Maturation Cycle of Short Mackerel, *Rastrelliger brachysoma, in South Sulawesi, Indonesia*

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Received May 13, 1999

Abstract

The maturation process of the short mackerel, *Rastrelliger brachysoma*, was studied based on the seasonal changes in GSI and histological observation of the gonads. Specimens were collected from the sea off the east and west coasts of South Sulawesi, Indonesia, where the onset of the rainy season differs, during the period from March 1996 to July 1997. The short mackerel was a multiple spawner with asynchronous development of the oocytes; minimum size of the fish at maturation was about 140 mm (fork length). Gonad developmental stages were divided into 7 stages; i.e. immature, developing, fully-developed, gravid, running-ripe, regressing, and resting stages. The individuals which reached maturation were considered to repeat the process from the developing stages to the resting stages. However, spawning fish or immediately post-spawning fish occurred throughout the year, and clear seasonal changes were not observed either area.

Key words; short mackerel, gonad development, oocyte, spawning season, rainy season

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Introduction

The short mackerel, *Rastrelliger brachysoma*, is widely distributed in the Indo-Pacific Ocean and is an important commercial fish in Southeast Asia[1]. The genus *Rastrelliger* comprises three species, *R. kanagurta*, *R. bracysoma* and *R. faughni*[2], and the distribution of *R. kanagurta* is wider than that of the two other species[1]. Research concerning the spawning season is important in order to assess fisheries resources. However, biological studies on *Rastrelliger* spp., especially concerning age, growth or the reproductive cycle, have been mainly limited to *R. kanagurta*[3-5]. Several investigations on *R. bracysoma* have been conducted in the gulf of Thailand as reported by Menasveta.[6] According to these studies, the fish spawns throughout the year showing two peaks, and the first spawning occurs when the fish is about 17.5 cm in total length and about 1 year old. In Indonesia, although *R. bracysoma* is an important resource for fisheries, biological studies in this fish are still limited. Around Sulawesi Island (Fig. 1), the onset of the rainy season varies among the areas. The peak of the rainy season occurs from April and July on the east coast of South Sulawesi, but runs from December to January on the west coast (Fig. 2). [*c] The objective of this study was to examine the maturation process of this species in relation to the area and season. We collected samples from the east and west coasts of South Sulawesi during the period from March 1996 to July 1997, and compared the differences in the spawning seasons between these two areas.

Materials and Methods

Individuals for this study were collected from the east coast (Sinjai) and the west coast of South Sulawesi (Maros and Pare-pare) between March 1996 and July 1997 (Table 1). A total of 1,387 individuals which had been caught by seine net or drift gill net with lighting were obtained from fish markets. Fishing grounds were located of a distance of 2 to 5 km offshore in each location. Fork length was measures and gonads were removed from a total of 523 females (204 females from the eastern coast and 319 females from the western coast) and fixed in 10% buffered formalin for histological examination. Gonad somatic index (GSI) was calculated as follows:GSI = (gonad weight) *100 / (body weight -

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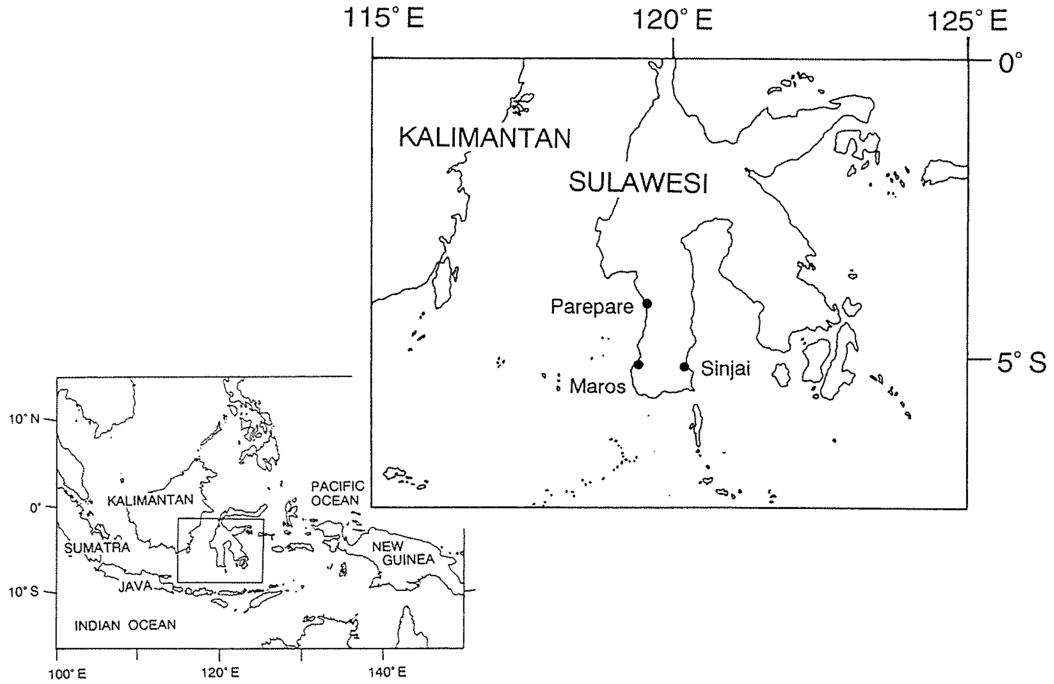

Fig. 1. Study areas in South Sulawesi, Indonesia.

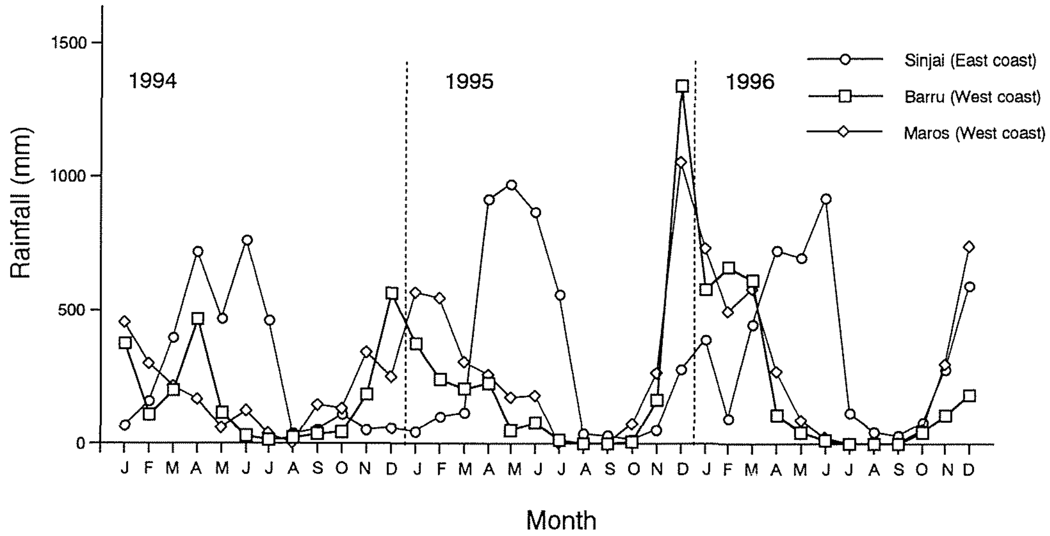

Fig.2. Monthly changes in rainfall in Maros, Parepare and Sinjai, South Sulawesi during the periods from 1994 to 1996.

Table 1. Sampling date and number of the individuals of short mackerel, *R. bracysoma*, in South Sulawesi, Indonesia

Sampling Date	Sampling Station	Total no. of samples	Fork length (range;mm)	Total no. of males	Total no. of females	Total no. of individuals with undetermined	Number of females sectioned
960411	Sinjai	51	132-194	15	19	17	19
960519	Sinjai	10	124-213	3	6	1	6
960723	Sinjai	50	135-178	13	30	7	30.
960824	Sinjai	30	116-170	21	9	0	6
960921	Sinjai	45	138-171	20	25	0	24
961022	Sinjai	54	117-153	20	28	6	9
961119	Sinjai	52	133-189	39	13	0	13
970302	Sinjai	50	143-178	17	30	3	30
970328	Sinjai	50	132-168	15	31	4	31
970428	Sinjai	1	144-144	1	0	0	0
970527	Sinjai	55	141-177	13	36	6	36
Sub total		448		177	227	44	204
960321	Maros	50	146-182	30	20	0	20
960425	Maros	50	130-175	14	34	2	34
960523	Maros	100	103-178	6	53	41	29
960627	Maros	50	134-152	29	20	1	20
960727	Maros	50	133-157	6	44	0	30
960826	Baruu	54	110-172	29	20	5	18
960930	Maros	49	106-134	11	11	27	0
961102	Maros	59	126-170	48	11	0	11
961128	Maros	50	190-223	22	28	0	27
970129	Maros	50	138-168	21	28	1	28
970227	Parepare	50	130-164	11	37	2	37
970429	Maros	100	109-157	0	1	99	0
970505	Parepare	53	145-165	30	23	0	23
970531	Parepare	54	130-161	28	24	2	24
970627	Maros	57	142-165	39	18	0	18
970729	Maros	63	134-162	22	35	6	0
Sub total		939		346	407	186 ·	319
Total		1387		523	634	230	523

gonad weight).

A small piece of tissue, which was removed from the central part of the gonads was embedded in paraffin, sectioned at 8 μm, and stained with Delafield's haematoxylin and eosin.

Each ovary was examined according to several criteria ; 1) determination of oocyte stage: perinucleolus, cortical alveoli, partially yolked, advanced yolked, hydrated or ovulated oocytes,[7] 2) examination for the presence of postovulatory follicles and

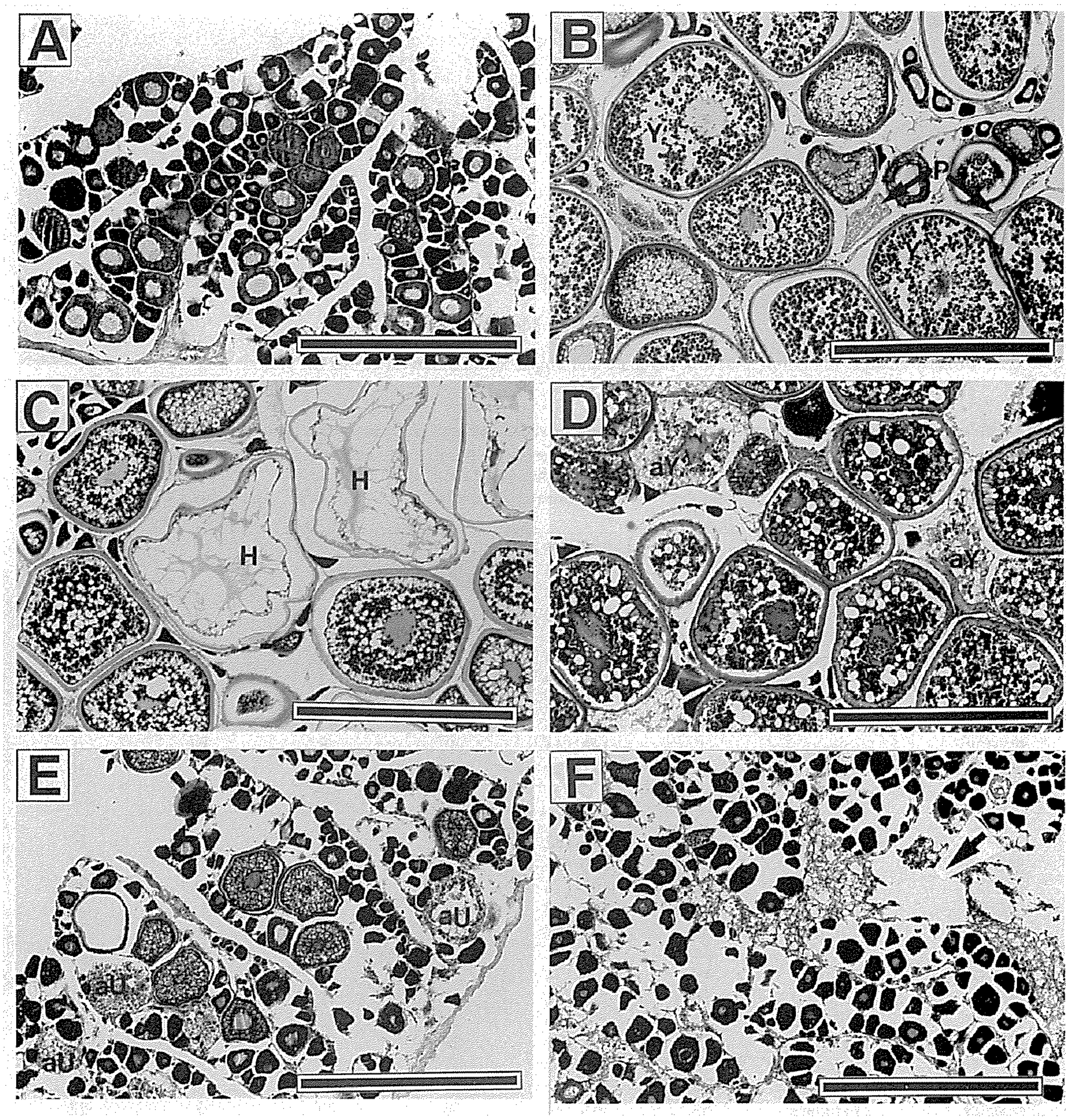

Fig.3. Photomicrographs of sections from the ovary of the short mackerel, *Rastrelliger brachysoma*. *Bar* indicates 0.5 mm. A. Immature stage of ovary, B. Ovary in fully-yolked stage; Y, fully-yolked oocyte. P, postovulatory follicles, C. Ovary during gravid stage; H, hydrated oocyte. D. Ovary in regressing stage in atretic state 2; aY, atretic yolked oocyte. E. Ovary in regressing stage in atretic state 3; aU, atretic unyolked oocyte. F. Ovary at resting stage with cavity (Arrow).

3) examination for the presence of atretic oocytes. Atretic oocytes were further divided into two types; atretic oocytes in which the original oocyte type (alpha stage) [8] could be identified, and atretic oocytes in which the original oocyte type (beta, gamma, and delta stages) could not be identified.

To analyze the atretic conditions of the ovaries, we defined four atretic states according to the classification of Hunter *et al.*[9], and Karlou-Riga and Economidis [10],

Atretic state 0 -no alpha atresia of yolked oocytes (yolked oocytes present).

Atretic state 1 - alpha atresia of yolked oocytes where <50 % of yolked oocytes were affected.

Atretic state 2 -alpha atresia of yolked oocytes where ≥50 % of yolked oocytes were affected.

Atretic state 3 -no yolked oocytes present and beta atresia observable.

After the examination of each section, fish were classified into 7 gonad developmental stages as follows:

1. Immature

Only unyolked oocytes (perinucleus and cortical alveoli) present; no atresia (Fig. 3-A).

2. Developing (partially yolked)

Oocytes undergoing primary growth to those which are partially yolked.

3. Fully developed

Oocytes undergoing primary growth to those in advanced yolked stages present. Occasionally, postovulatory follicles were present, and the atretic state is 0 or 1 (Fig. 3-B).

4. Gravid

Oocytes undergoing primary growth to those which are hydrated; postovulatory follicles may be present, and the atretic state is 0 or 1 (Fig. 3-C).

5. Running-ripe

Oocytes undergoing primary growth to those which are ovulated present. Postovulatory follicles are present.

6. Regressing

Oocytes undergoing primary growth were present; more than half of the yolked oocytes were undergoing atresia (atretic state 2; Fig.3-D) or yolked oocytes were not present and unyolked (cortical alveoli) oocytes were regressing (atretic state 3; Fig. 3-E).

7. Resting

Only oocytes undergoing primary growth were present. Those differ from immature fish by the existence of a cavity in the gonad (Fig. 3-F). Fish

Table 2. Fork length, body weight, gonad weight, GSI, and occurrence of POF (postovulatry follicles) and atretic oocytes in each maturity stage

Stage	No.	FL(mm)	BW(g)	GW(g)	GSI	POF	Atretic state			
							0	1	2	3
Immature	131	148.73(12.43)*1 (122-210)*2	57.69(18.00) (27.51-152.25)	0.27(0.17) (0.03-0.76)	0.45(0.21) (0.08-1.14)	0 (0)*3	0 (0)	0 (0)	0 (0)	0 (0)
Partially yolked	7	158.29(5.99) (151-166)	72.66(7.45) (60.12-79.50)	0.86(0.18) (0.54-1.07)	1.19(0.15) (0.91-1.36)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Fully yolked	121	155.50 (9.48) (139-189)	65.21(14.15) (43.69-121.27)	2.18(0.95) (0.74-6.01)	3.43(1.14) (1.05-7.47)	84 (69.4)	52 (43.0)	69 (57.0)	0 (0)	0 (0)
Gravid	4	147.75(11.32) (135-160)	53.13(9.57) (39.40-60.43)	2.36(1.19) (1.30-4.05)	4.82(2.50) (2.20-8.12)	3 (75.0)	1 (25.0)	3 (75.0)	0 (0)	0 (0)
Running-ripe	1	156 (156)	67.45 (67.45)	1.38 (1.38)	2.09 (2.09)	1 (100)	1 (100)	0 (0)	0 (0)	0 (0)
Regressing	226	152.43(11.63) (129-223)	62.29(16.78) (33.16-182.57)	1.20(1.12) (0.06-6.31)	2.11(2.17) (0.05-12.43)	9 (4.0)	0 (0)	0 (0)	135 (59.7)	91 (40.3)
Resting	33	181.97(28.62) (140-212)	102.81(40.15) (44.37-156.73)	0.43(0.23) (0.03-0.77)	0.43(0.17) (0.02-0.99)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

*1Average (Standard deviation), *2Range; (max. - min.), *3Occurrence ratio in each stage.

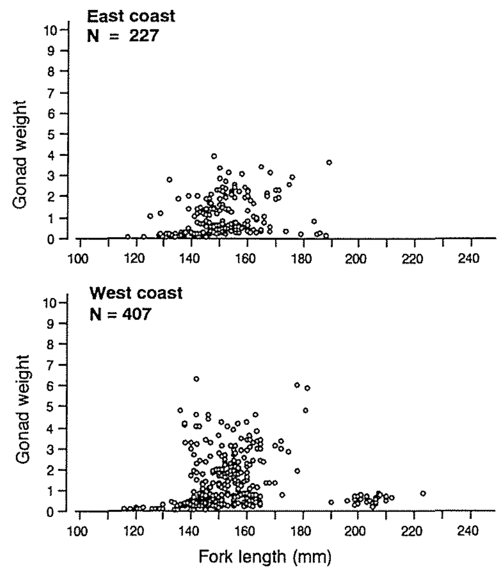

Fig. 4. Relationship between gonad weight and fork length in the short mackerel, *Rastrelliger bracysoma* on the east coast (Sinjai) and west coast (Maros and Parepare) of South Sulawesi.

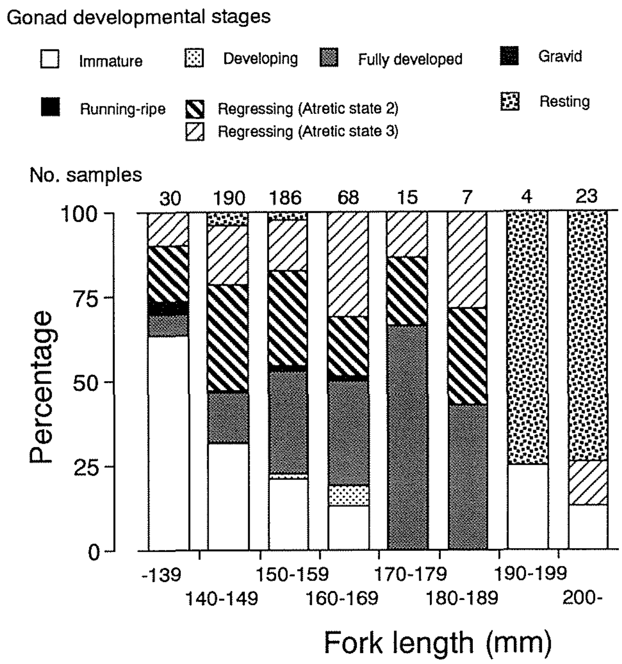

Fig. 5. Ratios of gonad developmental stages in each 10 mm size class.

which showed no evidence of past reproductive activity were classified as immature.

Results

1) Relationship between gonad developmental stages and gonad weight (GW), GSI and fork length

Average gonad weight and GSI increased during the immature stages until the fully yolked stages and decreased in the regressing stage (Table 2). The average gonad weight of fully yolked and gravid stages exceeded 2.18 g, and that of the gonads in the running-ripe stage was 1.38 g. Gonad weight in these two stages ranged from 0.74 to 6.01 and from 1.03 to 4.05, respectively. On the other hand, gonads in the immature and resting stages showed low gonad weights, averages weight were 0.27 and 0.43 g, the highest individual among these two stages was 0.77

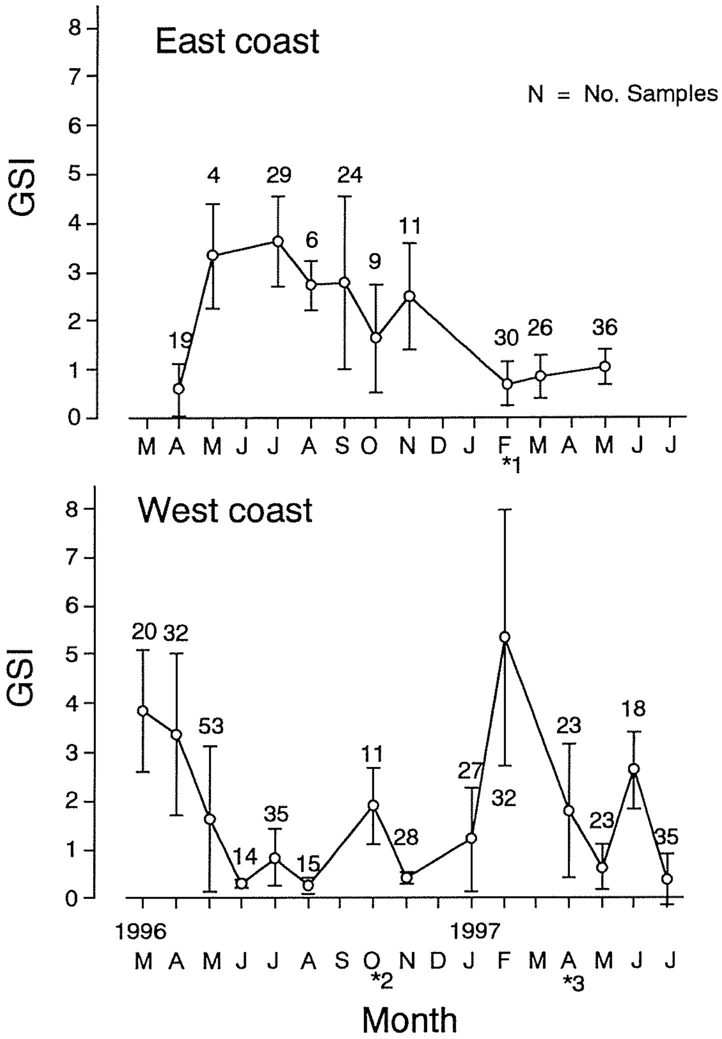

Fig. 6. Monthly changes in gonadal somatic index (GSI) for short mackerel, *Rastrelliger bracysoma* on the east coast (Sinjai) and west coast (Maros and Parepare) of South Sulawesi during the period from March, 1996 to July, 1997. *1 May 2, 1997, *2 November 2, 1996, *3 May 5, 1997.

g. The average gonad weight of fish in the partially yolked stage was 1.19, and the weight ranges from 0.54 to 1.07. When the gonad weight exceeded 0.77 g, it was considered that the gonads had begun to develop. The differences in GSI among each stage were not more distinct than those in the gonad weight. The range of GSI in each stage overlapped; i.e., in the immature stage GSI ranged from 0.08 to 1.14, and in the fully yolked stage, from 1.05 to 7.47.

2) Relationship between fork length and GW

Most of the fish which had gonads with a weight of more than 0.77 g (they were considered to have started maturation) showed a fork length of more than 140 mm (Fig. 4). The smallest fish in which the gonad weight more than 1.0 g was 125 mm in fork length from the east coast, but 140 mm was assumed to be a boundary between sexually developing and immature fish in both areas, except for a few individuals.

3) Relationship between fork length and gonad developmental stage

More than 63% of the fish less than 139 mm (fork length) were immature, while more than 80% of the individuals were classified as mature in each 10 mm size class above 150 mm. The size classes of more than 190 mm were observed in consisted of fish in the immature, regressing and resting stages. Observations of sectioned gonads also provided

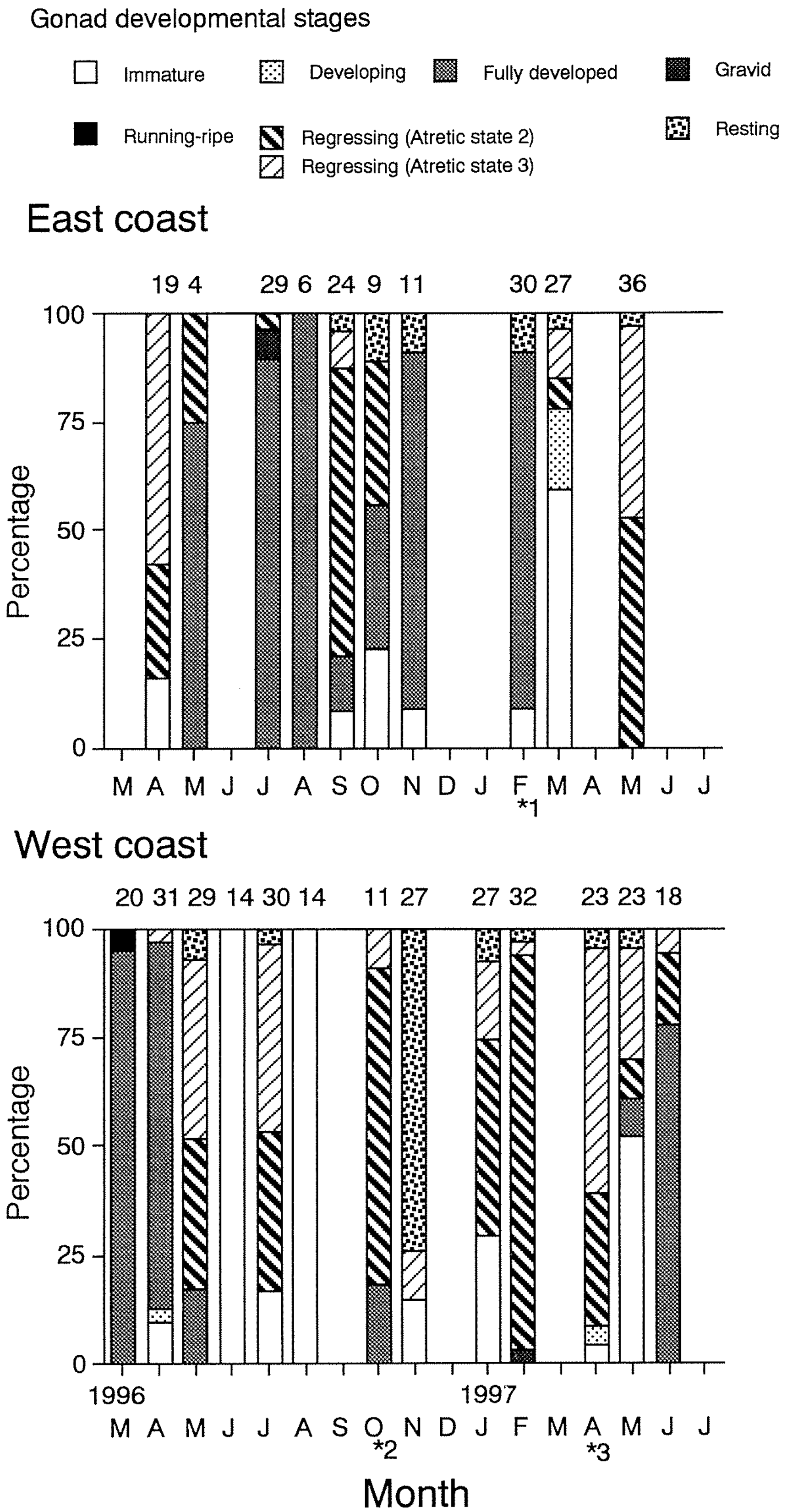

Fig. 7. Monthly changes in occurrence of each gonad developmental stages for the short mackerel, *Rastrelliger bracysoma* on the east coast (Sinjai) and west coast (Maros and Parepare) of South Sulawesi during the period from March, 1996 to July, 1997. *1 May 2, 1997, *2 November 2, 1996, *3 May 5, 1997.

evidence that the first maturation occurred when the fork length exceeded 140 mm in (Fig. 5).

4) Monthly changes in GSI

In order to examine the correlation between seasonal changes and ovarian development, we calculated GSI during each month among over 140 mm fish which had been considered to have started maturation. Average GSI was highest in July 1996 (average = 3.63), and that in May (3.33), September (2.78), August (2.73), and November (2.51) 1996 exceeded 2.0; in May 1997, GSI was low (1.05) on the east coast. On the west coast, average GSI was highest in February (5.33) 1997, and that in March (3.84), April (3.37) 1996 and June (2.6) 1997, it also exceeded 2.0. We could not define a distinct seasonal GSI cycle in each area (Fig. 6).

5) Monthly changes in gonad developmental stages

Only one stage occupied more than 75% of the individuals during a periods of 8 out of 10 months on the east coast and 10 out of 13 months on the west coast. Individuals in the fully developed stages (July, August and November 1996 and February 1997 on the east coast and March, April 1996 and June 1997 on the west coast) and regressing stages (Atretic state 2 and 3, April and September 1996, and May 1997 on the east coast and May, July and October 1996 and February and April 1997) were predominated during the months when the GSI was high. In June and August 1996, the gonads of all the fish were immature, and resting stage fish predominated in November 1996 on the west coast (Fig. 7).

However, seasonal changes in gonad developmental stages did not show clear seasonal cycles or patterns in either area. Spawning fish or regressing stage fish were collected almost throughout the year in these two areas.

6) Postovulatory follicle and atretic states

Postovulatory follicles were observed in the gonads in which staged as in the fully developed, gravid, running-ripe and regressing stages. Fishes in the fully yolked to running ripe stages had postovulatory follicles in high ratios (more than 69.4 %), but only 4 % of regressing stage fish had such postovulatory follicles.

Atretic state 1 was common among the spawning fish, with 57.0% of fully yolked staged fish and 75.0 % of gravid staged fish being classified into atretic state 1. The fish classified into atretic state 2 or 3 were in the as regressing stage, and in the 59.7 % of the fish in this stage had gonads in atretic state 2, and 40.3 % of fish had gonad in atretic state 3.

Discussion

The ovarian cycle of this species was similar to that of other scombroids fishes, including chub mackerel, *Scomber japonicus*[11]; yellowfin tuna, *Thunnus albacares*[12]; bigeye tuna, *Thunus obesus*[13]; skipjack tuna, *Katsuwonus pelamis*[14]; black skipjack, *Euthynnus lineatus*[15]; or other multiple spawning fishes, such as the northern anchovy, *Eugraulis mordax*[8,9]; or the European horse mackerel, *Trachurus trachurus*[10]. The short mackerel is considered to be multiple spawning type with asynchronous-type oocytes and spawns several times during a single spawning season. Only one fish that classified running-ripe stage (fish that have ovulated oocyte in the gonad) was observed, and this means ovulated oocyte immediately spawn and would not remain so long time in the gonad. In this study, after completing a single spawning season, oocytes which had been developing (yolked and cortical alveoli oocytes) began to regress, and these atretic oocytes were completely absorbed until the resting stage. The fish classified as resting stage had only perinucleolus stage oocytes in their gonad, and these oocytes would redevelop in the next spawning season. The minimum size spawning fish was 125 mm in this study, but most individuals started to mature when the fork length exceeded 140 mm. This size is smaller than that reported in previous studies[1,6]. Menasveta [6] reported that the minimum size of spawning fish was about 175 mm in total length, which corresponded to a folk length of 150 to 155 mm in our data, and about 160 mm in fork length in the report of Collete and Nauen [1]. The maturation size in around the South Sulawesi appeared to be smaller than in other areas as reported in other studies.

After reaching maturation, this species repeats the reproductive cycle in the gonads from the developing, spawning, regressing and resting stages. We separated the resting stage from the immature stage based on the presence a cavity in the gonads, because in the latter phase of the regressing stage also had a cavity in the gonad, and such gonads were not observed in obviously immature and small fish. However, we did not consider that all the post-spawning fish could be distinguished from fish classified as immature, because it was difficult to judge these two stages for some individuals, and fish which were not distinctly immature or resting were staged as immature. The largest fish classified as immature group was 210 mm, but such an individual may possibly undergo spawning.

In our study, however, no distinct spawning season recognized. On the east coast, spawning fish (developing to running-ripe stages) were collected from May 1996 to February 1997, and fish in regressing stage with atretic state 2 were caught before and after this period. On the west coast, spawning or atretic state 2 fish were collected almost all the time except in June, August and November 1996. Spawning fish were caught only during a period of 6 months (from March to May on the east coast, and in October 1996, and from May to June 1997 on the west coast), but fish classified into the atretic 2 state also occurred between these periods. Fish staged as regressing stage in atretic state 2 were considered to have just spawned, because the duration of atretic state 2 is not considered to be very long. In a laboratory study of northern anchovy, the average duration of this stage was only 9 days[8]. Our results suggest that spawning continues throughout this period around these areas and the spawning of each individual is not synchronized.

The gonad developmental stages in each month consisted of one dominant stage with a small number of other sequential stages. These results reflect the uniformity of gonadal states among fish caught each month. Since the changes in the gonad developmental stages did not show seasonal patterns, several schools of fish in which the gonad developmental stages differed may occure in these areas, but the state of maturation appeared to be similar in each school.

Some tropical species display sea sonal spawning patterns, but most species are reef fishes[16-18]. The spawning of these species is considered to be affected by the food supply, moon phase and rainfall[19]. As an example of coastal pelagic fishes in tropical areas, Engraulids and Spratelloidinae had been studied because of the importance of tuna bait fishes[20]. However, these species also spawn throughout the year, and even among the same species, spawning peaks differed according to the area. The short mackerel also showed similar reproductive characteristics, and the prediction of its spawning season may be difficult, as indicated by Milluton and Blader[20], because in such fishes did not found out clear stumble of spawning. We examined the seasonal changes in GSI and gonadal development in the two areas for one and a half years, but clear seasonal patterns were not observed. Therefore, it is necessary to investigate seasonal changes in the abundance of eggs, larvae and juveniles in these areas. As Robertson reported that the peaks of spawning and recruitment of some neotropical fishes often differ[17], research on early life history and recruitment also important for fishery management.

Acknowledgements

We thank to Dr. Marcy N. Wilder (Fisheries Division, Japan International Research Center for Agricultural Sciences) for reviewing the manuscript. We also thank to the staffs of Research Institute for Coastal Fisheries and Central Research Institute for Fisheries in Indonesia for assistance of our work.

References

1) Collette, B. B. and Nauen, C. E. (1983). FAO species catalogue Vol. 2 Scombrids of the world., FAO, Rome, pp.137.
2) Matsui, T. (1967). Review of the mackerel genera Scomber and Rastrelliger with description of a new species of *Rastrelliger. Copeia:* **1967**, 71-83.
3) Udupa, K.S. and Bhat,C.H.K. (1984). Age-and-growth equation of the Indian mackerel from purse-seine catches off Karnataka coast. *Indian J. Fish.* **31:** 61-67.
4) Mwebaza-Ndawula, L. (1990). Seasonal variation

in abundance of the Indian mackerel, *Rastrelliger kanagurta* Cuvier (Pisces: Scombridae) along the Zanzibar coast of East Africa. *Hydrobiologia*, **190**: 233-239.

5) Guanco, M.R. (1991). Growth and mortality of Indian mackerel *Rastrelliger kanagurta* (Scombridae) in the Visayas Sea, Central Philippines. *Fishbyte*, **9**: 13-15.

6) Menasveta, D. (1980). Resources and fisheries of the gulf of Thailand. SEAFDEC, 1-108.

7) Wallace, R. A. (1981). Cellular and dynamic aspects of oocyte growth in teleosts. *Amer. Zool.* **21**: 325-343.

8) Hunter, J. R. and Macewicz, B. J. (1985). Rate of atresia in the ovary of captive and wild northern anchovy, *Engraulis mordax. Fish. Bull. U. S.* **83**: 119-136.

9) Hunter, J. R., Macewicz, B. J., Lo, N. C. H. and Kimbrell, C. A. (1992). Fecundity, spawning, and maturity of female Dover sole *Microstomus pacificus,* with an evalution of assumptions and precision. *Fish. Bull. U. S.* **90**: 101-128.

10) Karlou-Riga, C. and Economidis, P. S. (1996). Ovarian atretic rates and sexual maturity of European horse mackerel, *Tranchurus trachurus* (L.), in the Saronikos Gulf (Greece). *Fish. Bull. U. S.* **94**: 66-76.

11) Dickerson, T. L., Macewicz, B. J. and Hunter, J. R.(1992). Spawning frequency and batch fecundity of chub mackerel, *Scomber japonicus,* during 1985. *CalCOFI Rep.* **33**: 130-140.

12) McPherson, G. R. (1991). Reproductive biology of yellowfin tuna in the Eastern Australian Fishing Zone, with special reference to the North-western coral sea. *Aust. J. Mar. Freshwater. Res.* **42**: 565-577.

13) Nikaido, H., Miyabe, N. and Ueyanagi, S. (1991). Spawning time and frequency of bigeye tuna, *Thunnus obesus. Bull. Nat. Res. Insti. Far-Seas Fish.* **28**: 47-73.

14) Hunter, J. R., Macewicz, B. J. and Sibert, J. R. (1986). The spawning frequency of skipjack tuna, *Katsuwonus pelamis,* from the south Pacific. *Fish. Bull. U. S.* **84**: 895-903.

15) Schaefer, K. M. (1987). Reproductive biology of black skipjack, *Euthynnus lineatus,* an eastern Pacific tuna. *Inter-American Trop. Tuna Comm.* **19**: 169-260.

16) Walsh, W. J. (1987). Patterns of recruitment and spawning in Hawaiian reef fishes. *Env. Biol. Fish.* **18**: 257-276.

17) Robertson, D. R.(1990). Differences in the seasonalities of spawning and recruitment of some small neotropical fishes. *J. Exp. Mar. Biol. Ecol.* **144**: 49-62.

18) Clifton, K. E.(1995). Asynchronous food availability on neighboring Caribbean coral reefs determines seasonal patterns of growth and reproduction for herbivorous parrotfish *Scarus iserti. Mar. Ecol. Prog. Ser.* **116**: 39-46.

19) Johannes, R. E. (1978). Reproductive strategies of coastal marine fishes in the tropics. *Env. Biol. Fish.* **3**: 65-84.

20) Milton, D. A., Blaber, S. J. M. (1990). Maturation, spawning seasonality, and proximate spawning stimuli of six species of tuna baitfish in the Solomon Islands. *Fish. Bull. U. S.* **89**: 221-237.

南スラベシにおけるグルクマ属の１種 *Rastrelliger brachysoma* の生殖周期

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（インドネシア　南スラベシ州　マロス）

摘要

グルクマ属の１種 Rastrelliger brachysoma の成熟特性を明らかにするため、1996年3月から1997年6月の間、インドネシア南スラベシ州の東海岸および西海岸から標本を採集し、月ごとの GSI（生殖腺体指数）の変化と、卵巣の発達を組織学的手法を用いて観察した。これらの観察に基づいて卵形成の特徴を明らかにした上で成熟度を設定し、両海域における産卵時期の比較を行った。本種の卵発達は非同期型を示したことから一産卵期に複数回産卵すると考えられた。また、産卵後の個体の卵巣には多数の退行卵が観察されたことから、産卵が終了した時点で卵巣中の発達途中の卵細胞は吸収され、次の産卵期には未熟な卵細胞が再び発達し産卵するものと考えられた。成熟した卵細胞を持つ個体は主に尾叉長140mm以上の個体に見られたことから、初回の産卵時の尾叉長は 140mm であると考えられた。しかし、産卵中または産卵直後の個体は調査期間中に年間を通して採集されたことから、両海域において本種の明確な産卵期はなく、産卵は一年を通して行われていると考えられた。

キーワード：グルクマ、卵発達、産卵期

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