Oseanoligi dan Limnologi di Indonesia 2003
No. 35 : 1-10

ISSN 0125 - 9830

AN EVALUATION OF THE EFFECTIVENESS OF OBLIQUE AND STEP TOWS FOR COLLECTING LEPTOCEPHALI

oleh

SAM WOUTHUYZEN[1], MICHAEL J. MILLER[2], GEN MINAGAWA[2], JUN AOYAMA[2], TETSUO FUKAMACHI[2], MARI KUROKI[2], SUTOMO[1], SASANTI R. SUHARTI[1], RHODORA AZANZA[3] and KATSUMI TSUKAMOTO[2]

ABSTRACT

Paired tows of the Isaacs Kidd Midwater Trawl (IKMT), namely oblique tow and step tow were used to determine which type of tow can be used to most efficiently sample assemblages of leptocephali. Two tows in the Sulawesi Sea were made at the same approximate location on 3 October 2002. Both tows collected very similar assemblages of leptocephali, despite minor differences in the length frequencies of some taxa. The assemblages collected by both tows were remarkably similar, suggesting that the amount of fishing effort of both types of tows was sufficient to adequately the sample abundant taxa of leptocephali. The collection of a few rare taxa such as *Anguilla* or Nettastomatidae in one or the other of the tows however, leaves the question of whether there are specific depth layers at which some taxa are more abundant, unanswered. But in general, the results of this experiment on towing styles shows that either type of towing technique may be sufficient to adequately sample the species assemblage of common species of leptocephali in any particular area. Future research should use depth-specific sampling gear to determine if there are taxa specific depth layers in the Indonesian Seas and other areas.

ABSTRAK

Dua cara tarikan jaring Isaccs Kidd Midwater Trawl (IKMT), yaitu tarikan secara obelik (oblique tow) dan tarikan seperti anak tangga (step tow) telah dilakukan untuk menentukan tipe tarikan mana yang paling efektif dalam melakukan pengambilan sample sekumpulan leptocephali. Kedua tarikan tersebut dilakukan di Laut Sulawesi pada lokasi yang sama pada tanggal 3 Oktober 2002. Kedua tipe tarikan ini mengkolesksi sekumpulan leptocephali yang relatif sama, kecuali sedikit berbeda dalam frekuensi panjang pada beberapa

[1] *Research Center for Oceanography, Indonesian Institute of Sciences, Jl. Pasir Putih 1, Ancol Timur, Jakarta 11480, Indonesia.*

[2] *Ocean Research Institute, The University of Tokyo, 1-15-1 Minamidai, NakanoTokyo, 164-8639 Japan.*

[3] *University of the Philippines, Marine Science Institute.*

taxa. Kemiripan dari kumpulan leptocephali yang dikoleksi dengan 2 cara tarikan di atas menunjukkan bahwa kedua cara tarikan jaring ini cukup dapat digunakan untuk mengkoleksi kelimpahan taxa leptocephali. Koleksi taxa yang jarang didapat, seperti Angguilia (sidat) dan famili Nettastomatidae dalam salah satu tarikan meninggalkan pertanyaan yang belum dapat dijawab, yakni apakah ada lapisan kedalamanan spesifik yang menunjukkan bahwa suatu taxa lebih melimpah ?. Namun hasil ekperimen ini menunjukkan bahwa kedua cara tarikan cukup dapat mengkoleksi kumpulan leptocephali yang umum dijumpai pada seluruh perairan. Pada penelitian di masa mendatang perlu digunakan alat khusus yang dapat mendeteksi kedalaman jaring pada saat jaring dioperasikan untuk menentukan apakah ada taxa yang spesifik memikiki kepadatan di kedalaman tertentu di perairan Indonesia.

Keywords: Leptocephali, Isaacs Kidd Midwater Trawl (IKMT), sampling techniques, species assemblage, Indonesians Seas.

INTRODUCTION

The Indonesian Seas are unique in many ways due to their unusual geography of islands and deep ocean basins that have a high biodiversity of marine organisms. However, to study the overall seasonal and regional abundance and diversity of organisms that inhabit the pelagic environment of this unique region it is necessary to conduct large-scale sampling surveys that encompass many different areas during the same research cruise and to standardize the sampling effort among cruises conducted during different seasons. This places great constraints on the amount of sampling effort in each individual area, and therefore determining the most efficient sampling techniques for the target species of each survey is of critical importance.

We have conducted two such relatively large-scale sampling surveys to collect the larvae of eels, or leptocephali, and other planktonic organisms, such as fish larvae, phyto-and zooplankton, in the Indonesian Seas that surround the largest island in the heart of the central the Indonesian archipelago, Sulawesi Island. During these cruises, an intense pressure for efficiency of sampling and conservation of ship time led us to conduct a carefully controlled experiment to attempt to determine the best towing method for collecting leptocephali. In the case of these cruises, the need for covering many areas is a result of the lack of knowledge about the spawning location of the tropical catadromous eels of the genus *Anguilla* that inhabit many of the freshwater habitats of Indonesia and the surrounding areas (JESPERSEN 1942, ARAI *et al.* 2001, SUGEHA *et al.* 2001) and a similar lack of knowledge about the regional biodiversity of the more diverse types of marine eels and other marine organisms. Therefore, as many areas as possible need to be sampled to locate potential spawning areas.

Leptocephali are morphologically quite different from most other fish larvae and have a laterally compressed virtually transparent body (CASTLE 1984; SMITH 1989a), and it has been found that both in the Pacific (KAJIHARA *et al.* 1988; OTAKE *et al.* 1998) and Atlantic (CASTONGUAY & MCCLEAVE 1987) both *Anguilla* and other families of leptocephali are most abundant in the upper 200 m and are collected in greatest numbers in the upper 100 m at night. This enables fishing effort for leptocephali to be concentrated in the upper layer of the ocean, although the depth distribution of leptocephali in the Indonesian Seas has not been documented.

We made paired tows with the IKMT that were started at the same location to test the hypothesis that a slow steadily retrieved oblique tow would collect about the same assemblage of a step tow that has greater fishing effort at several different depth layers when the retrieval of the wire was stopped. This type of step tow typically a takes longer time than the oblique tow when fished to the same maximum depth, so our objective was to determine if a slightly shorter duration oblique tow was as efficient as the longer duration step tows for sampling the assemblage of leptocephali at each location.

MATERIALS AND METHODS

Leptocephali were collected on 3 October 2002 during the BJ-02-4 cruise of the R/V Baruna Jaya VII of the Research Center for Oceanography of the Indonesian Institute of Sciences. During this cruise, sampling occurred at 34 stations in the waters around Sulawesi Island in areas including the Java Sea, Makassar Strait, Sulawesi Sea, Maluku Sea, and Tomini Bay and the location of the station used in this study is shown in Figure 1. Sampling for leptocephali at each station was done with the large pelagic trawl, the Isaacs Kidd Midwater Trawl (IKMT) that has a net opening of 8.7 m^2 and 1 mm mesh size (Figure 2). All sampling during this cruise occurred at night time (except for two stations in Tomini Bay) and for this particular experiment, a night time IKMT oblique tow to an approximate depth of 171 m (based on wire angle measurements) was compared to a step tow to an approximate depth of 211 m. The step tow was towed horizontally for 6 min at five depths at 450, 360, 230, 180, 90 m of wire out, which was designed to correspond to fishing depths of around 30, 60, 90, 120 and 150 m. Leptocephali were identified to the lowest possible level using TABETA and MOCHIOKA (1988); and BÖHLKE (1989). However, the leptocephali of the family Muraenidae are very difficult to separate into different species (SMITH 1989b), so the minimum estimated number of species was given for both tows, but is not an exact value. The two anguillid leptocephali will require identification using mtDNA analysis as described by AOYAMA *et al.* (1999) due to the overlapping morphological characters of most tropical anguillid leptocephali.

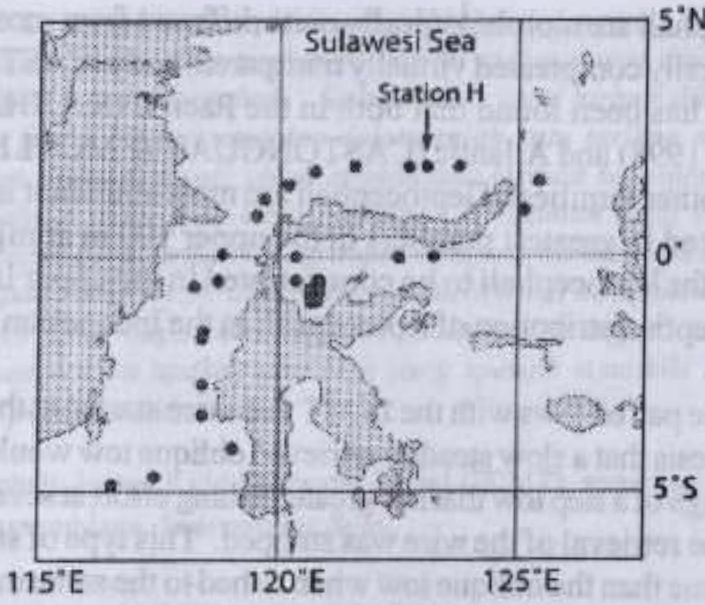

Figure 1. Map showing the location and Station H where the experiment to test the effectiveness of the two types of towing styles took place and also showing the locations of the other IKMT tows made during the cruise.

RESULTS AND DISCUSSION

A total of 167 leptocephali of 10 families of anguilliform eels and two leptocephali of the elopiform family Megalopidae were collected in the two tows at Station H, with both tows collecting approximately the same assemblage of leptocephali (Table 1). Leptocephali of the anguilliform families Nemichthyidae, Muraenidae, Serrivomeridae, and Congridae were the most abundant in both tows, and nine of the 11 families had leptocephali that were caught in both tows, which suggested that both of the types of fishing strategies were effective at collecting a representative sample of the most abundant taxa at a particular location. For example, similar collections were made of the mesopelagic eel leptocephali, *N. scolopaceous*, and *Serrivomer*, and of moray eel leptocephali of the family Muraenidae, and no more than two individuals of any of the taxa in Table 2 were collected in only one of the tows.

Most of the leptocephali of the various taxa also had similar size ranges, with relatively small numbers of either smaller or larger individuals being collected in one or the other of the two tows (Figure 3 and 4). The modes of the length frequencies of the two most abundant taxa, Muraenidae and *Nemichthys scolopaceous*, were relatively similar, and the total lengths were not significantly different for the leptocephali of the Muraenidae ($p = 0.3$), Nemichthyidae ($p = 0.5$), or Serrivomeridae ($p = 0.06$).

Table 1. Times, locations and basic characteristics of the two types of tows compared during this study at Station H in the southern Sulawesi Sea on 3 October 2002.

Towing Type	Start time	End time	Duration	Start location	End location	Ship Speed (knts)	Meters of wire	Tow volume (m^3)
IKMT-Oblique	19:53	20:57	1:03	1°59.936'N 123°22.248'E	1°56.931'N 123°24.334'E	35	500	42,008
IKMT-Step	21:39	22:53	1:14	1°59.702'N 123°22.228'E	1°56.930'N 123°24.087'E	35	500	46.139

However, there were some minor differences between the sizes of the leptocephali and the taxonomic compositions of the catches of both tows. Although there were no statistical differences in total lengths of the abundant taxa, and the sample sizes were too low to test for the others, some basic differences in the lengths of some individuals were observed (Figure 3 and 4). For example, three larger congrids were collected in the step tow, along with smaller chlopsids and ophichthids, and four smaller serrivomerid leptocephali were collected in the oblique tow. It is unclear though, if these differences were due to the sampling technique or to random chance differences in occurrences of the various sizes of leptocephali. Other differences between the two tows included the presence of two leptocephali of the slope family Nettastomattidae in the oblique tow, and two leptocephali of the catadromous eels of the genus *Anguilla* in the step tow. Therefore it is critical to determine if this difference is due to sampling technique or some other possible factor such as differential depth distributions of some species or size classes.

There is some evidence that different taxa of leptocephali may have somewhat different depth distributions (KAJIHARA *et al.* 1988; CASTONGUAY & MCCLEAVE 1987), and if this is true in the Indonesian seas, there could be some slight effects of the towing techniques on the catches of certain taxa or size classes, as was possibly observed during this study.

Although the numbers of leptocephali of these different taxa or size classes in this study were small enough to be possibly due to random chance events, there were different fishing efforts at different depths during the two tows that resulted from the two towing styles. The step tow stopped at five depths and towed for six minutes, but the winch speed between the different steps was faster than during the oblique tows, resulting in the step tows having greater fishing effort at the depths of the steps, but slightly less effort at the depths between steps. The possible effects of this can not be determined without more detailed research on the fine scale depth distribution of various taxa of leptocephali, but it could account at least for the slightly higher

Figure 2. Issac Kidd Midwater Trawl (IKMT net) used in this study.

catch rate observed in the oblique tow if the highest density layer of leptocephali at this particular location and time was missed by one of the steps. Alternatively, the slightly shallower

In conclusion, this comparison of two types of tows made at the same approximate location found that the same general assemblage was collected in both tows with the exception of a few leptocephali of two families. This means that this amount of fishing effort is probably enough for a useful sample of the leptocephali in a particular area, and when time is short during a tight cruise schedule, both of these types of tows could serve to adequately sample the assemblage of relatively abundant leptocephali, without requiring a replicate tow. Further research on the depth distributions of different taxa of leptocephali in the Indonesian Seas region will be needed however, to resolve the questions about the fine scale distribution of sampling effort between the two types of tows and to determine if certain depth layers should be targeted to collect anguillid or other species of interest.

Table 2. Numbers (N), catch rate (CR) and overall size range of the various taxa of leptocephali collected in the two types of tows compared during this study at Station H in the southern Sulawesi Sea on 3 October 2002. (Number in the bracket indicates the possibility of species number found in one family/ subfamily or genus).

Life history/ Family	Taxa	N in IK-O	CR in IK-O	N in IK-S	CR in IK-S	Total	TL range (mm)
Catadromous							
Anguilidae	*Anguilla*			2	4.3	2	
Shallow water							
Congridae	*Ariosoma*	5(2)	12.5	5(2)	10.8	10	23.4-197
	Conger	2	5.0	1	2.2	3	18.4-29.0
	Congrinae	1	2.5	1	2.2	2	13.5-56.0
	Gnathophis	1	2.5	3	6.5	4	23.2-64.7
	Uroconger			1	2.2	1	94.0
	Gorgasia	4	10.0	1	2.2	5	20.2-34.4
	Unknown species	1	2.5			1	23.4
Chlopsidae	*Chlopsis*			2	4.3	2	18.3-21.3
	Kaupichthys	2	5.0	1	2.2	3	45.6-52.0
	Unknown species	1	2.5			1	41.1
Muraenidae	Unknown species	23(5)	57.4	20(5)	43.3	43	16.5-61.7
Ophichthidae	*Neenchelys*			1	2.2	1	24.2
	Myrophinae			1	2.2	1	75.6
	Ophichthinae	3(3)	7.5	4(4)	8.7	7	22.5-87
Megalopidae	Unknown species	2	5.0	1	2.2	3	21.4-23.6
Slope							
Nettastomatidae	*Nettenchelys*	1	2.5			1	57.2
	Saurenchelys	1	2.5			1	41.0
Synappho-branchidae	Ilyophinae			1	2.2	1	37.5
	Synappho-branchinae	1	2.5			1	26.5
Open ocean							
Derichthyidae	*Nessorhamphus*			1	2.2	1	145.0
Nemichthyidae	*Avocettina*	1	2.5	3	6.5	4	101-148.9
	N.curvirostris	3	7.5	2	4.3	5	45.1-66
	N.scolopaceus	13	32.4	24	52.0	37	18.4-207
Serrivomeridae	Unknown species	15	37.4	12	26.0	27	5.0-61.5
Total leptocephali		80		87		167	
Min.No.of taxa		25		28			
Overall catch rate			199.6		188.6		

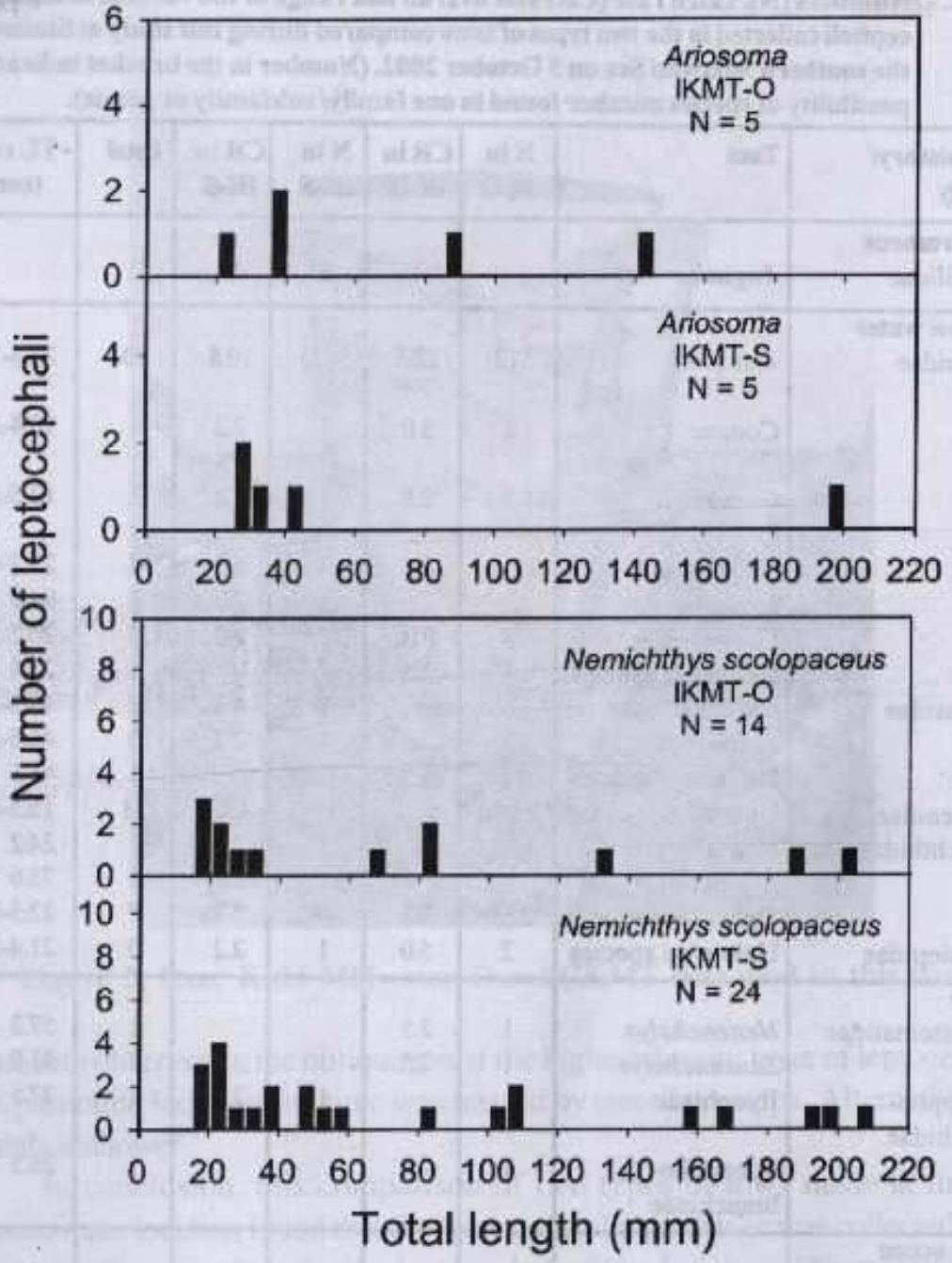

Figure 3. Length frequency distributions the leptocephali of *Ariosoma* (family Congridae) of shallow water leptocephali and *Nemichthys scolopaceus* (family Nemichthyidae) of open ocean collected in the oblique and step tow of the IKMT at Station H.

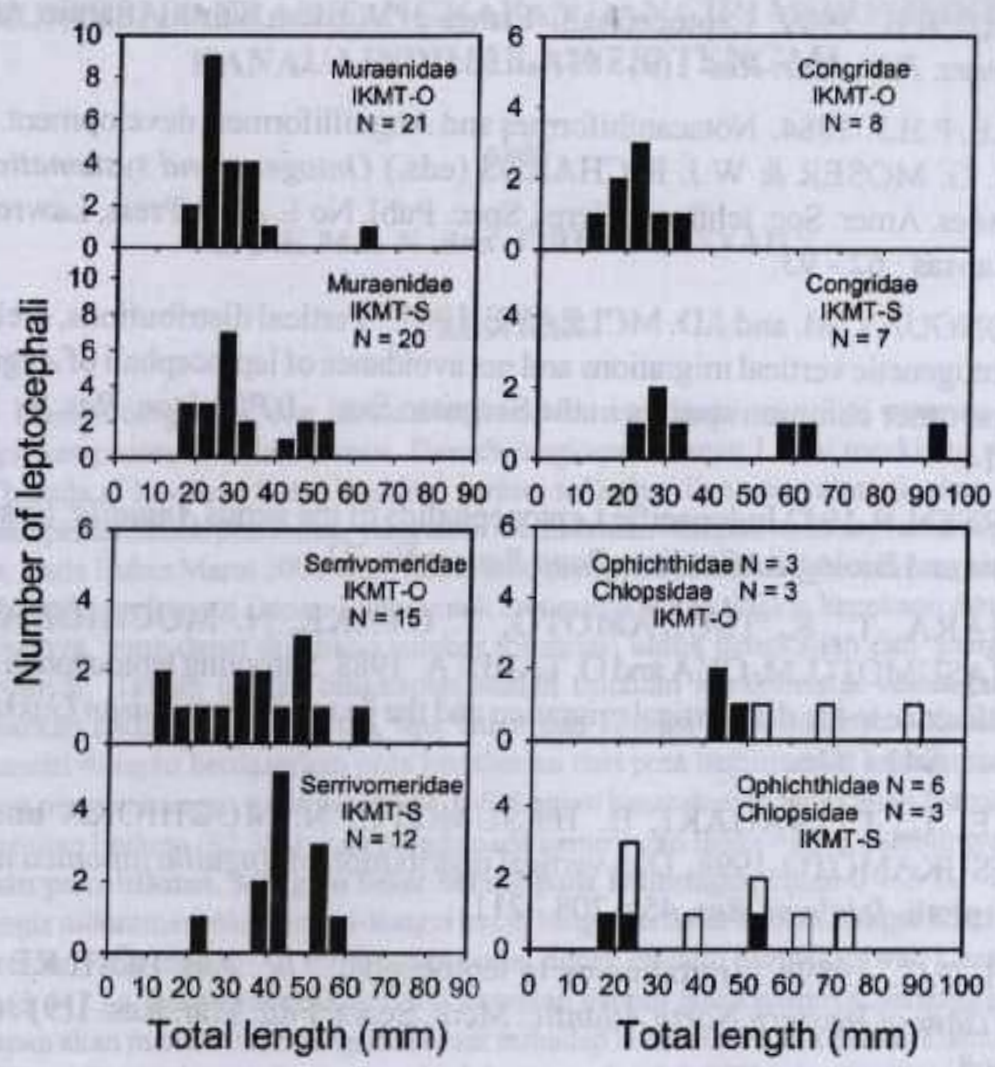

Figure 4. Length frequency distribution five families of leptocephali collected in the oblique and step tow of the IKMT at Station H.

REFERENCES

AOYAMA, J., N. MOCHIOKA, T. OTAKE, S. ISHIKAWA, Y. KAWAKAMI, P.H.J. CASTLE, M. NISHIDA & K. TSUKAMOTO 1999. Distribution and dispersal of anguillid leptocephali in the western Pacific Ocean revealed by molecular analysis. *Mar. Ecol. Prog. Ser.* 188 : 193 - 200.

ARAI, T., D. LIMBONG, T. OTAKE, K. TSUKAMOTO 2001. Recruitment mechanisms of tropical eels *Anguilla* spp. and implications for the evolution of oceanic migration in the genus *Anguilla*. *Mar Ecol. Prog. Ser.* 216 : 253 - 264.

BÖHLKE, E.B., 1989. Leptocephali. Fishes of Western North Atlantic, *Mem. Sears. Fdn. Mar. Res.* 1(9) : 657 - 1055.

CASTLE, P.H.J. 1984. Notacanthiformes and Anguilliformes: development. *In* : H. G. MOSER & W.J. RICHARDS (eds.) *Ontogeny and systematics of fishes*. Amer. Soc. Ichthyol. Herp., Spec. Publ. No 1. Allen Press, Lawrence, Kansas : 62 - 93.

CASTONGUAY, M. and J.D. MCLEAVE 1987. Vertical distributions, diel and ontogenetic vertical migrations and net avoidance of leptocephali of *Anguilla* and other common species in the Sargasso Sea. *J. Plankton. Res.* 9 : 195-214.

JESPERSEN, P. 1942 Indopacific Leptocephalids of the genus *Anguilla*: Systematic and Biological Studies. *Dana Report No. 22.*

KAJIHARA, T., K. TSUKAMOTO, T. OTAKE, N. MOCHIOKA, H. HASUMOTO, M. OYA and O. TABETA 1988. Sampling leptocephali with reference to the diel vertical migration and the gears. *Nippon Suisan Gakkaishi* 54 : 941 - 946.

OTAKE, T., T. INAGAKI, H. HASUMOTO, N. MOCHIOKA and K. TSUKAMOTO 1998. Diel vertical distribution of *Anguilla japonica* leptocephali. *Ichthyol. Res.* 45 : 208 - 211.

SMITH, D.G. 1989a. Introduction to leptocephali. *In* : E.B. BÖHLKE (ed.) *Fishes of Western North Atlantic*. Mem. Sears. Fdn. Mar. Res. 1(9) : 657 - 668.

SMITH D.G. 1989b. Family Muraenidae: Leptocephali. *In*: E.B. BÖHLKE (ed.) *Fishes of Western North Atlantic*. Mem. Sears. Fdn. Mar. Res. 1(9) : 900 - 916.

SUGEHA H.Y., T. ARAI, M.J. MILLER, D. LIMBONG and K. TSUKAMOTO 2001. Inshore migration of the tropical eels, *Anguilla* spp., recruiting to the Poigar River Estuary on Sulawesi Island. *Mar. Ecol. Progr. Ser.* 221 : 233 - 243.

TABETA, O. and N. MOCHIOKA 1988. Leptocephali. *In*: M. OKIYAMA (ed.) *An atlas of the early stage fishes in Japan*. Tokai Univ. Press. Tokyo : 15 - 64 (in Japanese).