stock, GULLAND (1971) obtained an estimate of total potential yield of 360,000 to 460,000 tons. A recent estimate of population size from a 1977 survey by DARK *et al.* (1979) is about 1.2 million tons. USSR and U. S. estimates of maximum sustainable yield based on trawl hydroacoustic surveys range from 120,000–270,000 tons (DARK, personal communication).

Following the results of a demersal trawl survey carried out in the Gulf of California, it has been estimated that the portion of the population in that area has a biomass of about 28,000 tons and that the potential yield of this stock may amount to about 5,000 tons annually (MATHEWS *et al.*, 1974).

9. Panama hake (*Merluccius angustimanus*)

Distribution:

Panama hake is distributed off the west coast of North and Central America and northern part of South America (from California to Colombia) (Fig. 60). Its northern limit is off Del Mar, California (32°57′N) and the southern limit is off Ensenada de Tumaco, Colombia (1°59.5′N) (GINSBURG, 1954; TESTAVERDE and ARTUDUAGE, 1974). Records of this hake are as follows: off Point Mala, Gulf of Panama (GARMAN, 1899), Gulf of California (LAVENBERG and FITCH, 1966; MATHEWS *et al.*, 1974; MATHEWS, 1975), off Bahia de Ballenas and off Santo Domingo, west coast of Lower California (GINSBURG, 1954) and off Buenaventura, Colombia (TESTAVERDE and ARTUNDUAGE, 1974). This hake was also recorded from Uncle Som Bank (25.5°N, 113.5°W) (Fisheries Agency of Japan, 1974).

The recorded depths range from 256 m to 311 m (off Colombia), 232 m to 525 m (Gulf of Panama), 640 m (mid-water off Del Mar, Calif.). 80 m to 500 m (from Isla San Pedro Nolasco to Mazatlan in the Gulf of California) and 86 m to 1,872 m (mid-water off the west coast of Lower California). On the Uncle Som Bank, it was recorded from depths between 102 m and 465 m and bottom temperatures between 7.9°C and 12.9°C.

In the northern part of the Gulf of California this hake was found at depths between 100 m and 500 m and all specimens were very small (MATHEWS *et al.*, 1974).

Biology:

Biological data on Panama hake is rare, and information on the population from the Gulf of California has only become available. Following the study of MATHEWS (1975) on the ecology of a population in the south-east Gulf of California, the age and growth of this hake is as follows (Table 30).

It lives up to seven years, and may reach 39 cm long although it does not usually exceed 32 cm. It was estimated that spawning began in April in 1971, and continued until

June or later. The minimum maturation length was 18–19 cm for both sexes. During a CalCOFI (California Cooperative Oceanic Fisheries Investigations) survey for adult spawning hake in January 1970, a number of small female hakes with ripening eggs were collected at a latitude approximately that of Magdelena Bay and just to the north. These hakes were maturing at sizes (126–202 mm) much smaller than expected for *M. productus*. These were a separate stock or *M. angustimanus* and spawned off Baja California about March or April (KRAMER and SMITH, 1970).

Table 30. Relationship between age and length (cm) of Panama hake (MATHEWS, 1975)

Age	2	3	4	5	6
Mean length	14.0	20.5	25.0	27.0	29.0

Fishery:

Because Panama hake is relatively rare and small in size, it has not been commercially exploited. In the Gulf of California the abundance of this hake was greatest in February and March, when the total biomass was estimated at about 280,000 tons (MATHEWS *et al.*, 1974).

10. Chilean hake (*Merluccius gayi*)

Distribution:

Chilean hake is distributed along the west coast of South America from northern Peru to central Chile (Fig. 61). This hake consists of Peruvian and Chilean subspecies.

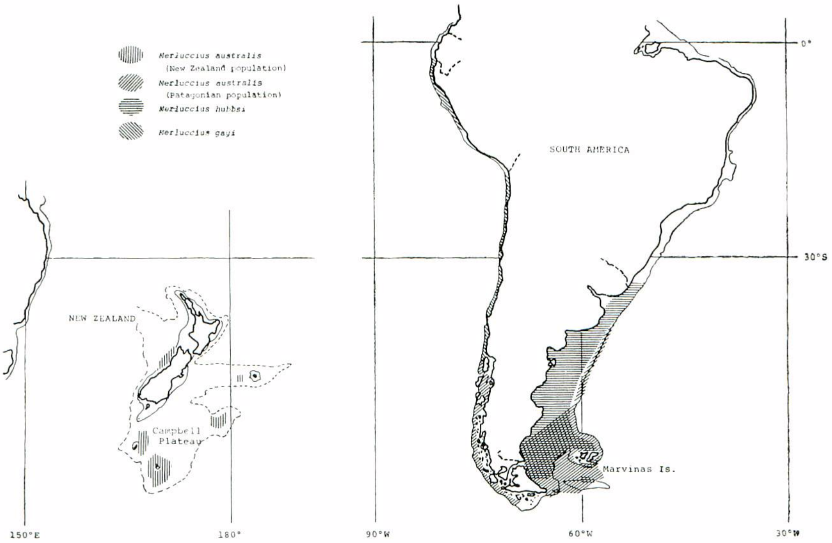

Fig. 61. Distribution of merlucciids in New Zealand and South American waters

The Peruvian subspecies (Peruvian hake) is distributed along the west coast of Peru. Its northern limit is around the Mancola Bank (3°45′S) or Paita (5°S) (Everman and Radcliffe, 1917). But Norman (1937) and Svetovidov (1948) noted that this hake extends northward to the Gulf of Panama and Boerema (1977) noted that this stock extends into Ecuadorian waters, to about 00°30′S latitude. Its southern limit is in about lat. 14°S in normal years, although in years when coastal sea surface temperatures rise above normal and the upwelling of cold water along the coast disappears (called El Niño), it may be found at least as far south as 18°S. There is no contact with the Chilean subspecies, although even if there were, it would be small, because of the narrow continental shelf and the presence of hydrogen sulfide in bottom layers between 13°S and 19°S. A dense population of this hake was found from Punta Parinas (4°41′S) to Huarmey (10°16′S) between 70 m to 200 m (Fig. 62) (Del Solar, 1968; Tabeta *et al.*, 1971). This hake mainly inhabits range of 45 m to 500 m with bottom temperatures of 8.0°C and 13.5°C (Doi, 1969a, 1971).

The Chilean subspecies (Chilean hake) is distributed along the west coast of Chile. Its northern limit is in the area off Coquimbo around lat. 30°S and the southern limit at the Chiloe Island (around lat. 44°S). This hake appears to be divided from the Peruvian hake at the northern part of Chile (north of Coquimbo), although there are a few records from several places along that coast: off Arica (19°S), off Caldera (26°21′S) and off Taltal (25°S) (Doi, 1969b, 1971; Trujillo, 1972) (Fig. 62). Svetovidov (1948) noted that the southern limit of this hake is in the Strait of Magellan and Tierra del Fuego, and Trujillo (1972) also noted its southern limit at Diego de Almagro Island

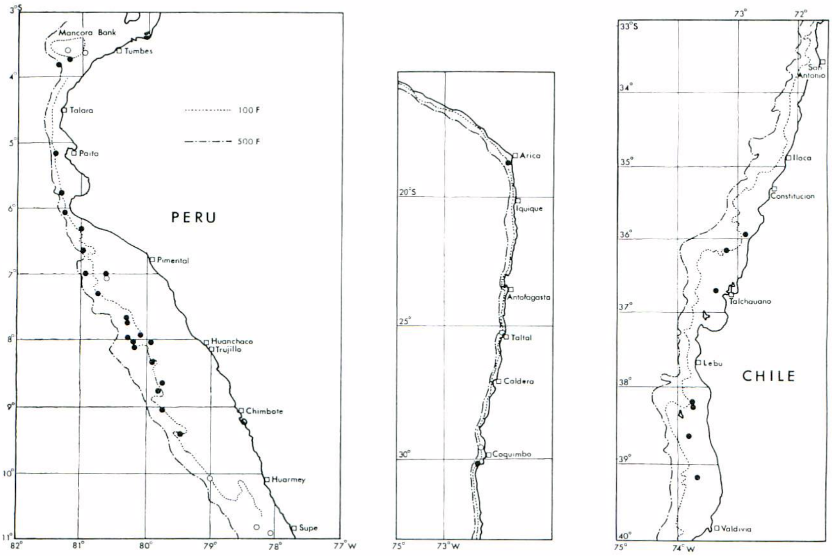

Fig. 62. Distribution of Chilean hake (*M. gayi*) off Peru and Chile caught by Japanese research vessel in 1967. solid circle, station collecting this hake ; open circle, station not recording this hake.

(51.5°S). Martínes (1976) gave the distribution of this hake as Antofagasta (23°38′S) to Canal Cheap (47°08′S). Delfin (1903) described this species in detail from Chile and stated its distribution as being from Chile to Uruguay through the Strait of Magellan, and further referred to the possibility of its occurrence in New Zealand. Japanese research vessels (1977-1979) found a rapid faunal change between 42°S and 44°S with an other hake, *Merluccius australis*, living below this latitude (Anon., 1979b, 1980). Chilean hake is most abundant from Coquimbo to Valdivia, and inhabits depths between 50 m and 550 m; it is especially abundant between 50-100 m and 200-350 m and at bottom temperatures between 8.0°C and 11.0°C (Doi, 1969b, 1971; Trujillo, 1972; Arana *et al.*, 1975).

Biology:

The average size of Peruvian hake declines from north to south, which shows that the younger fish lives further south (Boerema, 1977). The relation between length and latitude of this fish shows that large individuals are distributed in the northern area (4°S to 6°S) and the small ones in the southern area (8°S to 10°S) (Tabeta *et al.*, 1971). Length-weight relationship, and a growth curve in fork length were given by Misu and Hamasaki (1971).

Females grow faster than males and attain a much greater size. The relation between annual ring of otolith and fork length (calculated in mm at the mark formation) for both sexes is also given by Misu and Hamasaki (1971) (Table 31) using the data sampled in December. The estimated maximum length of Peruvian hake is 67.9 cm FL for males and 115.4 cm for females. Spawning takes place between August and March, with a peak in the southern spring, and mainly in the area between 4°S and 8°S (Boerema 1977).

Table 31. Relationship between annual ring of otolith and fork length (mm) of Peruvian subspecies (Misu and Hamasaki, 1971)

Mark group	L 1	L 2	L 3	L 4	L 5	L 6	L 7	L 8	L 9
Male	159	244	325	390	435	—	—	—	—
Female	167	252	332	410	472	532	592	651	710

Chilean hake produces transparent, spherical pelagic eggs that hatch into pelagic larvae. The eggs required 4 days to hatch when artificially incubated at 12.5°C to 15.0°C. The time between hatching and development of a functional mouth is 4.5 days (Fisher, 1959). The younger bottom stages together with very large ones are found far offshore. On the other hand, medium to large sized hakes predominate in coastal waters. It is probable that the larvae live over deep water and young hakes spend 2 to 3 years in deep water where they are spawned, then move shoreward to enter the demersal inshore population. Males grow more slowly than females especially after attaining 3 years

(POULSEN, 1957; VESTNES *et al.*, 1965). The relationships between age and growth of Chilean hake (Table 32) were given by ALBERTI and ZÚNIGA (1966) and SAETERSDAL and VILLEGAS (1968). The growth curve in fork length and the length-weight relationships were given by SAETERSDAL and VILLEGAS (1968) and the maximum length is estimated as 49 cm for males and 62 cm for females. The largest individual found by DELFIN (1903) was 87 cm long. Size at maturity is estimated to be about 32 cm for males and 42 cm for females, but the length at maturity varies clinally by latitude - with a smaller size at maturity toward the north. In the southern area fifty percent of males are mature at a length of 37 cm, while in the northern area at 30 cm. The main spawning period is August to November (southern spring), but some spawning also occurs later in summer and even in early autumn (POULSEN, 1957; SAETERSDAL and VILLEGAS, 1968; ARANA *et al.*, 1975). The scarcity of both spawning and spent females in the catch on the coastal fishing grounds indicates that most of the spawning occurs over deep water (POULSEN, 1957). Fecundity of Chilean hake is 280,000 to 660,000 eggs in fishes from 450 mm to 870 mm in length (DELFIN, 1903). This hake seems to undertake migrations along the coast, moving northwards during late winter or spring and southwards during the summer (TRUJILLO, 1972; BOEREMA, 1977). Sexually mature fishes of intermediate length move offshore to spawn during the spring and subsequently return to shallow water (POULSEN, 1957; LENGERICH, 1965). They also undertake diel vertical movements in which they move away from the seabed at night and return to the bottom near dawn. This movement is associated directly or indirectly with their feeding behavior (POULSEN, 1957). This fish feeds on fishes (*Merluccius gayi*, Gonostomatidae, *Scomberesox saurus*, *Macruronus magellanicus*), crustaceans (Euphausiacea, Penaeidae, Galatheidae) and squids. Sixty percent of stomach contents examined consisted of euphausiids (TABETA *et al.*, 1971; Anon., 1979b, 1980). The population off Valparaiso feeds mainly on euphausiids (74%) but also feeds on larval and adult stomatopod crustaceans (*Pterygosquilla armata*), shrimps (*Hetreocarpus reedi*), zoeid and megalopa larvae of decapod crustacens, fish larvae, small hakes, fishes (*Engraulis ringens*, *Normanichthys crokery*) and squids (ARANA and WILLIAMS, 1970).

Table 32. Relationship between age and growth (cm) of Chilean hake (SAETERSDAL and VILLEGAS, 1968)

Age	1	2	3	4	5
Male	14.0	27.0	35.5	40.5	—
Female	14.0	28.5	38.5	45.5	50.5

Fishery:

Peruvian hake stocks were only lightly exploited in the 1960's. In 1966, the landings reached 10,000 tons and 20,000 tons in 1967. Catch fluctuated at around that level until 1973, when it suddenly increased to 138,000 tons due to a greatly increased fishing effort, resulting from an arrangement with foreign vessels to fish in the area. After 1973, the landings (Table33) decreased somewhat (GULLAND, 1971; BOEREMA, 1977), and have increased suddenly to 466,000 tons in 1978.

During the 1940's the Chilean hake fishery consisted of Chilean fisherman working from small boats with nets or hook and line and the fish was marketed only as a fresh food item. In the mid-1950's the demand for fish meal became so great that the demands of the fresh market were not filled (GRINOLS and TILLMAN, 1970). About 30 percent of the catch was sold fresh for human consumption and the remainder made into fishmeal (LENGERICH, 1965). The fishery for this hake occurs mainly in the area between Coquimbo and Talcahuano and operates from the ports of Coquimbo, Quintero, Valparaiso, San Antonio and Talcahuano (JONES, 1974). The hake stocks off Chile were exploited at a fairly constant level from about 1955 until the early sixties, with the catches fluctuating between 70,000 and 80,000 tons. The catch rose to over 100,000 tons in 1963 and 1965, and fluctuated between roughly 70,000 and 130,000 tons, until 1974 when catches fell to somewhat over 40,000 tons. They declined further to 30,000 tons in 1976 (GULLAND, 1971; BOEREMA, 1977).

Table 33. Catch in thousand tons of the Chilean hake in Peruvian and Chilean waters (GULLAND, 1971 ; FAO, 1979)

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Peru	15	17	27	13	138	121	100	123	136	466
Chile	83	88	66	95	86	43	36	30	37	34
Total	98	105	93	108	224	164	136	153	173	500

GULLAND (1971) gave provisional estimates of the stock size and potential yield of Peruvian hake as 500,000 and 60,000 tons, respectively, but recent data indicate that the stocks are considerably larger. Peruvian Instituto del Mar (IMARPE) estimated from the survey of r/v *Professor Mesyatsev* in 1972 and 1973 that the hake biomass was about 1.4 million tons, with a potential annual yield of 200,000 or 250,000 tons (BOEREMA, 1977).

Various estimates have been made of the potential yield of Chilean hake. The standing stock of this hake in the region of Vaplaraiso (32°40′S-33°20′S), was estimated to range from 835 tons (spring) to 17,481 tons (winter) (ARANA *et al*., 1975). GULLAND (1971) pointed out that the average potential yield of the stocks might be of order of 120,000 to 130,000 tons. TRUJILLO (1972) determined that the standing stock of Chilean hake resources in the Talcahuano to Valdivia, ranged from 135,000 tons in summer to a maximum of 653,000 tons in the winter. The standing stock between 39°54′S and 47°32′S was estimated to be about 14,000 tons in March and April 1973 (BAHAMONDE, 1977). According to the results of a survey in August to September 1977, the standing stock of this hake between 40°S and 43°50′S was 22,600 to 25,400 tons (Bahamonde, 1978; Kono, 1980).

11. Argentine hake (*Merluccius hubbsi*)

Distribution:

Argentine hake is distributed along the east coast of the southern part of South America (Fig. 61). Its northern boundary is associated with the convergence of the inshore Falkland and offshore Brazil currents. This convergence of northerly flowing cold water and southerly flowing warm water varies seasonally but generally occurs at about 28°S-30°S off southern Brazil (Hart, 1948; Barcellos, 1966; Grinols and Tillman, 1970; Figueiredo and Menezes, 1978). Stray individuals have been recorded from Cape Frío (23°S), Brazil (Carvalho, 1950). Its southern most limit is around 54°S, near the Falkland Islands, Tierra del Fuego and the mouth of the Strait of Magellan, but there is no record from the Burdwood Bank (Fig. 63). It overlaps with the Patagonian popu-

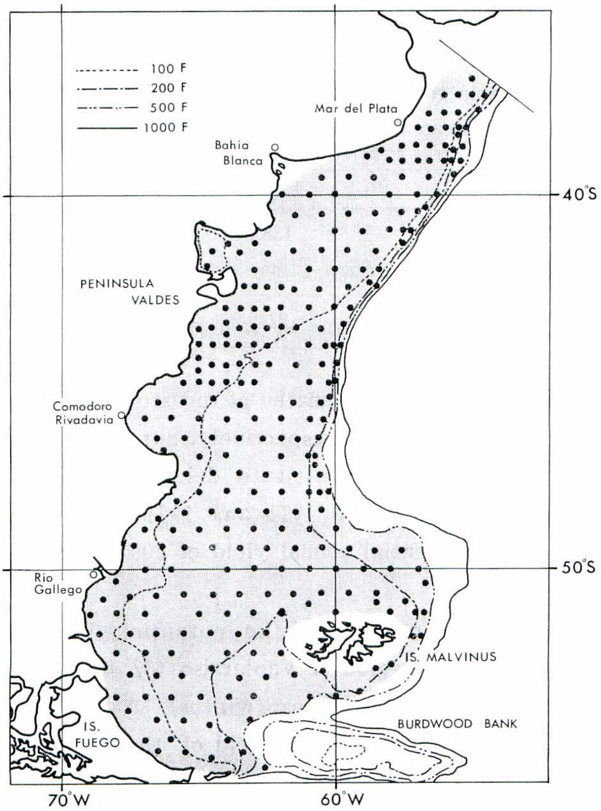

Fig. 63. Distribution of Argentine hake (*M. hubbsi*) off Argentine caught by Japanese research vessel in 1978-79. solid circle, station collecting this hake. Shaded areas show the sketchy distribution of this hake.

lation of the New Zealand hake (*M. australis*) between 49°S and 54°S. The center of abundance is in the Bonaelensis area (from the mouth of La Plata to Golfo San Matias). Argentine hake mainly inhabits the continental shelf in depths between 50 m and 500 m (mainly around 200 m), at temperatures between 3.8 °C and 6.5°C (mainly around 5.5°C), and at chlorinities between 18.4‰ and 18.9‰ (mainly around 18.7 ‰) (Anon., 1979c).

Biology:

Eggs and larvae are distributed mainly in shelf waters off the Argentina and Uruguay. The distribution is related to season, temperature, salinity, and in some cases to biomass of zooplankton as well as distribution of eggs and larvae of the anchovy, *Engraulis anchoita* (Ciechomski and Weiss, 1974). Length-weight relationship is expressed by Rojo and Silvosa (1969c, 1970a, 1970b). The von Bertalanffy growth equation for this hake and the relationship between age and length by sex (Table 34) are given by Otero (1977). The predominant ages in the fishery are 4 to 6 years old for males and 4 to 7 years old for females. Females grow faster than males from 3 years of age onwards. The largest individuals found by Postell (1966) was 90 cm long and 95 cm long by Zinkevich and Sauskan (1968). The mean length for both sexes generally increased with depth and latitude (i.e., larger fish were further south). The proportion of females also generally increased with depth and latitude. The overall sex ratio was 35.7% male and 64.3% female (Odemar and Silvosa, 1971a).

Table 34. Relationship between age and length (cm) of Argentine hake (Otero, 1977)

Age	1	2	3	4	5	6	7	8	9
Male	10.21	24.09	34.20	41.17	45.78	49.85	52.51	54.51	55.70
Female	12.68	24.84	35.00	43.91	50.91	56.75	61.88	65.57	69.30

This hake is most abundant in depths of 79 m to 100 m on the shelf north of 45°S and in depths of 45 m to 91 m in Golfo San Jorge (Odemar and Silvosa, 1971b). Greatest densities were found in waters near 8°C with salinities between 33.70‰ and 34.00‰ (Silvosa, 1971). Optimum temperature was from 5.3°C to 7.4°C and optimum salinity between 33.70‰ and 34.20‰ (Rojo and Silvosa, 1969a, 1970a).

Argentine hake appears to spawn in early summer (from late October to February) in inshore areas. The length at sexual maturity is 32 cm in males and 42 cm in females (Hart, 1946). Spawning appears to take place over a prolonged period, though apparently with a peak in December - January, the southern summer (Ciechomski and Weiss, 1974) and spawning can occur more than once, probably twice, in one spawning season (Ciechomski, 1967). The time of spawning varies from south to north (Rojo and Silvosa, 1969b).

In the southern summer Argentine hake are concentrated in shallow waters between

50 m and 150 m in the area south of 40°S, and can be found down to 350 m between 51°S and 54°S, but the concentration in the most southerly part is considerably less dense than north of 50°S. In the winter (from May to August) they move northward and concentrate in the area between 35°S and 40°S at depths between 70 m and 500 m (ZINKEVICH and SAUSKAN, 1968; BOEREMA, 1977). This hake also exhibits a seasonal onshore - offshore migration. Generally, adults and juveniles move inshore during the spring and summer, adults for spawning and juveniles for feeding. After spawning, adults move back offshore and are later joined by the juveniles in deep water wintering areas (HART, 1946). The Argentine hake also undertake diel migrations in which they move to upper layer at dusk and return to the bottom near dawn. During the day, this hake usually inhabits the bottom layers; however, sometimes the appearance of anchovy schools initiates vertical, short-term, upward feeding movements. During the night, hake migrates near the surface in pursuit of food (WRZESINKA, 1975).

Argentine hake stops feeding before spawning and feeds ravenously afterward. Food is comprised of the following organisms: fishes (*Clupea fuegensis*, *Merluccius hubbsi*, *Salilota australis*, *Macruronus magellanicus*, *Notothenia ramsayi*, *Stromateus maculatus*, *Thysanopsetta naresi*, *Engraulis anchoita*, etc.), squids (*Loligo* sp., *Illex* sp., etc), *Munida subrugosa*, *M. gregaria*, euphausiids, *Parathemisto gaudichaudii*, holothurians, asteroids, ophiuroids and sponge fragments. It is assumed that they are opportunistic feeders (WRZESINKA, 1975). During September-November the main food item is anchovy (up to 43%), the second is mysids (up to 32%), and third is young hake (up to 12%). Amphipods (up to 8%), squids and Notothenidae are somewhat less common. The largest hake eats fishes and squids, and the smaller ones mysids and amphipods (ZINKEVICH and SAUSKAN, 1968).

Like most other marine fishes, this hake is commonly infested with nematode, cestode and trematode worms. Almost all the specimens examined had nematodes in some part of the digestive tract or in the body cavity. Copepod parasites were evidently less numerous but not uncommon (HART, 1946). The percentage infested by the copepod parasite, *Trifur tortuosis* increases with the size of fish and was higher in females. This hake is also infested by *Chondracanthus palpifer* and *Braquiella lageniformis* (ODEMAR and SILVOSA, 1971a). Parasite infestetion was observed as follows: *Trifur tortuosis*, 2.0 to 10.1% (fish with parasites), *Chondracanthus palpifer*, 32.0 to 38.2%, *Brachiella lageniformis*, average 43.7% (ROJO and SILVOSA, 1970a; SILVOSA, 1971).

Fishery:

The fishery for Argentine hake began in the 1920's as a small, shallow water trawl fishery at the mouth of the Rio de la Plata. In the 1960's, refrigeration and quick-freeze facilities became available and the city of Mar del Plata became a center for frozen fish. At first frozen fillets were used for local consumption, but later, additional quantities were prepared for export to the United States as frozen fish blocks

(Hart, 1948; Grinols and Tillman, 1970). The principal fishery takes place on the continental shelf in depths of 90–180 m between 34°S and 48°S latitudes, but mainly within about 100 miles of Mar del Plata (Jones, 1974).

The stocks of this hake have been exploited for many years, mainly by Argentina, but also by Brazil and Uruguay. Total catch increased rapidly from 39,000 tons in 1961 to just over 100,000 tons in 1965. In 1966, a fleet of USSR long-range fishing vessels joined the fishery, with the result that the total landings increased sharply to about 600,000 tons in 1967. Thereafter, the catch decreased when the long-range vessels left the area following the Argentinean claims to wide territorial limits. Total landings decreased to 69,000 tons in 1969 but has since increased to 420,000 tons in 1978 (Gulland, 1971; Boerema, 1977; FAO, 1979) (Table 35).

Table 35. Catch in thousand tons of Argentine hake off Argentina and Uruguay (Boerema, 1977 ; FAO, 1979)

Year	1961	1962	1963	1964	1965	1966	1967	1968	1969
Total	39	59	66	96	103	146	598	183	69

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978
Total	108	117	139	184	173	126	226	352	417

Trawl surveys carried out by West Germany r/v *Walter Herwig* and *Cruz del Sur* on various occasions in the period 1966–1971 gave standing stock estimates of between 2.7 and 3.4 million tons for fish over 40 cm. A combined trawl and acoustic survey by the USSR r/v *Prof. Siedlecki* in the summer of 1974 gave a much higher estimate of about 6 million tons. The potential yield estimates of the stock, obtained from these biomass estimates are about 500,000 tons and 1,800,000 tons, respectively. Even though these estimates differ widely, they indicate that the stock potential is much higher than recent catches, and that there is ample room for further development of the hake fishery (Boerema, 1977). The results of the Japanese r/v *Shinkai Maru* research cruise in 1978–1979, indicated that the standing stock of Argentine hake off Argentina was 6.9 million tons in April and May, and 4.0 million tons in July and August (Hatanaka, personal communication).

12. New Zealand hake (*Merluccius australis*)

Distribution:

New Zealand hake are distributed in New Zealand and southern South American waters.

The New Zealand population is distributed around New Zealand (Hutton, 1872; Waite, 1911; Phillipps, 1927; Norman, 1937; Svetovidov, 1948). This hake is known from Chatham Island, the South Island of New Zealand and northward to East Cape on the North Island (HART, 1948) (Fig. 61). According to the results of Japanese research cruises (1970-1971, 1975-1977, 1977-1978). the species is distributed from Greymouth, at the northern slope of Chatham Rise to around Stewart Island, the Pukaki Rise, and Campbell Plateau (Fig. 64). The vertical distribution of this hake is at depths between 415 m and 1,000 m at bottom temperatures of 5.8°C to 8.0°C and at bottom salinities of 34.32 ‰ to 34.45 ‰. New Zealand hake is mainly found in 500-800 m depths and is distributed in areas that are influenced by subantarctic waters of lower temperature and lower salinity (SAISHU, 1972; Anon., 1976, 1979a; Fisheries Agency of Japan, 1978).

The Patagonian population is distributed in the Patagonian areas in the southern

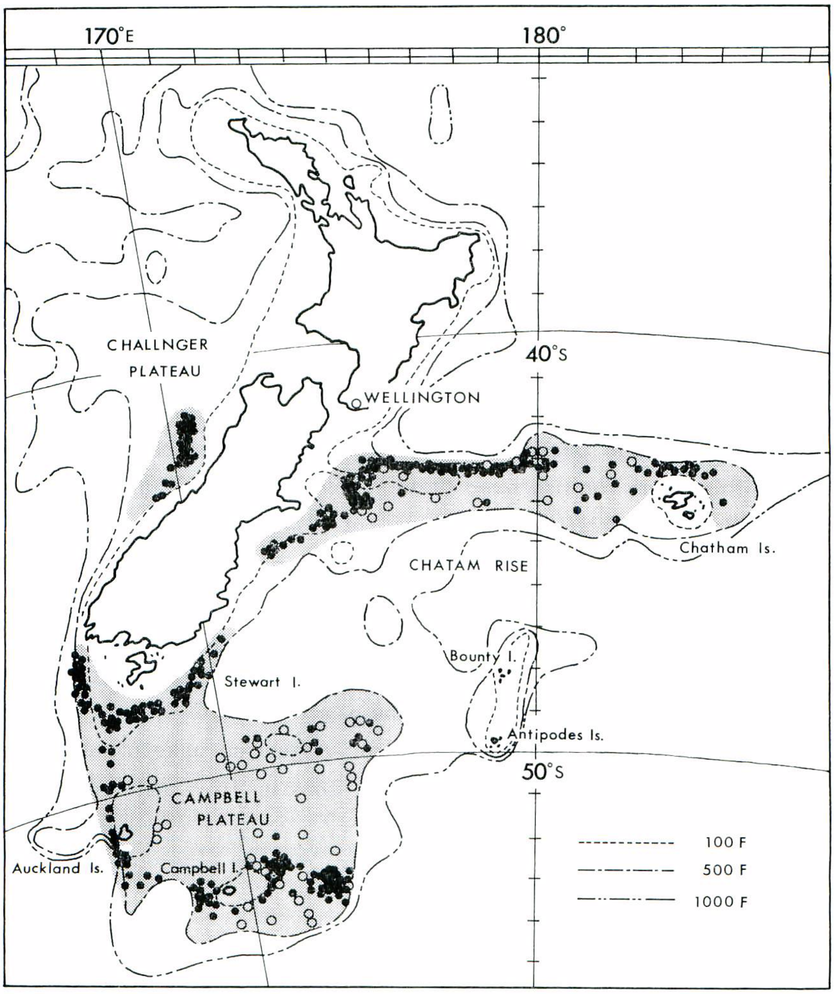

Fig. 64. Distribution of New Zealand hake (New Zealand population of *M. australis*) caught by Japanese research vessels. open circle, station collecting this hake by r/v *Kaiyo maru* in 1970-71, 1977-78 ; solid circle, station collecting this hake by r/v *Shinkai maru* in 1975-77. Shaded areas show the sketchy distribution of this hake.

part of South America on both Pacific and Atlantic sides (Fig. 61). On the Chilean side this hake is found south of 40°S (almost the northern part of Chiloe Island) to 56°S (southern tip of Chile) at depths from 62 m to 800 m and bottom temperatures from 4.5°C to 9.0°C. On the Argentine side it appears on the continental slope between 38°S and 49°S but on the continental shelf between 49°S and 55°S. Its depth range is between 100 m and 500 m (mainly around 200 m); preferred bottom temperatures from 3.8°C to 6.5°C (mainly around 5.5°C), and chlorinities between 18.4‰ and 18.9‰ (Hanamura, 1971; Anon., 1979b and c, 1980) (Fig. 65). This hake is also found at the Strait of Magellan

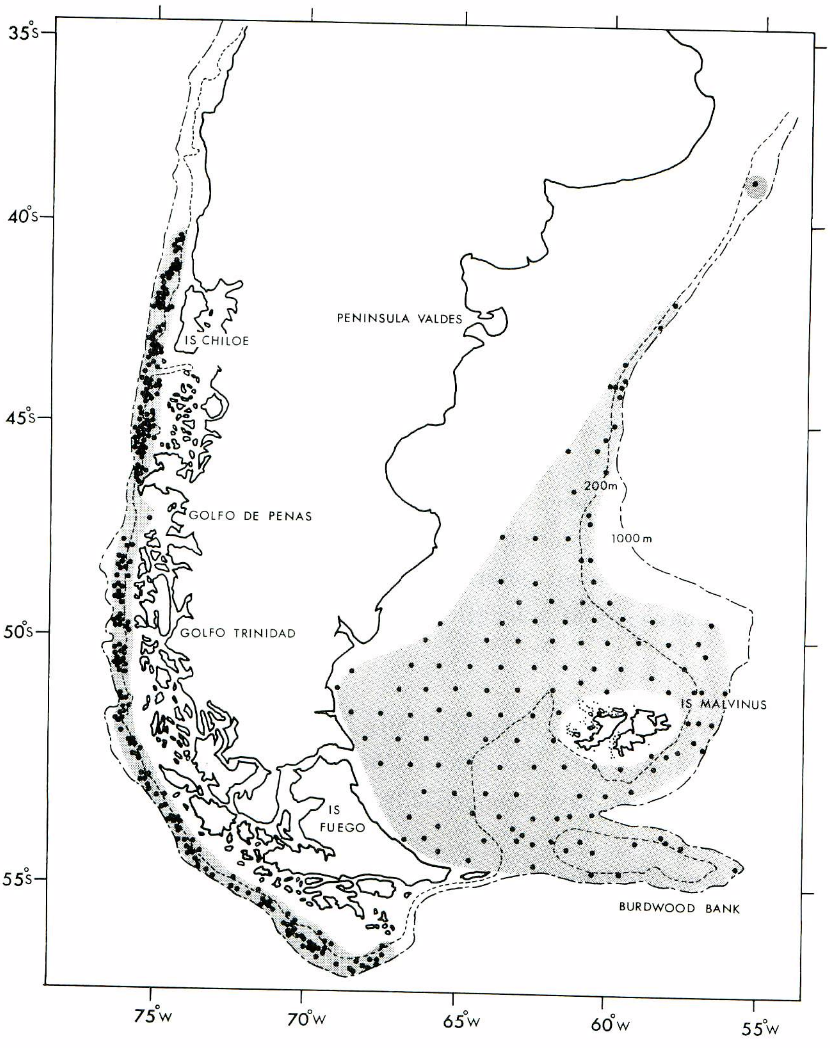

Fig. 65. Distribution of New Zealand hake (Patagonian population of *M. australis*) caught by Japanese research vessels in 1977-79. solid circle, station collecting this hake. Shaded areas show the rough distribution of this hake.

(NORMAN, 1937). The distribution of these populations from Chile and Argentina is continuous with each other through the Strait. This hake is mainly distributed in areas influenced by subantarctic waters.

Biology:

Biological data concerning New Zealand hake are rather sparce. It is surmised from knowledge on other species of hake that larvae develop in shallow coastal waters and adult hake probably migrate to the south in the southern summer for feeding and again return to the north in winter for spawning. According to the results of Japanese r/v *Kaiyo Maru* and *Shinkai Maru* research cruises, the spawning season for the New Zealand population was from July to August and one spawning area was found off the west coast of South Island (off Greymouth) at depths of 800-1000 m. The length of this fish ranges from 70 cm to 126 cm. The stomach contents mainly consist of squids and salps (SAISHU, 1972; Anon., 1976, 1979a).

According to the results of research cruises by Japanese r/v *Kaiyo Maru, Akebono Maru* No. 72 and *Shinkai Maru* in southern Chile and Argentina, the maximum length was 110 cm and gonad weight increased with size in fish above 70 cm. On the Chilean side, length ranged from 38 cm to 105 cm. Females were larger than males and the sex ratio was 4 (male): 6 (female). Stomach contents were mainly *Micromesistius australis, Merluccius australis,* and to a lesser extent *Salilota australis, Mugiloides* sp., *Macruronus magellanicus, Macrourus holotrachys,* squillids, hyperiids, euphausiids and benthos (HANAMURA, 1971; Anon., 1979b and c, 1980). This species also moves off the bottom at night to pursue food. But in cases when cold water masses invade the bottom area schools can be found in midwater even during the day. During the spawning season, especially in deep water, this hake does not migrate upward even at night. Fecundity is estimated to be about 5 millions eggs at a length of 105 cm.

Fishery:

This hake was only caught sporadically by New Zealand fishing boats and a few were marketed in Dunedin with the name of "haddock" (HECTOR, 1872). Recently foreign vessels began to fish this hake commercially, but the magnitude of the catches is not known.

Little is known of abundance. Even though catch rates are low, the total potential yield may still be very significant (BOEREMA, 1977). The standing stock off southern Chile was estimated at 13,000 tons between 39°54′S and 47°32′S latitudes, and 115,000-127,400 tons between 40°S and 57°S (BAHAMONDE, 1977, 1978; KONO, 1980). The standing stock of the Argentine population was estimated to be between 669,000 tons in autumn and 219,000 tons in winter (HATANAKA, personal communication). The biomass of the New Zealand population was estimated at 64,000 tons (NAGAI, personal communication).

V. Discussion

1. Taxonomy and key to the species of *Merluccius*

There are two viewpoints about the taxonomy of the family level of merlucciids. The opinion that the genus *Merluccius* should be included in the family Gadidae is supported by KAUP (1858), GÜNTHER (1862), REGAN (1903), SVETOVIDOV (1937, 1948, 1956b) and CADENAT (1937). SVETOVIDOV (1948), in his revisional work on Gadiformes, included the subfamilies Merlucciinae, Lotinae and Gadinae within the family Gadidae. NIKOL'SKII (1954) included the fossil genus *Palaeogadus* in the subfamily Merlucciinae with the present-day genus *Merluccius*. On the other hand, the establishment of the family Merlucciidae, which was proposed by GILL (1884), is followed by JORDAN and EVERMAN (1898), JORDAN (1923), BELLOC (1928), NORMAN (1937) and MARSHALL (1966). NORMAN (1937) included the genus *Macruronus* in this family on the basis of osteological features. MARSHALL (1966) studied the details of some of the morphological characters of related genera and concluded that the family Merlucciidae is composed of the genus *Merluccius, Macruronus, Lyconus, Steindachneria* and probably *Lyconodes*. But SVETOVIDOV (1969) noted that the genera *Merluccius, Lyconus, Macruronus* and *Steindachneria* cannot be placed in one family Merlucciidae and the latter three genera may be treated as a separate family. In 1973, MARSHALL and COHEN divided the order Gadiformes into 8 families including Merlucciidae and Steindachneriidae, the latter being a newly recognized family which is separated from Merlucciidae by the position of the anus and urogenital pores, and the genera *Merluccius, Lyconus* and *Macruronus* were included in the family Merlucciidae. This systematic arrangement was used by SVETOVIDOV (1973a), although he was doubtful of the systematic position of the latter two genera.

The first taxonomic revision of the genus *Merluccius* was presented by MARINI (1933). He recognized 7 species: *M. merluccius, M. capensis, M. bilinearis, M. productus, M. angustimanus* and *M. hubbsi*. His reasons for differentiating these species were based mainly on proportional dimensions such as the length of pectoral and pelvic fins and the head length. However, it appears that these characters are subject to considerable variation and do no reflect the actual differences between species. In 1937, NORMAN classified the species of the genus *Merluccius* and clarified the confused synonymy of the seven representatives, indicating the diferentiating characters between them, Later, SVETOVIDOV (1948) studied the morphology and biology of these seven species in detail and accepted NORMAN's (1937) diagnostic key for merlucciids, with some revisions. The differences between the species of *Merluccius* defined by NORMAN (1937) and SVETOVIDOV (1948) are based on the number of transverse rows of scales, gill-rakers, length of pectoral and pelvic fins and the ratio between them, and dimensions of eye and depth of body. All of these characters, especailly the proportional characters vary greatly within a species, and depend upon growth and sometimes sexual maturity. As was indicated by

SVETOVIDOV (1948), the apparent distinctions between some species resulted from the small number of specimens examined rather than by actual differences between the species. He also noted that there is very little basis for dividing representatives of the genus *Merluccius* into different species and that the majority of forms of this genus could be subspecies or perhaps only a few species.

In 1954, GINSBURG studied the morphology of the eight species, including two new species, on the American continents and presented a diagnostic key using number of gill-rakers, oblique rows of scales over lateral line, number of rays of second dorsal and anal fins, and relative length of head, pectoral and pelvic fins. He examined variation by individuals and growth of these characters in detail and compared the degree of intergradation or divergence between species. However, some overlapping characters between some species still remained and he did not comment on these. MANN (1954b) regarded all Pacific representatives and also the Argentine one as subspecies of *M. gayi* in his list of fishes of Chile; *M. gayi productus*, *M. gayi angusticeps*, *M. gayi gayi*, *M. gayi australis* and *M. gayi hubbsi*. CABO (1965, 1966) also referred the merlucciids of the Pacific coast of South America to subspecies of *M. gayi*.

For the eastern Atlantic species of *Merluccius*, CADENAT (1950) studied the characters of 4 species and 2 subspecies (*M. merluccius atlanticus*, *M. merluccius mediterraneus*, *M. senegalensis*, *M. polli* and *M. capensis*) and presented diagnoses for these merlucciids on the basis of fin rays counts of the first dorsal, number of gill-rakers and lateral line scales, mean value of vertebrae and relative length of head, and pectoral and pelvic fins. His diagnostic key for these species and subspecies seems not to be effective because of the small number of specimens, which did not allow consideration of infraspecific variation. For example, the numbers of first dorsal fin rays vary in these species and the relative length of the pectoral and pelvic fins is related to size. FRANCA (1962) also studied the taxonomy of merlucciids in the eastern Atlantic and concluded that all the merlucciids in this area are subspecies of *Merluccius merluccius*. He constructed a key for the differentiation of six subspecies according to the number of cervical vertebrae, total gill-rakers, and total vertebrae. This key for subspecific differentiation was accepted by ANGELESCU *et al* (1958). They suggested that the Atlantic species had smaller values of some meristic counts and shorter pectoral fins in adult females than in the Pacific. SOLIMAN (1973) studied on the meristic and morphometric characters of the eastern Atlantic and Mediterranean representatives, and accepted the taxonomy proposed by FRANCA (1962).

Recently studies appling electrophoretic technique to the taxonomy of *Merluccius* have been done, especially for closely related species or populations. JONES and MACKIE (1970) studied the differences between *M. capensis* and *M. paradoxus*, and ROJAS and SEPULVEDA (1975) studied the taxonomy of *M. gayi* and *M. polylepis* by using electrophoresis. SEPULVEDA and ROJAS (1973) used this analysis for a population study of *M. gayi*. MACKIE and JONES (1978) applied this method to the taxonomy of five species of

Merluccius; *M. merluccius*, *M. australis*, *M. productus*, *M. bilinearis* and *M. angustimanus*. An extension of this technique to other species should provide further information on the relationships between them, and it is necessary to take these results into consideration in studying the taxonomy of *Merluccius*, but electrophoresis is a different way to approach the taxonomy and beyond the scope of the present study.

In summation, many studies on the taxonomy of merlucciids have been published but a review of all the species in the world has not been attempted. This is because of the difficulty in obtaining enough specimens to examine effectively infraspecific variations. In addition, it is difficult to find key characters to differentiate species because of the minor differences between species and the wide variation within a species.

The author has recognized twelve species in this study and examined differences between them in internal and external morphology; he has devised a diagnostic key for species of the world. The differences are mainly based on meristic characters such as the number of gill-rakers, number of vertebrae and ribs, number of oblique rows of scales below the lateral line canal, number of anal fin rays and some morphometric characters such as the relative length of head, snout and upper jaw. The combined number of gill-rakers, anal fin rays and vertebrae are also adopted for key characters to differentiate species. When evaluating these characters, variation in growth by individuals was also taken into consideration. The key to these twelve species is complicated. Five convenient groups are arranged mainly by the total number of gill-rakers. Nevertheless, some species could not be separated by these characters because minor overlapping ranges were present. In these cases the author examined some characters by statistical methods and considered whether or not the differences between the two representatives diverged enough to warrant species recognition. The author counted the oblique rows of scales below the lateral line canal instead of the number of lateral line scales. But even with this method, it was difficult to count them accurately. However, this character is very important in order to distinguish between species and one is able to use this character for a key when the discontinuity is comparatively great. The number of ribs on the cervical vertebrae appeared also to be a useful character for distinguishing species if enough specimens were available (Table 36). Some specimens have been found to have a different number of ribs on each side. The examination of internal morphology did not show clear differences between species, except for the relative size of some structures such as: gill-rakers; teeth on both jaws ; intermuscular process of hyomandibular; shape of postcleithrum and urohyal; groove on cleithrum; and width of anterior part of infraorbital foramen. But these characters are not useful key characters because of the difficulty in dividing clearly the two or three types (Table 37). The colour of the body is usually not useful for a key character, but *M. polli* is usually blackish with a white margined caudal fin which is an effective character to discriminate this species from others.

During the course of this study on the external morphology of the species of

Table 36. Summary of the characters which make a difference from each other species. Characters not in parentheses mean the non overlapping characters, and those in parentheses mean the statistically significant differences which show the some part of overlapping with each other.

	M. merluccius	*M. senegalensis*	*M. polli*	*M. capensis*	*M. paradoxus*	*M. bilinearis*	*M. albidus*	*M. productus*	*M. angustimanus*	*M. gayi*	*M. hubbsi*
M. senegalensis	GR										
M. polli	(Vert)	GR Rib									
M. capensis	GR	(Vert) (HL) (IOW)	GR Ll Rib								
M. paradoxus	GR	(GR)	GR Rib	Vert							
M. bilinearis	GR Ll	Ll (UJL)	GR Rib	Ll (Vert) (HL)	Ll (GR) (UJL)						
M. albidus	Ll (DI)	GR Ll	(UJL)	GR Ll	GR	GR					
M. productus	GR	Rib (GR) (CPD)	GR	Cau-Vert Rib	Abd-Vert Rib	Abd-Vert Ll Rib	GR Ll				
M. angustimanus	GR	Abd-Vert Rib	Vert GR	Rib (HL)	Vert Rib	Vert Ll Rib	GR	Vert			
M. gayi	GR	Abd-Vert	GR	Ll (P1L)	Vert	Abd-Vert (Vert)	GR	(Vert) (P2L)	(GR)		
M. hubbsi	GR	(Abd-Vert) (IOW)	(Vert) (GR)	(GR) (HL)	GR Vert	Ll (Vert) (GR)	GR	GR	(GR) (HL)	GR	
M. australis	(Vert) (Anal) (P2L)	(Anal) (UJL)	Ll	(GR) (P2L)	GR	GR Ll	L	GR	GR Vert Ll	GR Ll	Ll

Note:

GR : total number of gill-rakers	Anal : number of anal fin rays
Vert : total number of vertebrae	HL : relative length of head to standard length
Abd-Vert : number of abdominal vertebrae	P1L : relative length of pectoral fin to standard length
Cau-Vert : number of caudal vertebrae	P2L : relative length of pelvic fin to standard length
Ll : number of oblique rows of scales	CPD : relative depth of caudal peduncle to standard length
Rib : number of ribs	UJL : relative length of upper jaw to head length
DI : number of first dorsal fin rays	IOW : relative width of interorbital to head length

Table 37. Characteristics of 7 internal morphological characters on 12 merlucciid species.

Species	length of gill-raker	size of teeth on both jaws	length of intermuscular process of hyomandibular	size of head of post-cleithrum	urohyal	groove on cleithrum	width of anterior part of infraorbital foramen
M. merluccius	short	large	long	large	thin	deep	narrow
M. senegalensis	medium	small	long	large	thin	deep	narrow
M. polli	short	small	long	large	thin	deep	narrow
M. capensis	medium	large	short	large	thin	deep	medium
M. paradoxus	long	large	long	large	thin	deep	medium
M. bilinearis	long	large	short	small	thin	deep	wide
M. albidus	short	small	short	small	thin	deep	wide
M. productus	long	small	short	small	thin	shallow	wide
M. angustimanus	long	small	short	medium	thin	deep	wide
M. gayi	long	small	short	medium	thin	shallow	wide
M. hubbsi	short	large	long	medium	thick	shallow	medium
M. australis	short	large	long	small	thin	deep	medium

Merluccius, the author recognized some interesting aspects of the differentiation of characters. The first is that geographic clines appeared in some characters. Some species in which distributions are overlapping or neighboring each other show clinal changes in some characters. The number of gill-rakers in species from the west coast of America shows the best example of this, and has been discussed in the section on *M. angustimanus*. Even within a species, this aspect was recognized in a species distributed over a wide geographical range, such as the number of vertebrae in *M. merluccius*, which was investigated by MAURIN (1952, 1954a and b, 1965, 1968a and b). The second is the tendency of some species to show major, non overlapping differences of characters, especially in the case of two species which have an area of geographical overlapping. Examples of this in *Merluccius* can be seen in many cases, for example differences in the number of gill-rakers between *M. merluccius* and *M. senegalensis*, *M. senegalensis* and *M. polli*, *M. polli* and *M. capensis*, *M. bilinearis* and *M. albidus*, *M. gayi* and *M. australis*, and the number of vertebrae between *M. polli* and *M. capensis*, *M. capensis* and *M. paradoxus*, *M. gayi* and *M. australis*, *M. hubbsi* and *M. australis* (Table 38). These aspects of the differentiation of characters in the above mentioned forms will serve as a basis for recognizing that they are true species. The third aspect is the similarity of characters observed in some species of *Merluccius* which are geographically distant from each other. The minor differences between *M. senegalensis* and *M. capensis*, and between *M. australis* and *M. merluccius* are good examples.

In summation, the genus *Merluccius* contains twelve distinct species in the world,

Table 38. Diagnostic characters for 12 merlucciid species

character	*M. merluccius*	*M. senegalensis*	*M. polli*	*M. capensis*	*M. paradoxus*	*M. bilinearis*	*M. albidus*	*M. productus*	*M. angustimanus*	*M. gayi*	*M. hubbsi*	*M. australis*
GR	8-11	13-18	8-12	15-20	18-23	16-20	8-11	18-23	16-18	18-25	12-16	11-15
Vert	49-54	51-56	53-57	49-53	54-58	53-57	51-55	53-54	49-52	48-53	50-53	53-58
Abd-Vert	23-25	25-28	24-28	23-26	26-28	26-29	23-26	23-25	21-23	21-24	23-26	24-28
Rib	3.4 (4.0)	4	3	4	4	4	3.4 (3.9)	3	3	3.4 (3.1)	3.4 (3.1)	3.4 (3.2)
Anal	36-40	37-40	36-42	37-41	38-41	37-42	35-41	39-44	36-39	36-42	36-41	40-46
Ll	127-156	124-155	102-127	132-149	121-143	101-110	104-119	125-144	121-134	106-130	120-142	144-171
GR+Anal	44-51	51-56	46-53	55-61	58-64	54-61	44-51	58-66	52-56	55-65	49-55	52-60
GR+Vert	59-64	65-71	63-66	68-72	74-80	70-75	61-66	71-76	66-70	69-75	63-66	66-72
colour of body	silvery	silvery	blackish	silvery	silvery	silvery	silvery	silvery	silvery	silvery	silvery	sivlery
HL (%)	25.1 -30.5	24.9 -27.7	24.8 -28.9	27.3 -30.2	26.0 -28.6	24.4 -27.4	26.8 -31.7	24.7 -28.9	30.1 -33.5	26.0 -32.4	24.4 -28.0	24.9 -28.3
Snout L/Head L (%)	30.2 -34.5	30.2 -34.1	30.2 -35.9	31.9 -36.5	30.6 -35.3	31.2 -35.1	31.0 -37.2	31.1 -35.4	27.8 -32.7	29.3 -34.1	31.0 -35.1	33.2 -39.0
UJL (%)	47.8 -53.3	47.1 -50.6	45.3 -51.3	48.2 -54.7	46.0 -51.6	50.0 -54.4	48.5 -55.2	45.8 -50.9	44.4 -48.5	43.7 -50.2	47.3 -52.2	48.2 -55.9

Note : see the abbreviations in foot note on table 36. Numeral in parentheses shows the mean value.

which have diverged to the specific level in some characters through the process of the above mentioned three aspects. Two subspecies each are included in *M. merluccius* and *M. gayi*, and it is possible to separate two populations (New Zealand and Patagonian) of *M. australis*.

Key to the species of *Merluccius*

1a. Total number of gill-rakers on first arch fewer than 12……………………**Group A**
1b. Total number of gill-rakers on first arch 12-15……………………**Group B**
1c. Total number of gill-rakers on first arch more than 15
  2a. Total number of vertebrae fewer than 53 ……………………**Group C**
  2b. Total number of vertebrae more than 52
    3a. Combined number of gill-rakers and anal fin rays fewer than 57……………**Group D**
    3b. Combined number of gill-rakers and anal fin rays more than 56……………**Group E**

Key to the species of Group A

1a. Scales large, fewer than 128 in number of oblique rows below lateral line canal; body reaches 68 cm.
  2b. Number of ribs 3; upper jaw length in % of HL 45.3-51.3 (mean 48.7) (=2.0-2.2 in HL); body usually blackish with white-margined caudal fin ……………………*M. polli* (eastern Central-Atlantic)
  2b. Number of ribs usually 4 (sometimes 3); upper jaw length in % of HL 48.5-55.2 (51.9) (=1.8-2.1 in HL); body usually silvery whitish ……………………*M. albidus* (western Central-Atlantic)
1b. Scales small, more than 126 in number of oblique rows; body reaches over 1 m
  3a. Total number of gill-rakers usually 9-11 (range 8-11); number of anal fin rays usually 36-39 (36-40); combined number of gill-rakers and anal fin rays 44-51; snout length in % of HL 30.2-34.5 (32.6) (=2.9-3.3 in HL) ……………………*M. merluccius* (eastern North-Atlantic)
  3b. Total number of gill-rakers usually 12-14 (11-15); number of anal fin rays usually 41-45 (40-46); combined number of gill-rakers and anal fin rays 52-60; snout length in % of HL 33.2-39.0 (36.1) (=2.6-3.0 in HL) ……………………*M. australis* (Patagonia, New Zealand)

Key to the species of Group B

1a. Total number of gill-rakers 12
  2a. Scales rather large, fewer than 143 in number of oblique rows; combined number of gill-rakers and vertebrae 63-66
    3a. Total number of gill-rakers usually 9-11 (8-12); total number of vertebrae usually 54-56 (53-57); body usually blackish with white-margined caudal fin…………*M. polli*
    3b. Total number of gill-rakers usually 13-16 (12-16); total number of vertebrae usually 50-52 (50-53); body silvery whitish…………*M. hubbsi* (western South-Atlantic)

2b. Scales small, more than 143 in number of oblique rows; combined number of gill-rakers and vertebrae 66-72 ……………………………………………………………………*M. australis*

1b. Total number of gill-rakers 13-15

4a. Number of oblique rows of scales fewer than 144; total number of vertebrae fewer than 54

5a. Total number of gill-rakers usually 13-16 (13-18); total number of vertebrae usually 52-55 (51-56); number of abdominal vertebrae 25-28; head length in % of SL 24.9-27.7 (26.5) (=3.7-4.0 in SL); size of teeth on both jaws medium ………………………………*M. senegalensis* (eastern Central-Atlantic)

5b. Total number of gill-rakers usually 16-20 (15-20); total number of vertebrae usually 49-52 (49-53); number of abdominal vertebrae 23-26; head length in % of SL 27.3-30.2 (28.6) (=3.3-3.7 in SL); size of teeth on both jaws large ……………………………………*M. capensis* (eastern South-Atlantic)

5c. Total number of gill-rakers usually 13-16 (12-16); number of abdominal vertebrae 23-25 (23-26) …………………………………………………………………………………*M. hubbsi*

4b. Number of oblique rows of scales more than 143; total number of vertebrae more than 52

6a. Total number of gill-rakers usually 13-16 (13-18); total number of vertebrae usually 52-55 (51-56); number of anal fin rays 37-40; length of gill-raker medium …………………………………………………………………… *M. senegalensis*

6b. Total number of gill-rakers usually 16-20 (15-20); total number of vertebrae usually 49-52 (49-53); number of anal fin rays 37-41; length of gill-raker medium ………………………………………………………………………*M. capensis*

6c. Total number of gill-rakers usually 12-14 (11-15); total number of vertebrae usually 55-57 (53-58); number of anal fin rays usually 41-45 (40-46); length of gill-raker short ……………………………………………………………………………………… *M. australis*

Key to the species of Group C

1a. Total number of gill-rakers 16

2a. Number of abdominal vertebrae 23-28; number of ribs 3 or 4; head length in % of SL 24.4-30.2 (=3.3-4.1 in SL)………*M. senegalensis*, *M. capensis*, *M. hubbsi* (see:B-4a)

2b. Number of abdominal vertebrae 21-23; number of ribs 3; head length in % of SL 30.1-33.5 (31.9) (=3.0-3.3 in SL); small sized fish attains at most 39 cm ………………………………*M. angustimanus* (eastern Central-Pacific)

1b. Total number of gill-rakers more than 16

3a. Number of oblique rows of scales fewer than 131

4a. Total number of gill-rakers 13-16 (13-18); number of abdominal vertebrae 25-28 …………………………………………………………………… *M. senegalensis*

4b. Total number of gill-rakers 16-18; number of abdominal vertebrae 21-23 ………………………………………………………………… *M. angustimanus*

4c. Total number of gill-rakers 19–23 (18–25); number of abdominal vertebrae 21–24 ………………………………………… *M. gayi* (eastern South-Pacific)

3b. Number of oblique rows of scales more than 130 ……………*M. senegalensis*, *M. capensis*, *M. angustimanus* (see:C-1a)

Key to the species of Group D

1a. Total number of gill-rakers 16

2a. Combined number of gill-rakers and vertebrae fewer than 67 ……………………………………*M. senegalensis*, *M. hubbsi* (see:B-4a)

2b. Combined number of gill-rakers and vertebrae more than 66

3a. Scales comparatively large, fewer than 111 in number of oblique rows ………………………………… *M. bilinearis* (western North-Atlanaic)

3b. Scales small, more than 123 in number of oblique rows ………………………………… *M. senegalensis*, *M. capensis* (see:B-4a)

1b. Total number of gill-rakers more than 16

4a. Number of abdominal vertebrae fewer than 25

5a. Number of oblique rows of scales fewer than 131; size of teeth on both jaws small ……………………………………………………………………… *M. gayi*

5b. Number of oblique rows of scales more than 131; size of teeth on both jaws large ………………………………………………………………………*M. capensis*

4b. Number of abdominal vertebrae more than 24 ………………*M. senegalensis*, *M. capensis*, *M. bilinearis* (see:D-2b)

Key to the species of Group E

1a. Total number of vertebrae 53

2a. Number of oblique rows of scales fewer than 111

3a. Number of abdominal vertebrae 21–24 ……………………………………………*M. gayi*

3b. Number of abdominal vertebrae 26–29 ……………………………………………*M. bilinearis*

2b. Number of oblique rows of scales 111–130

4a. Total number of vertebrae 53–54; number of abdominal vertebrae 23–25; number of ribs 3 ……………………………………………………*M. productus* (eastern North-Pacific)

4b. Total number of vertebrae usually 50–52 (48–53); number of abdominal vertebrae 21–24; number of ribs usually 3 (sometimes 4) ……………………………………*M. gayi*

2c. Number of oblique rows of scales more than 130

5a. Total number of vertebrae usually 49–52 (49–53); number of ribs 4………*M. capensis*

5b. Total number of vertebrae 53–54; number of ribs 3……………………………*M. productus*

1b. Total number of vertebrae more than 53

6a. Number of ribs 4; scales comparatively small, 121–143 in oblique rows …………………………………*M. paradoxus* (eastern South-Atlantic)

6b. Number of ribs 4; scales large, 101–110 in oblique rows…………………… *M. bilinearis*

6c. Number of ribs 3; scales comparatively small, 125–144 in oblique rows……*M. productus*

2. Historical zoogeography of the species of *Merluccius*

The purpose of this section is to discuss the supposed phylogenetic and historical distribution of various species of *Merluccius* in order to explain the present-day distribution of the twelve species.

The earliest known fossil merlucciids, *Palaeogadus* (=*Nemopteryx*) was found in the Lower Oligocene in Europe and disappeared toward the end of the Middle Oligocene. The origin of *Merluccius* has been repeatedly discussed in the paleontological and zoological literature. DANIL'CHENKO (1949, 1950) noted that *Merluccius* is the only surviving cod genus that has retained most of the basic morphological features of *Palaeogadus*. The most ancient fossil *Merluccius* appeared in the Middle (*M. inferus*) and Upper (*M. lednevi*) Oligocene. The genus *Merluccius* is phylogenetically related to *Palaeogadus* from which it is separated (DANIL'CHENKO, 1947, 1960; JERZMAŃSKA, 1968; FEDOTOV, 1976) and *Palaeogadus-Merluccius* is the rather ancient group from which other gadids and lotids undoubtedly originated (NICHOL'SKII, 1954). It has been suggested that the genus *Merluccius* became adapted to life at a considerable range of depths and consequently modifications came about in the structure of the parapophyses which serve as a kind of container for the swim-bladder (DANIL'CHENKO, 1947, 1960).

According to SVETOVIDOV (1940, 1948, 1956a), the origin of the gadoids was in the Atlantic-boreal region. The presence of many endemic genera of gadids in the North Atlantic compared with the North Pacific suggests the North Atlantic, or even the Arctic, origin of the gadids and the derivation of the Pacific gadids from the Atlantic. Following this point of view, it is proposed that the merlucciids also developed in the North Atlantic during the Middle Oligocene to the Lower Miocene. From the fossil records, merlucciids penetrated into the Tethys from northern areas and inhabited the subtropical or temperate environment in the Oligocene (DANIL'CHENKO, 1960; FEDOTOV, 1976).

Based on the above mentioned considerations, the history of merlucciids may be supposed to have occurred as follows. The ancestor of merlucciids evolved in the north eastern Atlantic, including the Tethys Sea, and adapted to living in relatively deep water, spreading to warmer waters. On one hand, dispersal to the west could have taken place in the Miocene along the connection between Europe and North America that was supposed to be present at this time in North Atlantic, and from which some species entered the Pacific Ocean by way of a Central American submergence. Another possibility is that the Pacific invasion took place through the Bering strait, but it seems that the North Polar Sea at this time would have already been occupied by other gadids which preferred cooler waters, thereby preventing the merlucciids from invading this sea. Before the closing of the passage between the Atlantic and Pacific Oceans across Central America (until Upper to Lower Pliocene) (EKMAN, 1953; Anon., 1970; OLSSON, 1972; PEARSON, 1978), the ancestral species of the Pacific merlucciids would have probably entered into the Pacific Ocean from the Atlantic and spread north and south along the west coast of the American Continents. Akazaki (1962) also noted that sparids entered the west coast of America from the Atlantic while the Panamanian land bridge had been submerged. To the north, the merlucciids could not enter the North Pacific because other gadid species occupied similar ecological niches. After they reached the southern most regions, the merlucciids invaded the eastern coast of southern South America around Cape Horn during the Interglacial period of the Pleistocene (after the collaspse of the land bridge between Patagonia and the Antarctica). The dispersal from west to east of the ancestor of these species was interrupted by the cold waters of southern Patagonia during the Glacial period of the Pleistocene. The idea that the Pacafic merlucciids could have dispersed from the North Atlantic through the South American coasts (Svetovidov, 1956a) would be difficult to imagine, because of the strong barrier of the Amazon River which produced low salinity waters in that area would have been already present during the Pleistocene. Even if the merlucciids were bathypelagic, they would have to spend some periods during their juvenile stage near the coastal areas. So the low salinity waters in that area would have inhibited the southern dispersal of merlucciids along the east coast of South America. My idea of historical divergence is also supported by Kabata's (1970) study of parasites. On the other hand, Szidat (1955) noted from the study of parasites that the Pacific merlucciids originated in the North Pacific. But the opinion that the origin of Gadidae was in the North Pacific, has not been accepted by recent taxonomists and zoogeographers.

Danil'chenko (1949) noted that the extinct species *M. errans* from Upper Oligocene to Lower Miocene is similar to the present day species *M. merluccius* with respect to many characters, and thus the ancestral species of merlucciids could have developed in the Tethys Sea as well as in the North Atlantic during the Miocene and Pleistocene. But merlucciids did not enter the Indian Ocean because of the presence in the eastern basin of the Tethys Sea of low salinity and a high level of hydrogen sulphide layer (Fedotov, 1976), or other environmental differences between the Tethys and the Indian Ocean. The present subspecies in the Mediterranean Sea (*M. merluccius smiridus*) would be a recent invader judging from its close relationship with the Atlantic subspecies (*M. merluccius merluccius*). Other species originating from the north eastern Atlantic migrated to southern warm waters through the deep sea during the Tertiary along the west coast of Africa and reached the southern tip of South Africa. In the course of historical migrations, certain specific divergences and speciation events must have taken place. It is supposed that the present *M. merluccius* and *M. senegalensis* evolved off the north westen Africa, and *M. polli* developed in rather deep equatorial waters. These three species are closely related and some characters diverged because of geographical clines. The South African species, *M. capensis* and *M. paradoxus*, should have derived from common or different ancestral species of the North Atlantic. *M. capensis* adapted to rather shollow and warmer waters while *M. paradoxus* adapted to deep and colder waters, and these two species show clear-cut differences in some characters. Migrations of these two species to the Indian Ocean around the southern tip of South Africa would be inhibited by the warm Mozambique Current flowing to the south along the east coast of South Africa. It seems probable that the ancestor of *M. australis* of the southern South American (Patagonian) population must have been derived from an eastern Atlantic species. The characters of *M. australis* are quite different from *M. hubbsi* and other Pacific species; it has rather wide gaps in some meristic characters such as the number of scales and some morphometric characters. On the other hand, this species is rather similar to eastern Atlantic species in some charaters. Of all the merlucciids, *M. australis* is adapted to the coldest waters. Considering the possible transport of juvenile or adult fish the derivation of the Patagonian population of *M. australis* from the eastern Atlantic appears to be contradicted by the eastward current of the West Wind Drift the direction of which has not changed for 65 million years (TAKANO, 1976). However, the westward current, which would have been situated more northely, would have had a lower temperature in the Glacial period of the Pleistocene than at the present time and, judging from their behavior, merlucciids might have been able to drift across the sea. Therefore, there is some possibility that dispersal from east to west occurred in the southern Atlantic. The presence of *M. capensis* at Valdivia Bank will serve as proof of this theory. The New Zealand population of *M. australis* must have been derived from southern South America. This migration to the west occurred in the Antarctic during the Interglacial period. Only one gadid species in the southern hemisphere, *Micromesistius australis*, is distributed in southern South America (Patagonian region) and New Zealand

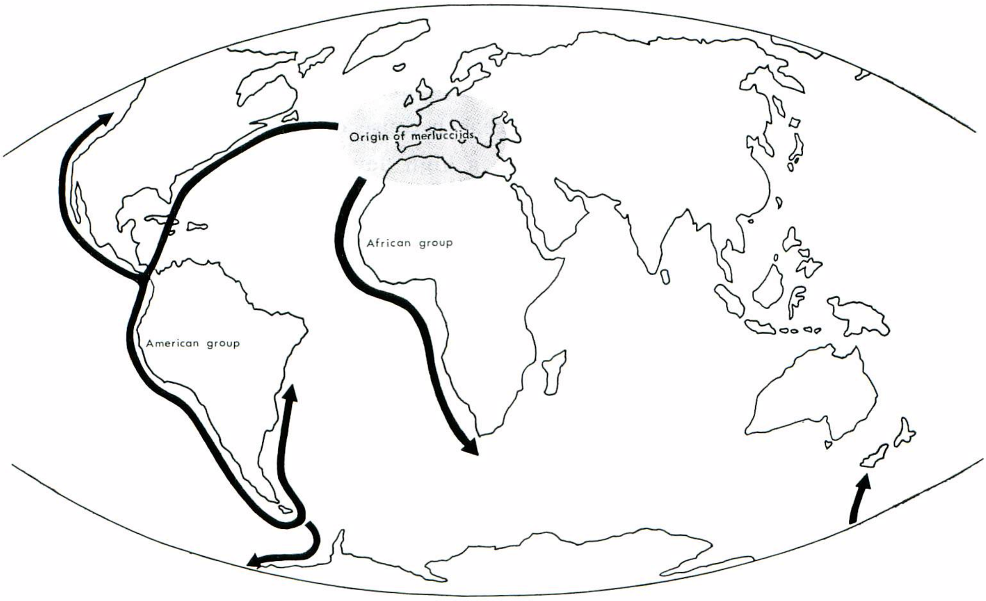

Fig. 66. Schematic figure showing the geographical divergence of merlucciids through the history.

(INADA and NAKAMURA, 1975). It is supposed that the New Zealand population of this species, is also derived from southern South America. Some other fishes such as *Macruronus, Genypterus* and *Callorhynchus* are distributed in South Africa, southern South America and New Zealand. This suggests that some species migrated between these regions in the past (ANGELESCU *et al.*, 1958).

In summation, merlucciid dispersal must have taken place along two main routes from the north eastern Atlantic to the Pacific and Southern Hemisphere (Fig. 66). The present-day distributions of the merlucciids would have been determined in the Pliocene to the Pleistocene and speciation took rather long periods of time. The minor differences between species indicate that the merlucciids have not changed their morphology drastically for a long time, judging from their long history. The merlucciids are still adapting to environments of the present era.

Acknowledgements

The author wishes to express his sincere gratitude to Dr. Tamotsu IWAI, Professor of Kyoto University, under whose guidance this investigation was made possible to be conducted, for his invaluable suggestions. The author is also deeply indebted to Dr. Ikuo IKEDA of the Far Seas Fisheries Research Laboratory, Fisheries Agency of Japan, for his continuous encouragement and the use of facilities for this study and Dr. Daniel M. COHEN of the U.S. National Marine Fisheries Service, NOAA, for his loaned specimens and his invaluable criticisms in reviewing the manuscript. Drs. Thomas A. DARK and Susumu KATO of the U.S. National Marine Fisheries Service, NOAA, and Dr. Teruya UYENO of the National Science Museum, Tokyo reviewed the manuscript and made valuable suggestions for improving it.

Thanks are due to many generous people for their courtesy through various kinds of help during the course of this study: Dr. Izumi NAKAMURA and Mrs. Reiko NAKAMURA of the Fisheries Research Station of Kyoto University; Dr. Osamu KIBEZAKI, the former director of the Far Seas Fisheries Research Laboratory; Drs. Tetsuya SATO, Hiroshi HATANAKA and Messers Takashi SASAKI, Kiyoshi WAKABAYASHI, Shigeyuki KAWAHARA and Tatsuki NAGAI of the Far Seas Fisheries Research Laboratory; Dr. Fumio MITANI of the former Nansei Regional Fisheries Research Laboratory; Dr. Kozo SAISYU and Mr. Tetsuo OGATA of the Japan Sea Regional Fisheries Research Laboratory; former Professor Reizo ISHIYAMA, Messers Zin HATTORI, Kiyoshi FUJITA and Akira ZAMA of Tokyo University of Fisheries; Dr. Osamu OKAMURA of Kochi University; Mr. Takashi MINAMI of Kyoto University; Mr. Eiichi FUJII of the Suruga Bay Marine Biological Research Group; Drs. Tokiharu ABE, Keiji NASU, Hideo KONO, Kei-ichi MITO and Toru NAKAO, Messers Yasuo TANINO, Michinori KUROIWA and Toshiro SATO of Japan Marine Fishery Resource Research Center. Most of the present work was carred out at the Far Seas Fisheries Research Laboratory, Shimizu, and Japan Marine Fishery Resource Research Center, Tokyo, to the staff of which I am much obliged for facilities for this study.

Acknowledgement is also due to Professor Jack A.F. GARRICK of Victoria University of Wellington, Mr. Gavin JAMES of the Fisheries Research Division, Wellington, and Mr. Alan COAKLEY of the Fisheries Management Division, Christchurch, New Zealand; Dr. Atila E. GOSZTONYI of Instituto Investigación Biofisicus, Buenos Aires, Drs. Victor ANGELESCU and Roque H. CALABLESSE of Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Argentina; Dr. Yasunobu MATSUURA of Instituto Oceanografica da Universitat de São Paulo, Brazil; Dr. Fernando BALBONTIN of Universitat de Chile, Drs. Roberto BAHAMONDE and Antonio VIDAL of Instituto de Fomento Pesquero, Santiago, Chile; Dr. P.A. HULLEY of the South African Museum, Cape Town, Dr. L. BOTHA of Division of Sea Fisheries of Cape Town, South Africa; Dr. J.C. QUERO and Dr. C. MAURIN of Institut Scientifique of Technique des Pêches Maritimes, Paris, France; Dr. C.P. MATHEWS of Kuwait Institute for Scientific Research; Dr. Z. KABATA of Pacific Biological Station, Nanaimo, Canada; Miss Susan JEWETT of U.S. National Museum, Washington, D.C., Dr. Andrew W. VROOMAN of the National Marine Fisheries Service, NOAA, Washington, D.C., Messers Duane RODMAN and Ronaldo TANINO of the National Marine Fisheries Service, NOAA, Seattle, Dr. Tomio IWAMOTO of California Academy of Sciences, San Francisco, U.S.A., for their contributions of various informations and papers.

References

AHLSTROM, E. H. 1968 : An evaluation of the fishery resources available to California fishermen. *Univ. Washi. Publs. Fish.*, **4**, 65-80.

——— and R. C. Counts 1955 : Eggs and larvae of the Pacific hake *Merluccius productus*. *U. S. Fish Wildl. Serv., Fish. Bull.*, **99** (56), 294-329.

AKAZAKI, M. 1962 : Studies on the spariform fishes. Anatomy, phylogeny, ecology and taxonomy. *Misaki Mar. Biol. Inst., Kyoto Univ., Special Rept.*, **1**, 1-368. (In Japanese).

ALBERTI, V. B. and L. M. ZÚÑIGA 1966 : Estudio de la edad y cremento de la merluza (*Merluccius gayi*, GUICH.) de la zona de Valparaiso (1960-1963). *Cienc. Mar. J., Univ. Catolica de Valparaiso, Chile*, **1**, 83-107.

ALTON, M. S. and M.O. NELSON 1970 : Food of Pacific hake, *Merluccius productus*, in Washington and northern Oregon coastal waters. *U.S. Fish Wildl. Serv. Circ.*, **332**, 35-42.

ALVERSON, D. L. 1968 : Fishery resources in the northeastern Pacific Ocean. *Univ. Wash. Publs. Fish.*, **4**, 86-101.

——— and H. A. LARKINS 1969 : Status of knowledge of the Pacific hake resource. *Calif. Coop. Oceanic Fish. Invest. Rep.*, **13**, 24-31.

———, A. T. PRUTER and L. L. RONHOLT 1964 : A study of demersal fishes and fisheries of the northeastern Pacific Ocean. 190 pp., H. R. McMillan Lectures in Fisheries, University of British Colombia, Vancouver.

ANDREU, B. 1956 : Observaciones sobre el ovario de merluza (*Merluccius merluccius* L.) y características del mecanismo de la puesta. *Inv. Pesq.*, **4**, 49-62.

ANGELESCU, V., F. S. GNERI and A. NANI 1958 : La merluza del mar Argentino (biologia y taxonomia). 225 pp., Sec. Mar., Serv. Hidrogr. Naval, Buenos Aires.

ARANA, E. P., F. T. MELO, N. L. NOZIGLIA, V. I. SEPÚLVEDA, S. N. SILVA, G. G. YANY and R. E. YÁÑEZ 1975 : Los recursos demersales de la región de Valparaiso, Chile. *Rev. Com. Perm. Pacifico Sur*, **3**, 39-61.

——— and S. F. WILLIAMS 1970 : Contribución al conocimiento del régimen alimentario de la merluza (*Merluccius gayi*). *Inv. Mar.*, **1** (7), 139-154.

AYRES, W. O. 1855 : Description of the new species of California fishes. *Proc. Cal. Acad. Nat. Sci.*, **1** (1855), 23-77.

BAGENAL, T. B. 1954 : The growth rate of the hake, *Merluccius merluccius* (L.), in the Clyde and other Scottish Sea areas. *J. Mar. Biol. Ass. U.K.*, **33** (1), 69-95.

BAHAMONDE, F. R. 1977 : Distribucion y abundancia relativa (preliminar) de los principales recursos demersales entre Corral y Golfo de Penas. 45 pp., *Inst. Fom. Pesq., Santiago.* (Mimeo).

——— 1978 : Distribucion y abundancia relativa de los principales recursos demersales entre Corral (40° LS) y el Cabo de Hornos (57° LS). *Inst. Fom. Pesq.*, **28**, 1-23.

BARCELLOS, B. N. 1966 : Informe geral sôbre a pesca Rio Grande do Sul. 120 pp., Banco Regional de Desenvolvimento do Extremo Sul BRD- CODESUL, Pôrto Alegre.

BARNARD, K. H. 1925 : A monogrph of the marine fishes of South Africa. *Ann. S. Afr. Mus.*, **21** (1), 1-418.

Basioli, J. 1965: Hake (Oslić, *Merluccius merluccius* L.). Poslovno Udruzenje za ulov ribe "Jugoatlantik", *Pula. Mosk. Ribarst*, **17** (9-10), 182-184. (English translation).

Beamish, R. J. 1979: Differences in the age of Pacific hake (*Merluccius productus*) using whole otoliths and sections of otoliths. *J. Fish. Res. Bd. Canada*, **36**, 141-151.

Belloc, G. 1928: Hydrology and oceanography. The cruise of the Tanche in July-August 1928. *Rev. Trav. Off. Péch. Marit.*, **2** (1), 13-29.

——— 1937: Note sur la précence du merlu dans les eaux de la presqu'ile du Cap. Vert. *Ibid.*, **10** (3), 341-346.

Berg, L. S. 1940: Classification of fishes, both recent and fossil. *Tr. Zool. Inst. Akad. Nauk SSSR*, **5** (2), 87-517. (English translation).

Berry, F. H. 1965: Taxonomy of the eastern Pacific hake (*Merluccius*). 8 pp. (unpublished manuscript).

Best, E. A. 1963: Contribution to the biology of the Pacific hake, *Merluccius productus* (Ayres). *Calif. Coop. Oceanic Fish. Inv. Rep.*, **9**, 51-56.

Bigelow, H. B. and W. C. Schroeder 1953: Fishes of the Gulf of Maine. *U.S. Fish Wildl. Serv., Fish. Bull.*, **53** (74), 1-577.

——— and ——— 1955: Occurrence off the Middle and North Atlantic United States of the Offshore hake *Merluccius albidus* (Mitchill) 1818, and of the blue whiting *Gadus* (*Micromesistius*) *poutassou* (Risso) 1826. *Bull. Mus. Comp. Zool.*, **113** (2), 205-226.

——— and W. W. Welsh 1925: Fishes of the Gulf of Maine. *Bull. U. S. Bur. Fish.*, **40** (1), 1-567.

Blache, J., J. Cadenat and A. Stauch 1967: Clés de détermination des poissons de mer signalés dans l'Atlantique Oriental (enter le 20° parallele N. et le 15° parallele S.). Fauna Tropicale XVIII, 479 pp., ORSTOM.

Boerema, L. K. 1977: The hake resources in Latin American waters. *FAO FI*, HI/LA/77/25, i–ii+1–12.

*Borodin, N. A. 1934: Fishes [Sci. Res. of the yacht 'Alva' Medit. Cruise 1933]. *Bull. Vanderbilt mar. Mus.*, **1** (4), 103-123.

Botha, L. 1971: Growth and otolith morphology of the Cape hakes *Merluccius capensis* Cast. and *M. paradoxus* Franca. *Inv. Rep. Div. Sea Fish. S. Afr.*, **97**, 1-32.

——— 1973: Migrations and spawning behaviour of the Cape hakes. *S. Afi. Shipp. News Fish. Ind. Rev.*, April, 61-67.

Breder, C. M. and D. E. Rosen 1966: Modes of reproduction in fishes. 941 pp., Natural History Press, New York.

Buen, F. de. 1954: Contribuciones a la ictiologia. X. La pescada (*Merluccius gayi*) en la zona de Valparaiso (Chile) en los meses de agosto a noviembre de 1953 y algunas consideraciones sobre su biologia. *Rev. Chilena Hist. Nat.*, (7), 73-93.

——— 1958: Investigaciones sistemáticas y biológicas sobre la merluza. *Bol. Soc. Biol. Concepcion, Chile*, **33**, 107-124.

Burne, R. H. 1909: The anatomy of the olfactory organ of teleostean fishes. *Proc. Zool. Soc. London*, 1909, 610-663.

Cabo, F. L. 1965: Las merluzas atlánticas. *Publ. Tec. Junta Estud. Pesca*, **4**, 11-31.

——— 1966: Las merluzas atlánticas. *Puntal. Revista Marit. Pesq.*, **13** (152), 2-8.

CANDENAT, J. 1937 : Recherches systématiques sur les poissons littoraux de la côte occidentale d'Afrique, rècoltês par le navire "Président Théodore Tissier", au cours de sa 5^e croisière (1936). *Rev. Trav. Off. Pêch. Marit.*, **10** (4), 425-562.

——— 1950 : Note sur les merlus de la côte occidentale d'Afrique. *In* Congr. péch. pêch. Un. franç. d'outre Mer, pp. 128-130, Inst. Colon., Marseille.

——— 1952 : Note au sujet des merlus de la région de Dakar. *J. Cons. Perm. Int. Explor. Mer*, **18** (2), 230-233.

CARVALHO, J. de P. 1950 : Resultados científicos do cruzeiro do "Baependí" e do "Vega" á I. da Trindade. *Peixes. Bol. Inst. Paul. Oceanografica, São Paulo*, **1** (1), 97-133.

CASTELNAU, M. F. de. 1861 : *Merluccius capensis* (n. sp.). *In* Mémoire sur les poissons de l'Afrique australe, pp. 68-69, J.-B. Baillière et Fils Edit., Paris.

CASTRO, J. de. 1955 : La merluza, el bacalao y especies afines. *Pub. Inst. Esp. Ocean., Ser. Inf.*, 1-45.

CERVIGON, M. F. 1966 : Los pesces marinos de Venezuela. Vol. I. 436 pp., Fondo de Cultura Cientifica, Caracas.

CHANG, A. G., G. F. ARRATIA and V. H. ALEGRIA 1971 : Sistema óseo en *Merluccius gayi* (GUICHENOT, 1848). *Bol. Mus. Nac. Hist. Nat. Chile*, **32**, 299-347.

CHAPMAN, W. M. 1941a : The osteology and relationship of the isospondylous fish, *Plecoglossus altivelis* TEMMINCK and SCHLEGEL. *J. Morph.*, **68** (3), 425-455.

——— 1941b : The osteology and relationships of the osmerid fishes. *Ibid.*, **69** (2), 279-301.

CIECHOMSKI, J.D. de. 1967 : Carácter del desove y fecundidad de la merluza argentina, *Merluccius merluccius hubbsi*, del sector Bonaerense. *Bol. Inst .Biol. Mar., Mar del Plata*, **13**, 1-30.

——— and G. WEISS 1974 : Distribucion de huevos y larvas de la merluza, *Merluccius merluccius hubbsi*, en las aguas de la plataforma de la Argentina y Uruguay en relacion con la Anchoita, *Engraulis anchoita*, y las condiciones ambientales. *Physis, Buenos Aires*, **33** (86), 185-198.

CLAY, D. and H. CLAY 1979 : Bibliography of the hake family (Pisces : Merlucciidae). *ICNAF Res. Doc.*, 79/VI/78, 3-61.

CLEMENS, W. A. and G. V. WILBY 1961 : Fishes of the Pacific coast of Canada. *Fish. Res. Bd. Canada, Bull.* **68** (2nd ed.), 1-443.

COLLETT, R. 1890 : Diagnoses de poissons nouveaux provenant des campagnes de l'Hirondelle'. *Bull. Soc. Zool. Fr.*, **15**, 105-109.

CONOVER, J. T., R. L. FRIZ and M. VIEIRA 1961 : A morphometric study of Sliver hake. *U. S. Fish Wildl. Ser., Spec. Sci. Rep. Fish.*, **368**, 1-13.

CUNNINGHAM, R .O. 1871 : Notes on the reptiles, amphibia, fishes, mollusca, and crustacea obtained during the voyage of H. M. S. 'Nassau' in the years 1866-69. *Trans. Linn. Soc. London*, **42**, 465-502.

DANIL'CHENKO, P. G. 1947 : Phylogenetic relations between the genera *Palaeogadus* and *Merluccius*. *Doklady Akademii Nauk SSSR.*, **58** (4), 659-662. (English translation).

——— 1949 : The genus *Merluccius* in Maikopian Deposits of the Caucasus. *Trudy Paleont. Inst., Acad. Nauk SSSR.*, **20**, 130-140. (English translation).

——— 1950 : The genus *Palaeogadus* and its development. *Ibid.*, **25**, 3-25. (English translation).

——— 1960 : Bony fishes of the Maikop Deposits of the Caucasus. *Ibid.*, **78**, 1-247.

(English translation).

DARK, T. A. 1975 : Age and growth of Pacific hake, *Merluccius productus*. *Fish. Bull. U. S.*, **73**, 336-355.

———, H. H. SHIPPEN and K. D. WALDRON 1970 : Pacific ocean perch and hake studied off west coast. *Com. Fish. Rev.*, **32** (3), 25-30.

———, M. O. NELSON, J. J. TRAYNOR and E. P. NUNNALLEE 1979 : Distribution, abundance, and biological characteristics of Pacific hake, *Merluccius productus*, in the California-British Colombia region during July-September 1977. 56 pp., Nat. Mar. Fish. Serv., Seattle. (unpublished manuscript).

DAVIES, D. H. 1949 : Preliminary investigations on the foods of South African fishes with notes on the general fauna of the area. *S. Afr. Fish Mar. Biol. Surv. Div., Commerce and Industry*, **1**, 2-36.

de BEER, G. R. 1937 : The development of the vertebrate skull. xxxiv+552 pp., Oxford University Press, London.

DE KAY, J. E. 1842 : The American hake. *In* Zoology of New-York or New-York Fauna. Natural history of New York. Part Ⅲ, pp. 280-282, New York.

DE la HOZ, U. E. and D. G. ARENAS 1976 : Contribucion al estudio de la osteologia cefalica de *Merluccius gayi* (GUCIHENOT). *Ann. Mus. Hist. Nat. Valparaiso*, **9**, 115-125.

DELFIN, F. T. 1903 : Contribucion Ictiologia Chilena. *Rev. Chil. Hist. Nat.*, **7**, 268-273.

DEL SOLAR, E. M. 1968 : La merluza *Merluccius gayi* (GUICHENOT), como indicador de la riqueza biotica de la plataforma continental del Norte del Peru. 20+i−xii pp., Publ. Auspiciada Soc. Nac. Pesq., Limas.

DINEEN, C. F. and P.S. STOKELY 1954 : Osteology of the central Mudminnow, *Umbra limi*. *Copeia*, 1954 (3), 166-179.

DOI, N. (ed.). 1969 a : Report of scientific expedition on fishes off Peru, 113 pp., Fisheries Agency of Japan, Tokyo.

——— 1969b : Report of scientific expedition on fishes off Chile. 134 pp., Fisheries Agency of Japan, Tokyo.

——— 1971 : Report of the Kaiyo Maru research cruise in 1967 (Peru and Chile). 408 pp., Fisheries Agency of Japan, Tokyo. (In Japanese).

DOUTRE, M. P. 1960 : Les merlus du Senegal. Mise en évidence d'une nouvelle espèce. *Rev. Trav. Inst. Scient. Tech. Peche*, **24** (4), 513-536.

DREOSTI, C. M. 1961 : The development of the South African fish industry. *In*. G. BORGSTROM and A. J. HEIGHWAY (eds.), Atlantic Ocean Fisheries, pp. 182-191, Fishing News (Books) Ltd., London.

EKMAN, S. 1953 : Zoogeography of the sea. 417 pp., Sidgwick and Jackson Ltd., London.

ENGHOLM, B. 1961 : Fishery conservation in the Atlantic Ocean. *In*. G. BORGSTROM and A. J. HEIGHWAY (eds.), Atlantic Ocean Fisheries, pp. 40-48, Fishing News (Books) Ltd., London.

ERMAKOV, Yu K. and A. N. POLUTOV 1967 : Fishery and biological description of the Vancouver Island and Washington-Oregon regions. 38 pp., Pacific Research Institute for Fisheries and Oceanography (TINRO). (unpublished manuscript).

EVERMAN, B. W. and L. RADCLIFFE 1917 : The fishes of the west coast of Peru and the Titicaca Basin. *Bull. U. S. Nat. Mus.*, **95**, i−xi+1-166.

FAHAY, M. P. 1974 : Occurrence of Silver hake, *Merluccius bilinearis*, eggs and larvae along the middle Atlantic continental shelf during 1966. *Fish. Bull. U. S.* **72** (3), 813-834.

FAO. 1979 : 1978 yearbook of fishery statistics. catches and landings. *FAO Stat. Ser.*, **46**, 1-372.

FEDOTOV, V. F. 1976 : Gadidae of the Palaeogene-Neogene from the USSR. *Trudy Paleont. Inst.*, **157**, 1-84. (English translation).

FIGUEIREDO, J. L. and N. A. MENEZES 1978 : Manual de peixes marinhos do sudeste do Brasil. II. Teleostei (1). 110 pp., Museu de Zoologia, Universidade de São Paulo, São Paulo.

FIGUERAS, A. 1955 : Datos sobre la edad y crecimiento de la pescadilla (*Merluccius merluccius* L.) de Lavante (sector Castellón) determinados por medio de los otolitos. *Inv. Pesq.*, **1**, 73-86.

——— 1964 : Edad y crecimiento de la merluza (*Merluccius merluccius* L.) del noroeste del Mediterráneo espanol. *Ibid.*, **28**, 81-96.

FISCUS, C. H. 1979 : Interactions of marine mammals and Pacific hake. *Mar. Fish. Rev.*, October, 1979, 1-9.

FISHER, W. K. 1959 : Huevos, crias y prelarvas de la merluza (*Merluccius gayi*), GUICHENOT. *Rev. Biol. Mar.*, **9** (1/3), 229-249.

Fisheries Agency of Japan. 1972 : Report of the Kaiyo Maru research cruise in 1971 (off western coast of Africa). 151 pp., Fisheries Agency of Japan, Tokyo. (In Japanese).

——— 1974 : Report of the Kaiyo Maru research cruise in 1974 (mid-eastern Pacific and off coast of northern South America). 139 pp., Fisheries Agency of Japan, Tokyo. (In Japanese).

——— 1978 : Report of the Kaiyo Maru research cruise in 1978 (southern waters of New Zealand). 259 pp., Fisheries Agency of Japan, Tokyo. (In Japanese).

*FLEMIING, J. 1828 : A history of British animals exhibiting the descriptive characters and systematical arrangements of the genera and species of quadrupeds, birds, reptiles, fishes, mollusca and radiata of the U.K., including the indigenous, extirpated and extinct kinds, together with periodical and occasional visitants. xxiii+565 pp., Edinburg, London. (2nd ed., 1842, same pag.).

FOWLER, H. W. 1936 : The marine fishes of West Africa based on the collection of the American Museum Congo Expedition, 1909—1915. *Bull. Am. Mus. Nat. Hist.*, **70** (1.2), i-vii+1-1493.

FRANCA, P. da 1952 : *Merluccius merluccius* (L.) e *Merluccius senegalensis* CADENAT, seus caracters distintivos. *Notas Estud. Inst. Biol. Mar., Lisboa*, **3**, 1-36.

——— 1954 : Contribuiçao para o conhecimento do género *Merluccius* no Atlântico oriental ao sul do equador. *Trabhs. Miss. Biol. Marit.*, **8**, 46-98.

——— 1956a : Contribuiçao para o conhecimento do gén. *Merluccius* no Atlântico oriental ao sul do equador. *An. Junta. Inv. Ultram.*, **9** (2), 1-50.

——— 1956b : Breves consideracões âcerca das espécies angolanas do género "*Merluccius*" RAF. (pescadas). *Bol. Pesca, Lisboa*, **50**, 49-68.

——— 1960a : Sobre a variaçâo do nùmero de lamelas olfactivas em *Merluccius* africanos. *Mem. Junta Inv. Ultram.*, **2** (18), 1-14.

——— 1960b : Nova contribuiçâo para o conhecimento do género *Merluccius* no Atlântico oriental ao sul do equador. *Ibid.*, **2** (18), 57-101.

——— 1962 : Considérations sur la taxonomie des *Merluccius* de l'Atlantique oriental. *Ibid.*, **2** (36), 7-48.

——— 1971 : Hipótese acerca da provável ocorrência de *Merluccius merlucius paradoxus* FRANCA 1960 em águas Angolanas. *Notas Centro Biol. Aquát. Trop.*, **26**, 1-18.

FRITZ, R. L. 1960 : A review of the Atlantic coast whiting fishery. *Com. Fish. Rev.*, **22** (11), 1-11.

——— 1965 : Autumn distribution of groundfish species in the Gulf of Main and adjacent waters, 1955-1961. *In* Ser. Atlas Mar. Environ., Folio 10, pl.5 (no pagination), Am. Geogr. Soc., New York.

GARMAN, S. 1899 : Report on an exploration off the west coasts of Mexico, Central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U.S. Fish Commission steamer "Albatros" during 1891, XXVI (The fishes). *Mem. Mus. Comp. Zool. Harvard Coll.*, **24**, 1-431.

GEIGER, W. 1954 : Le cerveau de *Merluccius merluccius* (L.) et de *Merluccius senegalensis* CADENAT. Contribution à l'étude comparative des deux espèces. *Bull. Inst. Péches Marit., Maroc*, **2**, 68-76.

GILL, T. 1863 : Descriptions of the genera of gadoid and brotulid fishes of western North America. *Proc. Acad. Nat. Sc. Phila.*, 1863, 242-254.

——— 1884 : On the anacanthine fishes. *Ibid.*, 1884, 167-183.

GINSBURG, I. 1954 : Whitings on the coasts of the American continents. *U.S. Fish Wildl. Serv., Fish. Bull.*, **96** (56), 187-208.

GIRARD, C. 1856 : Contributions to the ichthyology of the western coast of the United States, from specimens in the Museum of the Smithsonian Institution. *Proc. Acad. Nat. Sci. Phila.*, 1856, 132.

GOODE, G. B. 1884 : Natural history of useful aquatic animals. *In* The fisheries and fishing industries of the United States. Section I, pp. 240-243, Government Printing Office, Washington, D.C.

GOODRICH, E. S. 1930 : Studies on the structure and development of vertebrates. xxx+837 pp., McMillan, London.

GOSLINE, W. A. 1961 : The perciform caudal skeleton. *Copeia*, 1961 (2), 265-270.

——— 1963 : Considerations regarding the relationships of the percopsiform, cyprinodontiform and gadiform fishes. *Occ. Pap. Mus. Zool., Michigan Univ.*, **629**, 1-38.

GOTSHALL, D. W. 1969 : Stomach contents of Pacific hake and arrowtooth flounder from northern California. *Calif. Fish Game*, **55** (1), 75-82.

GRAHAM, M. (ed.). 1956 : Sea fisheries, their investigation in the United Kingdom. 487 pp., Edward Arnold (Publisher) Ltd., London.

GREGORY, W. K. 1933 : Fish skull : A study of the evolution of natural mechanism. *Trans. Am. Phil. Soc.* (new ser.), **23** (2), i-vii+75-481.

GRINOLS, R. B. and M.F. TILLMAN 1970 : Importance of the worldwide hake, *Merluccius*, resource. *Circ. Fish Wildl. Ser., Wash.*, **332**, 1-21.

*GRONOW, L.T. 1854 : Catalogue of fishes collected and described by Laurence Theodore GRONOW, now in the British Museum. Edited from the manuscript, by John Edward GRAY. vii+196 pp., London.

GUICHENOT, A. 1848 : Historia fisica y politica de Chile (in GAY, C.). *Zoologia*, **2**, 328-330.

GULLAND, J. A. 1968: A preliminary assessment of Sliver hake in subarea 5. *ICNAF Res. Doc.*, 68/76, (no pagination). (Mimeo).

———(ed.) 1971: The fish resources of the ocean. 255 pp., Fishing News (Books) Ltd., England.

GÜNTHER, A. 1860: Catalogue of the fishes in the British Museum. vol. 2., 548 pp., Tayler and Francis, London.

——— 1862: Catalogue of the fishes in the collection of the British Museum. vol. 4., 534 pp., Tayler and Francis, London.

——— 1880: Report on the shore fishes procured during the voyage of H.M.S. Challenger in the year 1873-1876. *Rep. Sci. Res. Expl. Voy. H.M.S. Challenger, Zool.*, **1** (6), 1-82.

HANAMURA, N. (ed.). 1971: Report of the Kaiyo Maru research cruise in 1969 (Argentine Patagonia). 458 pp., Fisheries Agency of Japan, Tokyo. (In Japanese).

HART, J. L. 1973: Pacific fishes of Canada. *Fish. Res. Bd. Canada, Bull.*, **180**, 1-740.

HART, T. J. 1946: Report on trawling surveys on the Patagonian continental shelf. Compiled mainly from manuscripts left by late E.R. GÜNTHER, M.A., *Discovery Rep.*, **23**, 223-408.

——— 1948: The distribution and biology of hake. *Biol. Rev. Cambridge Phil. Soc.*, **23** (1), 62-80.

HARRINGTON, R. W. 1955: The osteocranium of the American cyprinid fish, *Notoropis bifrenatus*, with an annotated synonymy of teleost skull bones. *Copeia*, 1955 (4), 267-290.

HECTER, J. 1872: Note on the edible fishes of New Zealand. *In* Fishes of New Zealand, pp. 96-133., Colonial Museum and Geological Survey Department, Wellington.

HICKLING, C. F. 1927: The natural history of the hake. Part I. Periodic changes in the fishery, and II. Food and feeding habits of the hake. *U.K. Min. Fish. Agr. Food, Fish. Inv., Ser.* 2, **10** (2), 1-100.

——— 1930: The natural history of the hake. Part Ⅲ. Seasonal changes in the condition of the hake. *Ibid., Ser.* 2, **12** (1), 24-57.

——— 1933: The natural history of the hake. Part Ⅳ. Age-determination and the growth-rate. *Ibid., Ser.* 2, **13** (2), 3-120.

HILDEBRAND, S. F. 1946: A descriptive catalog of the shore fishes of Peru. *Bull. U. S. Nat. Mus. Wash. D. C.*, (189), 1-530.

HUBBS, C. L. and K. F. LAGLER 1947: Fishes of the Great Lake Region. *Bull. Cranbrook Inst. Sci.*, **26**, i–xi+1-186.

HUTTON, F. W. 1872: Fishes of New Zealand. Catalogue with diagnoses of the species. 93 pp., Colonial Museum and Geological Survey Department, Wellington.

INADA, T. 1981: Two nominal species of *Merluccius* from New Zealand and southern South America. *Japan. J. Ichthy.*, **28** (1): 31-36.

——— and I. NAKAMURA 1975: A comparative study of two populations of the gadoid fish *Micromesistius australis* from the New Zealand and Patagonian-Falkland regions. *Bull. Far Seas Fish. Res. Lab.*, **13**, 1-26.

JENSEN, A. C. 1967: A brief history of the New England offshore fisheries. *U. S. Fish Wildl. Serv., Fish. Leafl.*, **594**, 1-14.

JERZMAŃSKA, A. 1968: Ichtyofaune des couches a ménilite (flysch des karpathes). *Acta Palaeont. Polonica*, **13** (3), 379-488.

JONES, B. W. 1967: The biology and population dynamics of the Cape hake, *Merluccius capensis. ICES Demersal Fish (Southeɹn) Committee*, CM 1967/G. 6, 7 pp. (Mimeo).

——— and T.H. van ECK 1967: The Cape hake: its biology and the fishery. *S. Afr. Shipp. News Fish. Ind. Rev.*, Nov., 90-97.

——— and I. M. MACKIE 1970: An application of electrophoretic analysis of muscle myogen to taxonomic studies in the genus *Merluccius*. *Comp. Biochem. Physiol.*, **32** (2), 267-273.

JONES, F. R. H. 1974: World resources of hakes of the genus *Merluccius*. *In* Sea Fisheries Research in Honour of M. GRAHAM, pp. 139-166., Elek Science, London.

JORDAN, D. S. 1923: A classification of fishes, including families and genera as far as known. *Stanford Univ. Publ., Biol. Serv.*, **3** (2), 79-243.

——— and B. W. EVERMANN 1898: Fishes of North and Middle America, Ⅲ. *Bull. U. S. Nat. Mus.*, **47** (3), 2529-2531.

——— and ——— 1917: The genera of fishes from LINNAEUS to CUVIER, 1758-1833. seventy-five years, with the accepted type of each. *Publ. Stanford Univ. Calif.*, **1** (1), 1-161.

——— and C. H. GILBERT 1882: Synopsis of the fishes of North America. *Bull. U.S. Nat. Mus.*, **16**, i–lvi+1-1018.

KABATA, Z. 1970: Discovery of *Brachiella lageniformis* (Copepoda: Lernaeopodidae) in the Canadian Pacific and its significance to zoogeography of the genus *Merluccius* (Pisces: Teleostei). *J. Fish. Res. Bd. Canada*, **27** (12), 2159-2165.

KARNELLA, C. 1973: The systematic status of *Merluccius* in the tropical western Atlantic Ocean including the Gulf of Mexico. *Fish. Bull., U. S.*, **71** (1), 83-91.

KAUP, J. 1858: Uebersicht der Familie Gadidae. *Arch. Naturg., Berlin*, **24** (1), 85-93.

KAWAHARA, S. and T. NAGAI 1980: On the mixture of three species of *Merluccius* in the ICSEAF Area. *Far Seas Fish. Res Lab.*, 7 pp. (Mimeo).

KLIMA, E. F. 1976: A review of the fishery resources in the western central Atlantic (WECAF). *FAO WECAF Studies*, **3**, 38-40.

KONO, H. 1980: Preliminary report of fishery resource survey in Chilean waters by F/V Akebono maru No. 72. 35 pp., *Japan Mar. Fish. Resource Res. Center*. (Mimeo).

KRAMER, D. and P. E. SMITH 1970: Seasonal and geographic characteristics of fishery resources. *Com. Fish. Rev.*, **32** (7), 41-44.

KRUGLOV, L. A. and I. A. TRUNOV 1966: Distribution of hake in the Southeast Atlantic. *Rybnoe Khozyaistvo*, **12**, 6-9. (English translation).

KUNTZ, A. and L. RADCLIFFE 1918: Notes on the embryology and larval development of twelve teleostean fishes. *Bull. U. S. Bur. Fish.*, **35**, 87-134.

KUSAKA, T. 1974: The urohyal of fishes. 320 pp., University Tokyo Press, Tokyo.

LACEPÈDE, B. 1803: Histoire naturelle des poissons. vol. 5., xlviii+803 pp., Paris.

LAGLER, K. L., J.E. BARDACH and R.R. MILLER 1962: Ichthyology. xii+545 pp., Wiley and Sons Inc., New York.

LANGTON, R. W. and R. E. BOWMAN 1980: Food of fifteen Northwest Atlantic gadiform fishes. *NOAA Tech. Pap.*, NMFS SSRF-740, i–iv+1-23.

LAVENBERG, R. J. and J. E. FITCH 1966: Annotated list of fishes collected by midwater trawl in the Gulf of California, March-April 1964. *Calif. Fish Game*, **52** (2), 92-110.

LEBOUR, M. V. 1919: The food of young fish. *J. Mar. Biol. Ass. U.K.*, **12** (2), 261-324.

LEIBLE, D. M. and G. E. MARTINEZ 1974: Taxonomía de muestra comuesta de *Merluccius gayi* (Pisces: Merlucciidae). *Inv. Oceanol. Chil.*, **1** (1), 3-13.

LEIM. A. H. and W. B. SCOTT 1966 : Fishes of the Atlantic coast of Canada. *Bull. Fish. Res. Bd. Canada*, **155**, 1-485.

LENGERICH, N. J. 1965 : Analisis estadistico de la pesca de la merluza en Chile. *Inst. Fom. Pesq. Publ.*, **7**, 1-15.

LETACONNOUX, R. 1950 : Le stock de merlus dans le golfe de Gascogne en 1949. *Ann. Biol., Copenh.*, **6**, 50-51.

——— 1952 : Note sur le merlu de la Cote d'Afrique. *J. Cons. Perm. Int. Explor. Mer*, **18** (2), 223.

——— 1953 : Rapport sur le merlu. *Cons. Int. Explor. Mer, Comité Atlantique*, 5 pp. (Mimeo).

L'HERROU, R. 1972 : Les merlus de l'Atlantique du nord-ouest et leur Peche. *Sci. Pêche. Bull. Inst. Pêches Marit.*, **220**, 1-17.

LINNAEUS, C. 1758 : Systema Naturae. 10th ed., vol. 1., 824 pp., Nantes and Pisces : 230-338. (Reprint, 1956, London).

*LOWE, R. T. 1840 : Description of certain new species of Madeiran fishes, with additional information relating to those already described. *Proc. Zool. Soc. Lond.*, **8**, 36-39.

MACGREGOR, J. S. 1966 : Fecundity of the Pacific hake, *Merluccius productus* (AYRES). *Calif. Fish Game*, **52** (2), 111-116.

——— 1971 : Additional data on the spawning of the hake. *Fish. Bull., U.S.*, **69** (3), 581-585.

MACKIE, I. M. and B. W. JONES 1978 : The use of electrophoresis of the water-soluble (Sarcoplasmic) proteins of fish muscle to differentiate the closely related species of hake (*Merluccius* sp.). *Comp. Biochem. Physiol.*, **59B**, 95-98.

MALM, A. W. 1877 : Göteborg och Bohusläns fauna. Ryggradsbjuren. 674 pp., Göteborg.

MANN, F. G. 1954 a : El mar chileno y sus regiones biogeográficas. *Inv. Zool. Chilenas, Santiago*, **2** (5), 75-85.

——— 1954b : *Merluccius gayi*. In vida de los peces en aguas chilenas. pp. 181-184, Univ. Chile, Santiago.

MARAK, R.R. 1967 : Eggs and early larval stages of the Offshore hake, *Merluccius albidus*. *Trans. Am. Fish. Soc.*, **96**, 227-228.

MARINI, T. L. 1933 : La merluza argentina. *Rev. Physis, Buenos Aires*, **11**, 321-326.

MARSHALL, N. B. 1966 : The relationships of the anacanthine fishes, *Macruronus*, *Lyconus*, and *Steindachneria*. *Copeia*, 1966, 275-280.

——— and D. M. COHEN 1973 : Order Anacanthini (Gadiformes), characters and synopsis of families. *Mem. Sears Found. Mar. Res.*, **1** (6), 479-495.

MARTINEZ, G. E. 1976 : Variabilidad de los caracteres meristicos en *Merluccius gayi* (GUICHENOT, 1848) en la costa de Chile. *Rev. Biol. Mar. Dep. Oceanol. Univ. Chile*, **16** (1), 71-93.

——— and D. M. LEIBLE 1974 : Influencia del sexo en el estudio biométrico de una muestra compuesta de *Merluccius gayi* (Pisces : Merlucciidae). *Inv. Oceanool. Chil.*, **1** (2), 27-39.

MATHEWS, C. P. 1975 : Some observations on the ecology and the population dynamics of *Merluccius angustimanus* in the South Gulf of California. *J. Fish Biol.*, **7** (1), 83-94.

———, J. L. GRANADOS and J. ARVIZU 1974 : Results of the exploratory cruises of the Alejandro de Humboldt in the Gulf of California. *Calif. Mar. Res. Comm., Calcofi*

Rept., **17**, 101-111.

MATSUBARA, K. 1955 : Fish morphology and hierarchy. Part Ⅰ.Ⅱ and Ⅲ. xi+1605 pp., Ishizaki Shoten, Tokyo. (In Japanese).

——— 1963 : Dobutsu Keito-bunruigaku. Ⅸ. viii+531 pp., Nakayama Shoten, Tokyo. (In Japanese).

MATTEWS, J. P. and B. V. D. de JAGER 1951 : The development of the Cape stockfish (*Merluccius capensis*). *Un. S. Afr., Fish Mar. Biol. Sur. Div., Invest. Rept.*, **23**, 1-10.

MAURIN, C. 1952 : Les merlus des côtes Atlantiques du Maroc. *J. Cons. Perm. Int. Explor. Mer*, **18** (2), 224-229.

——— 1954a : Etude comparative du "merlu blanc" (*Merluccius merluccius* L.) et de "merlu oir" (*Merluccius senegalensis* CADENAT). *Ibid.*, **19** (3), 345-349.

——— 1954b : Les merlus du Maroc et leur Pêche. *Bull. Inst. Pêch. Marit. Maroc*, **2**, 7-37.

——— 1965 : Les merlus des mers européennes et nord-ouest africaines. Importance de la moyenne vertébrale dans la détermination des sous-espéces et groupements raciaux. *Rapp. Com. Int. Explor. Sci. Medit.*, **18** (2), 215-220.

——— 1968a : Les merlus des côtes nord et nord-ouest d'Afrique (Atlantique et Méditerranée). Theses l'Univ. Nancy, 43 pp. (Mimeo).

——— 1968b : Écologie ichthyologique des fonds chalutables Atlantiques (de la Baie Ibéro-Marocaine a la Mauritanie) et de la Méditerranée Occidentale. *Rev. Trav. Inst. Pêches Marit.*, **32** (1), 1-136.

MCKENZIE, R. A. 1956 : Silver hake, *Merluccius bilinearis*, in the Gulf of St. Lawrence. *Copeia*, 1956 (2), 111.

*MINDING, J. 1832 : Lehrbuch der Naturgeschichte der Fische. xii+132 pp., Berlin.

MISU, H. and S. HAMASAKI 1971 : Age and growth of Peruvian hake, *Merluccius gayi* (GUICHENOT). *Bull. Seikai Reg. Fish. Res. Lab.*, **41**, 93-105.

MITCHILL, S. L. 1814 : Report in part on the fishes of New York. *Trans. Lit. Phil. Soc., New York*, **1**, 7.

——— 1818 : Description of three species of fish. *J. Acad. Nat. Sci. Phila.*, **1**, 407-412.

MOMBECK, F. 1970a : Vorläufiger Bericht über Seehecht-Untersuchungen im SO-Atlantik. *Archiv. Fishereiwiss*, **21**, 45-61.

——— 1970b : Weitere Mitteilungen über den Seehecht im Südafrikanischen Raum. *Ibid.*, **21**, 62-66.

——— 1970c : Notes on the distinction of Northwest Atlantic hakes, *Merluccius albidus* and *M. bilinearis*. *ICNAF Res. Doc.*, 70/91, 1-3.

MONOD, T. 1968 : Le complexe urophore des poisson téléostéens. *Mém. Inst. Fond. Afrique Noir.*, **81**, 1-705.

MÖCKLINGHOFF, G. 1973 : Management and development of fisheries in the North Atlantic. *FAO FI*, FMD/73/R-10, 1-24.

MUJIB, K. A. 1967 : The cranial osteology of the Gadidae. *J. Fish. Res. Bd. Canada*, **24** (6), 1315-1375.

NELSON, M. O. 1969 : Availability of Pacific hake (*Merluccius productus*) related to the harvesting process. *FAO Fish. Rep.*, **62** (3), E/34, 619-644.

——— and H. A. LARKINS 1970 : Distribution and biology of Pacific hake : A synopsis. *Circ. U. S. Fish Wildl. Serv.*, **332**, 23-33.

NEWMAN, G. 1977 : The living marine resources of the Southeast Atlantic. *FAO Fish. Tech. Pap.*, FIR/T178 (En), 1-59.

NICHY, F. E. 1969 : Growth patterns on otoliths from young Silver hake, *Merluccius bilinearis* (MITCH.). *Int. Comm. Northwest Atl. Fish., Res. Bull.*, **6**, 107-117.

NIKOL'SKII, G. V. 1954 : Subfamily Merlucciinae. *In* Special Ichthyology. pp. 339-340., Gosudarstvennoe izdatel'stvo "Sovetskaya nauka", Moskva. (English translation).

NORDEN, C. R. 1961 : Comparative osteology of representative salmonid fishes, with particular reference to the grayling (*Thymallus arcticus*) and its phylogeny. *J. Fish. Res. Bd. Canada*, **18** (5), 679-791.

NORMAN, J. R. 1937 : Coast fishes. Part II. The Patagonian region. *Discovery Rep.*, **16**, 1-150.

——— 1966 : A draft synopsis of the order, families and genera of recent fishes and fish-like vertebrates. 649 pp., British Museum (N.H.), London.

ODEMAR, M. W. and J. M. SILVOSA 1971a : Abundancia, distribucion y biologia de la merluza del sector Bonaerense en primavera (Campaña "merluza 70-III" 30 de setiembre-14 de octubre 1970). *Infmes. Tec. Proy. Des. Pesq.*, **31**, 1-27.

——— and ——— 1971b : Distribucion, abundancia y biologia de la merluza y otras especies demersales en el sector Bonaerense y Patagonico durante el verano (Campaña "merluza 70-IV" 8 de diciembre al 19 de diciembre, 1970 Campaña "merluza 71-I" 5 de enero al 21 de enero, 1971). *Ibid.*, **35**, 1-52.

OKAMURA, O. 1966 : The brain of the fishes of the order Gadida, with special reference to its morphological differentiation. *Japan. J. Ichthy.*, **13** (4/6), 103-111. (In Japanese).

——— 1970 : Studies on the macrouroid fishes of Japan. Morphology, ecology and phylogeny. *Rep. Usa Mar. Biol. Sta.*, **17** (1-2), 1-179.

OLSSON, A. A. 1972 : Origin of the existing Panamic molluscan biotas in terms of their geologic history and their separation by the Isthmian land. *Bull. Biol. Soc. Wash.*, **2**, 117-123.

OTERO, H. O. 1977 : Edad y crecimiento de la merluza (*Merluccius merluccius hubbs*). *Buenos Aires Physis* (*Seccion A*), **36** (92), 41-58.

O'TOOLE, M. J. 1978 : Aspects of the early life history of the hake *Merluccius capensis* CASTELNAU off South West Africa. *Fish. Bull. S. Afr.*, **10**, 20-36.

PCHENITCHNY, B. P. 1979 : The morphometric characteristics of the Angola hake, *Merluccius polli*. *J. Ichthy.*, **19** (4), 17-22.

——— and V. V. ASSOROV 1969 : Some biological characteristics of hake (*Merluccius*) of the Atlantic Ocean near the south west coast of Africa. *Vop. Ikhtiol.*, **9** (3), 423-430.

PEARSON, R. 1978 : Climate and evolution. 274 pp., Academic Press Inc. Ltd., London.

PHILLIPPS, W. J. 1927 : Bibliography of New Zealand fishes. *N.Z. Mar. Dept., Fish. Bull.*, **1**, 1-68.

POLL, M. 1953 : Poissons : III Téleostéena Malacoptérygiens. Exp. Ocean. Belge. (1948-1949), Résultats Scientifiques, **4** (2), 208-216.

POSTEL, E. 1966 : Le merlu et sa pêche. *Pêche Marit.*, **1061** (1966), 3-7.

POULSEN, E. M. 1957 : The hake fisheries off the west coast of Chile. *Proc. Eighth Pac. Sci. Cong.*, **3**, 241-245.

QUERO, J. 1973 : Les merlus d'Afrique du Sud et leur pêche. *Rev. Trav. Inst. Pêches Marit.*,

37 (1), 117-136.

RAFINESQUE, S. 1810a : Caratteri di alcuni nuovi generi e nuove specie di animalie piante dolla Sicilia. 105 pp., Palermo. (Reprint A. Asher, Amsterdam, 1967).

——— 1810b : Indice d'ittiologia sicilina ossia catalogo metodico dei nomi latini, italiani, e siciliani dei pesci, che si rinvengono in Sicilia. 69 pp. (Reprint, A. Asher, Amsterdam, 1967).

RATTRAY, J. M. 1947 : Observations on the food-cycle of the South African stockfish, *Merluccius capensis* CAST. off the west coast of South Africa ; with a note on the food of the kingklip, *Genypterus capensis* (SMITH). *Ann. S. Afr. Mus.*, **36** (4), 315-331.

REGAN, T. C. 1903 : On the systematic position and clasification of the gadoid or anacanthine fishes. *Ann. Mag. Nat. Hist.*, **7** (11), 459-466.

RIBEIRO, A. de M. 1915 : Merlucciidae. *In* 'Fauna Brasiliense'. Peixes (eleutherobranchios aspirophoros) Physoclisti, pp. 1-2, Arch. Mus. Nac., Rio de J.

RIKHTER, V. A. 1968 : Features on the springtime behavior and distribution of Silver hake (Whiting) in the western Atlantic. *Ryb. Khoz., Moskva*, (11), 15-17. (English translation).

*RISSO, A. 1826 : Histoire naturelle des principales productions de l'Europe meridionale et particulierement de celles des encirons de Nice et des Alpes maritimes. vol. Ⅲ., xvi+486 pp., Paris et Strasbourg.

ROHR, B. A. and E.J. GUTHERZ 1977 : Biology of Offshore hake, *Merluccius albidus* in the Gulf of Mexico. *Fish. Bull. U. S.*, **75** (1), 147-158.

ROJAS, P. Z. and J. V. SEPULVEDA 1975 : Nota sobre el comportamiento electroforético de las protrínas del cristalino ocular de *Merluccius polylepis* y *Merluccius gayi* (Pisces : Merlucciidae). *Inv. Mar.*, **6** (3), 41-48.

ROJO, A. 1976 : Osteología de la merluza argentina (*Merluccius hubbsi*, MARINI 1933). *Bol. Inst. Espa. Oceano., Madrid*, **219**, 1-61.

ROJO, A. L. and D. A. A. CAPEZZANI 1971 : Características morfométricas y merísticas de la merluza argentina (*Merluccius merluccius hubbsi*). *Inv. Pesq.*, **35**, 589-637.

——— and J. M. SILVOSA 1969a : Stock invernal de la merluza (*Merluccius merluccius hubbsi*) del talud del sector Bonaerense. 30 de julio-9 de agosto 1969. *Infmes. Tec., Proy. Des. Pesq.*, **20**, 1-42.

——— and ——— 1969b : Estudio biologico de la merluza (*Merluccius merluccius hubbsi*) del sector Patagonico. Campaña exploratoria sur 69-1. Patagonia (24 febrero-24 marzo 1969), Seccion Biologica. *Ibid.*, **18**, 1-40.

——— and ——— 1969c : Investigaciones sobre la merluza (*Merluccius merluccius hubbsi*) del sector Bonaerense (Campaña "merluza 68-1"-20 nov. - 5 dic. 1968). *Ibid.*, **17**, 1-34.

——— and ——— 1970a : Campaña exploratoria de primavera en la plataforma Bonaerense (Campaña "merluza 69-11"-21-27 se sept. de 1969). *Ibid.*, **22**. 1-18.

——— and ——— 1970b : La merluza de los Golfos San Matias, nuevo y de la plataforma adyacente (Campaña "merluza 70-1"-28 enero-10 febrero 1970). *Ibid.*, **23**, 1-44.

ROSEN, D. E. and C. PATTERSON 1969 : The structure and relationships of the Paracanthopterygian fishes. *Bull. Am. Mus. Nat. Hist.*, **141** (3), 357-417.

ROUX, E. R. 1949 : Migrations of the Cape hake or Stockfish (*Merluccius capensis* CAST.) on the west coast of South Africa. *Trans. Roy. Soc. S. Afr.*, **32**, 217-231.

Saetersdal, G. and L. Villegas 1968 : Estudio del tamaño, crecemiento y madurez de la merluza (*Merluccius gayi*) en aguas Chilenas. *Pub. Inst. Fom. Pesq., Santiago*, **34**, 1-52.

Saishu, K. (ed.). 1972 : Report of the Kaiyo Maru research cruise in 1970 (New Zealand). 2 vols : 292 pp. 290 pp., Fisheries Agency of Japan, Tokyo. (In Japanese).

Sartins, A. A. and V. I. Sauskan 1967 : Hydrological conditions and distribution of Silver hake, *Merluccius bilinearis*, on Georges Bank and off Nova Scotia in 1962-64. *ICNAF Res. Bull.*, **4**, 76-86.

Sauskan, V. I. and V. P. Serebryakov 1970 : Reproduction and development of the Silver hake (*Merluccius bilinearis*, Mitchill). *Vop. Ikhtiol.*, **9** (3), 423-430. (English translation).

Sepulveda, J. V. and P. Z. Rojas 1973 : Comportamiento electroforético de algunas proteinas tisulares de la merluza (*Merluccius gayi* (Guichenot)). *Inv. Mar.*, **4** (4), 113-136.

Shippen, H. H. and M. S. Alton 1967 : Predation upon Pacific hake, *Merluccius productus*, by Pacific dogfish, *Squalus acanthias*. *Calif. Fish Game*, **53** (3), 218-219.

Silvosa, J.M. 1971 : Biologia de la merluza y experimentos de selectividad de la red comercial en el sector Bonaerense. *Infmes. Tec., Proy. Des. Pesq.*, **30**, 1-39.

Smith, J. L. B. 1949 : The sea fishes of southern Africa. 5th ed., xvi+580 pp., Central News Agency, Cape Town.

Soliman, I. A. 1973 : Variations of fishes of genus *Merluccius* in Atlantic Ocean and Mediterranean Sea. *Acta. Ichth. Pisc.*, **3** (2), 29-64.

Starks, E. C. 1901 : Synonomy of the fish skeleton. *Proc. Wash. Acad. Sci.*, **3** (7), 507-539.

——— and E.L. Morris 1907 : The marine fishes of southern California. *Univ. Calif. Publ. Zool.*, **3** (11), 159-251.

Sverdrup, H.U., M.W, Johnson and R.H. Fleming 1961 : The oceans their physics, chemistry and general biology. 1087pp. Prentice-Hall, Englewood Cliffs, N.J.

Svetovidov, A. N. 1937 : Über die Klassifikation der Gadiformes Order Anacanthini. *Bull. Acad. Sci. URSS*, **4**, 1281-1288.

——— 1940 : The problem of distribution of the Gadidae and of the other families of Gadiformes. *Bull. Soc. Nat. Moscow, Sec. Biol.*, **94** (1), 50-60.

——— 1948 : Fauna of the U. S. S. R., Fishes 9 (4) : Gadiformes. 221 pp, Zool. Inst. Akad. Nauk. (English translation).

——— 1953 : Materialy po stroeniyu mozga ryb. 1. Stroenie mozga treskovykh. *Trudy Zool. Inst., AN SSSR*, **13**, 390-419.

——— 1956a : The Atlantic origin of some groups of fishes. Proc. XIV Intern. Congr. Zool., Copenhagen, 5-12 Aug. 1953, 118-124.

——— 1956b : Morphological principles of the classification of the Gadidae. *Ibid.*, 535-540.

——— 1969 : O sistematicheskom polozhenii roda *Euclichthys*, (Pisces, Cadiformes). *Zool. Zhurnal*, **48** (12), 1824-1831. (English translaion).

——— 1973 a : Merlucciidae. *In* Check-list of the fishes of the north-eastern Atlantic and of the Mediterranean (eds. J.C. Hureau, and Th. Monod). pp. 300-302 Clofnam I, Unesco.

——— 1973b : *Merluccius merluccius* (Linnaeus, 1958). *In* FAO species identification sheets for fishery purposes (ed. W. Fisher), Vol. I, 2 pp., FAO, Rome.

Swainso, W. 1838 : On the natural history and classification of fishes, amphibians and reptiles or monocardian animals. vol. 1., 368 pp., London.

SZIDAT, L. 1955: La fauna de parsáitos de "*Merluccius hubbsi*" como carácter auxiliar para la solución de problemas sistemáticons y zoogeograficos del género "*Merluccius*" L. *Cienc. Zool., Buenos Aires*, **3** (1), 1-54.

TABETA, O., H. MISU and S. KANAMARU 1971: Distribution of bottom fishes in the waters off the Pacific coast of South America. Reading Paper for XII Pac. Sci. Congr., 15 pp. (Mimeo).

TAKANO, K. 1976: A possible baroclinic world ocean circulation of 65 million years B.P. *La mer (Bull. Soc. franco-japonaise d'oceanographie)*, **14** (2), 75-84.

TESTAVERDE, S. A. and E. ARTUNDUAGE 1974: Occurrence of *Merluccius angustimanus* off the Pacific coast of Colombia. *Copeia*, 1974 (2), 564-566.

TOMINAGA, Y. 1968: Internal morphology, mutual relationships and systematic position of the fishes belonging to the family Pempheridae. *Japan. J. Ichthy.*, **15** (2), 43-95.

TRUJILLO, H. 1972: Distributión y abundancia de recursos demersales capturados durante pescas exploratorias realizadas a lo largo de la costa chilena (con énfasis en las merluzas), 1964- 1969. *Bol. Cient. Inst. Fom. Pesq., Santiago*, **17**, 1-94.

TYLER, A.V. 1971: Periodic and resident components in communities of Atlantic fishes. *J. Fish. Res. Bd. Canada*, **28**, 935-946.

UYENO, T. 1975: Gyorui. *In* Koseibutsu-gaku Ⅲ (ed. T. SHIKAMA). 527 pp., Asakura Shoten, Tokyo. (In Japanese).

van ECK, T.H. 1969: The South African hake: '*Merluccius capensis*'- or '*Merluccius paradoxus*'? *S. Afr. Shipp. News Fish. Ind. Rev.*, May, 95-97.

VERGARA, R. 1978: Merlucciidae. *In* FAO species identification sheets for fishery purposes (ed. W. FISHER), vol. Ⅲ, 4 pp., FAO, Rome.

VESTNES, G., A. STROM and L. VILLEGAS 1965: Report on the exploratory survey with M/S "Carlos Darwin" in the Talcahuano-Valdivia area. Decemebr 1964 to February 1965. *Inst. Fom. Pesq. Publ.*, **6**, 1-32.

VINOGRADOV, V. I. 1971: Daily feeding rhythms and food rations of the Silver hake, *Merluccius bilinearis*, and the Red hake, *Urophycis chuss*, in the North-West Atlantic 1965-1967. *ICNAF Res. Doc.*, 71/114, 17 pp.

VLADYKOV, V. D. 1954: Taxonomic characters of the eastern North American chars (*Salvelinus* and *Cristivomer*). *J. Fish. Res. Bd. Canada*, **11** (6), 904-932.

VROOMAN, A. M. and P. A. PALOMA 1976: Dwarf hake off the coast of Baja California, Mexico. *Calif. Coop. Oceanic Fish. Inv. Pep.*, **19**, 67-72.

WAITE, E. R. 1911: Scientific results of the New Zealand government trawling expedition, 1907. Pisces. *Rec. Canterbury Mus.*, **1** (3), 157-272.

WEITZMAN, S.H. 1974: Osteology and evolutionary relationships of the Sternoptychidae, with a new classification of stomiatoid families. *Am. Mus. Nat. Hist.*, **153** (3), 327-478.

WHEELER, A. 1969: The fishes of the British Isles and northwest Europe. 613 pp., Macmillan and Co. Ltd., London.

WHITEHOUSE, R. H. 1935: Structure of the caudal fin of the cod. *Nature*, 1935 (January), 70.

WHITLEY, G.P. 1937: Further ichthyological miscellanea. *Mem. Queensland Mus.*, **11** (2), 113-144.

——— 1968: A check-list of the fishes recorded from the New Zealand region. *Aust. Zoologist.*, **15** (1), 1-102.

WILIMOVSKY, N. J. 1954: List of the fishes of Alaska. *Stanford Ichthy. Bull.*, **4** (5), 279-294.

WILLIAMS, F. 1968: Report on the Guinean Trawling Survey. Vol. I. General report. OAU/STRC Publ., **99**, 1-828.

WRZESINKA, O. 1975: Relation between *Engraulis anchoita* concentrations and presence of *Merluccius hubbsi* on the Patagonian continental shelf. *Mar. Biol.*, **32** (1), 13-17.

WYSOKINSKI, A. 1974: Taxonomic position of hake *Merluccius polylepis* GINSBURG, 1954, from the Falkland Islands and Tierra del Fuego region. *Acta. Ichth. Pisc.*, **4** (2), 19-31.

ZINKEVICH, V. N. and V. I. SAUSKAN 1968: On the biology and the fishing of the Patagonian hake. *Ryb. Khoz., Moskva*, (2), 22-24. (English translation).

Anonymous 1970: Separation of the Transisthmian Ocean. *In* Atlantic-Pacific Interoceanic Canal Study Commission, Appendix 16. p. 2., Nat. Acad. Sci., Nat. Res. Council, Wash. D.C.

——— 1973: Report of feasibility study on the new overseas fishing ground by bottom trawler in 1972-eastern North Atlantic. *Rep. Japan Mar. Fish. Resource Res. Center*, 47 (10), 1-148+1-575. (In Japanese).

——— 1975: Report of feasibility study on the new overseas fishing ground by bottom trawler in 1974-off western north Africa. *Ibid.*, 49 (10), 1-791. (In Japanese).

——— 1976: Report of feasibility study on the new overseas fishing ground (deep sea) by bottom trawler in 1975-southern waters of New Zealand. *Ibid.*, 50 (9), 1-616. (In Japanese).

——— 1977: Poland's 1976 fish catch off U.S. west coast drops. *Mar. Fish. Rev.*, **39** (10), 34-35.

——— 1978a: Report of feasibility study on the new overseas fishing ground (deep sea) by bottom trawler in 1977-southern Indian Ocean. *Rep. Japan Mar. Fish. Resource Res. Center*, 52 (12), 1-375+1-346. (In Japanese).

——— 1978b: Report of feasibility study on the new overseas fishing ground by bottom trawler in 1977-off west coast of southern Africa. *Ibid.*, 52 (7), 1-541+1-1026. (In Japanese).

——— 1979a: Report of feasibility study on the new overseas fishing ground (deep sea) by bottom trawler in 1976-southern waters of New Zealand. *Ibid.*, 51 (11), 1-470+1-778. (In Japanese).

——— 1979b: Report of feasibility study on the new overseas fishing ground by bottom trawler in 1978-waters off Chile. *Ibid.*, 53 (10-B), 1-265+1-162. (In Japanese).

——— 1979c: Report of feasibility study on the new overseas fishing ground (deep sea) by bottom trawler in 1978-off Argentine. *Ibid.* (unpublished manuscript).

——— 1980: Report of feasibility study on the new overseas fishing ground by bottom trawler in 1979-waters off Chile. *Ibid.*, 54 (10), 1-416. (In Japanese).

Asterisks mark those to which the author did not gain across

メルルーサ科魚類の研究

稲 田 伊 史

要 約

いわゆるヘイク，あるいはメルルーサと呼ばれる魚類は分類学上，タラ目メルルーサ科メルルシウス属に属し，2つの背鰭及び1つの臀鰭がほぼ軟条から構成され，また第2背鰭及び臀鰭に深い欠刻を有することで特徴づけられる。メルルーサ類は世界の大陸棚及び陸棚斜面に広く分布し，漁業上重要な資源となっている。メルルーサ類は古くからその存在が知られており，LINNE (1758) 以来多くの研究がなされている。分類学上の研究では NORMAN (1937)，SVETOVIDOV (1948) が世界の本属魚類を7種に整理し，GINSBURG (1954) はアメリカ大陸の本属を8種に分類した。また，FRANCA (1962) は大西洋東部の本属魚類について分類学上の地位を検討し，これら全てを亜種として扱った。形態学上の研究は SVETOVIDOV (1948) が主要な種についてそれらの中軸骨格を比較研究し，その後 MUJIB (1967)，ROJO (1976) 等が2，3の種の頭骨を詳しく研究した。生態学上の研究は主として漁業生物学上から各々の種について多くの研究がなされており，特にヨーロッパヘイクについては HICKLING (1927，1930，1933) が，パシフィックヘイクについては，AHLSTROM and COUNTS (1955) が詳しい研究を行っている。また GRINOLS and TILLMAN (1970)，BOEREMA (1977) は世界のメルルーサ類の漁業資源について総述を行っている。

本研究は世界のメルルーサ類の全ての種の分類を明らかにするとともに，これらの内部形態を詳しく吟味し，あわせて現在まで得られている生態学上の知見を総述した上，本属魚類の系統回遊を論じることを目的として行われた。メルルーサ類の分類学研究のため，全ての種の569個体について10の計数形質を，また1404個体について28の体部比の形質を吟味し比較を行った。その結果，鰓耙数，脊椎骨数，肋骨数，側線下の縦列鱗数，臀鰭鰭条数及び体色，また頭長，吻長，上顎長等の相対値などにより12種に分類することが妥当であることがわかった。なお，いくつかの種の間では外部形態上の相違は小さいが，統計的方法を用いて検討した結果，これらはすでに種の段階に分化していることが認められた。ここではメルルシウス属と12種4亜種の外部形態を記載した。メルルーサ類の形態学研究のため，各形質の種内変異を十分に考慮して，鰾，脳を含む主として骨格系の14の内部形質を比較検討した。その結果，鰓耙，両顎歯，眼窩孔，舌顎骨，尾舌骨，鎖骨及び後鎖骨の形態において種の間で若干の傾向的な相違が認められた。しかしながら他の形質は種内の変異の幅が大きく，種間における形態上の相違はほとんど見られなかった。ここではメルルシウス属魚類の内部形態を記載し，種内変異や種間の相違についても言及した。メルルーサ類の生態学研究のため，12種4亜種についてそれらの分布及び生活史等を総述した。主として北半球の漁業上重要な種については多くの研究がみられ，これらの文献を引用することにより各々の種の生態をとりまとめた。また近年の日本漁船による調査結果をもとにいくつかの種，特に南半球の種についてそれらの生態の一部を明らかにした。しかしながら一部の種，特に熱帯水域の種については実施された調査が少いためそれらの生態についてはほとんど明らかにすることができなかった。なお，いくつかの種については漁業の歴史と資源の現存量，漁獲可能量の大きさについて現在まで得られている知見を総述した。最後にメルルーサ類の分類学研究の歴史を総述し，世界の12種について主として計数形質をもとにした検索表を示した。また本研究を通じていくつかの形態上にみられた傾向的特徴と古生物学上の証拠を引用してメルルシウス属の種の分散過程を推定した。その結果，本属魚類は北東大西洋海域を分散の起源とし，ある地質時代を通じアフリカ西岸を南下した経路と，中央アメリカを経由して南北アメリカ大陸の太平洋岸に回遊した経路を主軸とした分散により現在の本属魚類の分布が決定されたと考えるのが最も妥当であるとの結論を得た。