Segara Anakan Lagoon (SAL): Fish Biodiversity and the Ecological Role

Setijanto¹* and Siti Rukayah²

¹Fishery and Marine Science Faculty of General Soedirman University
²Biology Faculty of General Soedirman University

*Corresponding author: setijantos@yahoo.com

ABSTRACT

Two life stages of fish were sampled to examine the fish biodiversity and the ecological role of Segara Anakan lagoon (SAL). The fish were observed during 2004 – 2014 while the larvae were sampled twice monthly during the full moon and dark periods in daylight hours only over 11 month periods (Novembre 2005 to Septembre 2006) at 10 sites located at SAL, Cilacap. Each trip two samples of the high tide and low ebb periods were taken from each station. The mature fish were sampled at Klices and Karanganyar. The fish were also collected from fisherman. At least 90 genera of 48 family (65 mature fish and 64 larvae) were recorded at SAL. Gobidae (range between 67.3 – 72.9 %) and Engraulidae (16.7 – 19.3 %) are the two most abundant larvae captured. Of the fish, at least 40 genera belongs to 16 families are of resident species that inhabit SAL for whole their life cycles. In other hand, 50 genera belongs to 31 families use SAL as temporary habitat (migratory). This finding suggests the important ecological role of SAL for fish.

Keywords: segara anakan lagoon, biodiversity, ekological role

1. Introduction

It has been established that estuaries are coastal lagoon where temperature, salinity, oxygen, and turbidity fluctuate dramatically occur because of the influence of tides and mixing of salt and freshwater. This makes the estuaries are highy dynamic and diverse region of high productivity with fish faunas (Gunter, 1961; Haedrich, 1983; Day et al., 1989).

At this time SAL is facing some ecological problems. One of them is sedimentation, the one that causes the narrowing the SAL which is coming from Citanduy, Cibeureum, and Cikonde Rivers. In the past, Segara Anakan had around 4603 ha of mangrove areas. However, illegal logging had caused the decrease the area of mangrove forest. It was around 1454 ha between 1974 and 1987. In 1989, about 16.5 ha of mangrove forest in the Segara Anakan areas had been converted into shrimp ponds (Nuryanto and Susanto, 2010). A high rate of exploitation and declining of the Segara Anakan areas are presumed to have direct impact on its animal communities, including fish assemblages and the ecological role of SAL.

As an estuarine ecosytem, SAL is inhabited by many fish, both migratory and resident species, therefore SAL Segara Anakan as an estuarine ecosytem has an important ecological role for these organism, particularly for fish. It is well known that many aquatic organisms use the lagoon as spawning ground, nursery ground and feeding ground, since the lagoon rich of nutrient for their growth and development (Dando, 1984; Neira et. al., 1994; Tominaga et al., 2000). Infact, the study of the ecological role of Segara Anakan for fish is scarce. For this reson, we conducted the study to investigate the ecological role of Segara Anakan and to determine the inhabitant status of fish in using the SAL as habitat.

2. Material and Methods

To record the biodiversity and to determine the ecological role of Segara Anakan a survey on the existence of the mature fish was done since Novembre 2004 to Septembre 20014. Mature fish was sampled using “apong net” and collected from fisherman. The reproductive stage of fish are examined. Samples of larvae were collected twice monthly, during the full moon and dark periods in daylight hours only, from Novembre 2005 to Septembre 2006. Each observation, samples were taken from ten stations in the lagoon. (Figure 1). Ichthyoplankton samples were preserved in the field with 4% buffered formaldehyde. In the laboratory the fish larvae were sorted with the aid of a stereomicroscope. Larvae were identified to the lowest possible taxon using the criteria of Leis and Rennis.
The status whether the resident or migratory fish was determined based on the occurrence of fish both larvae or/and mature stage, bearing eggs or not, the origin of fish (freshwater or marine). The origin of marine fish is referred to the fisherman information (by showing the fish) and Kottelat & Whitten (1996), Axelrod et al. (1995), Setijanto et al. (1999), Setijanto and Meinita. (2004). The fish is categorized of migratory fish (M) if the fish use SAL for spawning, nursery or feeding. The fish is determined resident species (R) if it is only found both larval and mature stage at SAL and not found at surrounded areas (freshwater or marine). The determination of migratory status is determined as follows: both larvae and bearing eggs fish are found at SAL while at the surrounded freshwaters mature fish only (spawning ground), larval stage only found at SAL (nursery ground), or not bearing eggs mature fish only (feeding ground). Fish is categorized resident species if all life stage are found at SAL and absent at surrounded area.

3. Results

3.1. Study area

SAL (51.700 ha; 1992) is an estuarin ecosystem located at west of Cilacap, Central Java. It is situated between Java Island and a rocky 10.300 ha barrier island (Nusakambangan). The estuary has 24.000 ha of mangrove forest. Many rivers (Citanduy, Cibereum, Cimeneng and Cikonde) end at the lagoon. It is estimated that the Citancuy River supplies 95% of water to the lagoon. SAL directly connected with Indian ocean through two canals namely west canal at Plawangan and east canal at Kembang Kuning. This topographical feature present a unique ecosystem. The lagoon is much infleneced by the tide and the freshwater input from the rivers. Thus, SAL is an ecosystem as a result of interaction of lagoon, mangrove forest, terrestrial, and marine ecosystem. The study of Setijanto et al. (2003) reveals that based on physicochemical features (salinity, temperature, turbidity, nutrient, dissolved oxygen) there are 3 zonation at SAL. First, the zone that is associated with Indian ocean (Plawangan); second, the zone that is associated with Citanduy river (Majingklak and Karanganyar); and third, the the zone that is influenced by both Indian ocean and Citanduy river (Cibeurem, Muara Dua, Klaces). The 3 zones varied in salinity, nutrient, and turbidity. The first zone, which is directly connected with Indian ocean, is characterised by dramatic fluctuation of salinity (0 – 35 ‰). The second zone, where the river Citanduy ends at, is characterised by high nutrient and high turbidity, while the third zone which is far from the both Indian ocean and Citanduy estuary is more stable. Variation in salinity (Weinstein et al., 1980; Peterson and Ross, 1991 and water clarity (Blaber et al., 1994) can be a primary factor influencing fish distributional patterns along estuarine gradients. Based on this belief, the sites were located at first zone (2 sites), second zone (2 sites), and (4 sites).

![Figure 1. Segara Anakan Lagoon and the sites allocated (A – J)](image)
3.2. Fish biodiversity and ecological role of SAL

Including fish reported by Sulistiono dan Kohno (1993) and Pemda Tk. II Cilacap-LPPM, (1998) there are 90 genera of 48 family (65 mature fish and 64 larvae) inhabit SAL. The species richness might be more than 90 as the fish particularly larval stage is not able identified down to species level. Numerically, the monthly larvae samples were dominated by Gobiidae (range between 67.3 – 72.9 %) and Engraulidae (16.7 – 19.3 %). Similar findings are also reported by Neira et. al. (1994) at Normalup-Walpole Estuary (Gobiidae 39.4 % and Engraulidae 56.7%), by Jenkins (1986) at Port Phillip Bay, Victoria, Yamashita et.al. (1984) at Outsuchi Gulf, Japan and Ekau et al., (2001). Subiyanto et al. (2008) who conducted the study at Plawangan showed Pomacentridae (29.84%), Atherinidae (28.66%), Gobiidae (20.31%), Clupeidae (11.19%), while for other types of larvae found only in quantities little, i.e. less than 2%.

Of the fish, at least 40 genera belongs to 16 families are of resident species that inhabit SAL for whole their life cycles. In other hand, 50 genera belongs to 31 families use SAL as temporary habitat (migratory). It shows that SAL has important ecological role for those fish. List of the taxaons found at SAL and their status in using SAL as habitat presented at Table 1. The resident species inhabit SAL for their entire life, using the SAL for spawning, nursery during larval stage, feeding ground and growth. The fish includes Apogonidae, Bothidae, Centropomidae, Chaetodontidae, Cynoglossidae, Gobiidae, Hemirhanphalididae, Legocephalidae, Leio gnathidae, Platycyaehalidae, Scatophagidae, Sillaginidae, Sparidae, Synodontidae, Trypauchenidae and Engraulidae. It has been known that some of those are of economically important, Engraulidae for example. In addition most of the are of edible fish.

SAL play important ecological role for surrounded area fish, whether from marine or freshwater habitats. It is shown that by the facts that many fish found are of those come from ocean or freshwater habitats (rivers) whether in larval stage or mature. Kohno et. al., (1993), found that there are many migratory fish caught by fisherman are economically important. Most marine origin fish are carnivores, feed on fish, crustacean, and other crustacean. The fish use SAL, mainly as feeding ground. It has been established that coastal area and estuary are used for nursery ground by some marine species (Neira et. al.,1994). Marine fish which often caught at both the lagoon and open ocean are Serri nidae, Carangidae, Lutjanidae, Haemulidae, Sparidae dan Scianeidae (Kohno et al., 1993). This indicates that SAL is a nursery ground for those families.

SAL is also used as a transit habitat for migratory fish during their travel to the spawning ground. As an estuary, SAL is a transitional habitat from freshwater to marine environment, vice versa. Migratory fish may use the SAL for acclimatitation and adaptation to the salinity change. Some migratory fish, such as Anguilla at all life stages are found at SAL (Setijanto et al., 2003). Anguilla is a catadromous fish that spawn at the open sea and migrate to the freshwater habitat when they are mature. In their return to the rivers, Anguilla uses the SAL for nursery ground. Apart from the food availability, SAL provide protective shelter for fish from bigger predator. There are some reports showing that fish at stage of post larvae, juvenile, and small mature fish are more abundant at the cranny and ditch of mangrove compared to the clear or open habitat (Duke et. al., 1977). Apart from marine fish, some fluviatile species Mugilidae and some spesies of Gobiidae for example, spawn and nurse at SAL. Mugilidae is targeted caught by fisherman as it has an important economical value.

| Family     | Genus/Species | Local name | Larvae | Mature | Status | Reference |
|------------|---------------|------------|--------|--------|--------|-----------|
| Anguillidae| Anguilla      | Sidat      | +      | +      | M      |           |
| Apogonidae | Apogon        | Prempeng   | +      | +      | R      |           |
| Ariidae    | Arius maculatus | Jahan   | +      | +      | M      |           |
| Belonidae  |               |            |        |        |        |           |

Table 1. List of fish and inhabitant status at Segara Anakan Lagoon (SAL)
| Family         | Species                      | Location   | Ind | Pre | Mode | Role |
|---------------|------------------------------|------------|-----|-----|------|------|
| Bothidae      | Tylosurus sp                 | Seroang    | -   | +   | M    | B    |
| Cyprinidae    | Crossorhombus azureus        | Tapel borok| +   | +   | R    |      |
| Carangidae    | Alectis indicus              | Jemberet   | -   | +   | M    | B    |
|               | Caranx melampygus            |            | +   | +   | M    | A    |
|               | Alepes sp. 1                 | Martaji    | -   | +   | M    |      |
| Centropomidae | Ambassis buruensis           |            | -   | +   | R    | A    |
| Chaetodontidae| Chaetodon aureofasciatus     | Boso       | +   | +   | R    |      |
| Chirocentridae| Chirocentrus                 | Teri       | +   | +   | R    |      |
| Clupeidae     | Sardinella                   | Teri       | +   | +   | M    |      |
|               | Etrumeus                     | Teri       | +   | +   | M    |      |
|               | Anchoviella                  | Teri       | +   | +   | M    |      |
| Congeridae    | Conger sp                    |            | +   | +   | M    |      |
|               | Clariger                     |            | +   | +   | M    |      |
|               | Ariosoma                     |            | +   | +   | M    |      |
| Cynoglossidae | Cynoglossus abbreviatus      | Lendra     | +   | +   | R    |      |
| Drepanidae    | Drepane longiman             | Gedebeg    | -   | +   | M    |      |
| Elopidae      | Megalops                     |            | +   | +   | M    |      |
|               | Elops sp.                    |            | +   | +   | M    |      |
| Engraulidae   | Stelephorus                  | Teri       | +   | +   | M    |      |
|               | Thyrsa mystax                | Bibiran    | +   | +   | M    | A, B |
|               | Engraulis                    | Teri       | +   | +   | R    |      |
|               | Collia nusus                 |            | +   | +   | R    |      |
|               | Setipina                     | Bilis      | +   | +   | R    |      |
| Gerridae      | Gerres sp.                   | Kapasan    | +   | +   | R    |      |
| Gobiidae      | Acantogobius                 |            | +   | +   | R    |      |
|               | Chaenogobius                 |            | +   | +   | R    |      |
|               | Glossogobius                 |            | +   | +   | R    |      |
|               | Pterogobius                  |            | +   | +   | R    |      |
|               | Boleoptalmus                 |            | +   | +   | R    |      |
|               | Rhinogobius                  |            | +   | +   | R    |      |
| Family                  | Genus                                      | Species | Habitat | Notes |
|------------------------|--------------------------------------------|---------|---------|-------|
| Priolepsis             | Oxyurichthys                               | +       | +       | R     |
|                        | Apocryptodon                               | +       | +       | R     |
|                        | Elostris                                   | +       | +       | R     |
|                        | Ctenotrypauchen                            | +       | -       | R     |
|                        | Leucosparion                               | +       | -       | R     |
|                        | Luciogobius                                | +       | +       | R     |
|                        | Parioglossus                               | +       | +       | R     |
|                        | Pseudogobius                               | +       | +       | R     |
|                        | Acentrogobius                              | +       | +       | R     |
|                        | Hemirhamphidae                             | +       | +       | R     |
|                        | Hemirhamphus georgii                       | Tracas  | +       | R     | B     |
|                        | Hyporhampus                                | +       | -       | R     |
| Labridae               | Labridae                                   | +       | +       | M     |
|                        | Sphaeroides lunaris                        | +       | +       | R     |
|                        | Lagocephalidae                             | Buntak  | +       | R     |
|                        | Lagocephalus                               | +       | +       | R     |
|                        | Lagocephalus                               | Petek   | +       | R     |
|                        | Lutjanidae                                 | +       | +       | M     |
|                        | Lutjanus                                   | Tambalan| +       | M     |
|                        | Caesio                                     | +       | +       | M     |
| Monachantidae          | Thamnaconus                                | +       | -       | M     |
|                        | Mugilida                                   | Moolgarda perusii | - | + | M | A |
|                        | Mugil cephalus                             | Belanak | +       | +       | M |
| Mullidae               | Upeneus tragula                            | Kajang  | +       | +       | M |
|                        | Muraenesocidae                             | Muraenosox | Remang | - | + | M |
|                        | Paralichthydae                             | Paralichthys sp. | + | - | M |
|                        | Pseuderhambus                              | +       | -       | M     |
| Platycephaulidae       | Platycephalus                              | Ipuh    | +       | +       | R |
| Polynemidae            | Eleutheronema                               | -       | -       | R     | A     |
|                        | Polynemus                                  | Baleng  | -       | +       | R     | B     |
|                        | Polydactilus                               | +       | -       | R     |
| Pomadasysidae          | Plectorhynchus gibosus                      | Krekekan| +       | +       | M     |
|                        | Pomadasys hasta                            | Krekekan| +       | +       | M     |
| Family           | Genus             | Species   | Location  | Habitat | Notes |
|------------------|-------------------|-----------|-----------|---------|-------|
| Ratabouridae     | Rataboura bicolor | Oleng     | +         | M       | B     |
| Scatophagidae    | Scatophagus       | Kiper     | +         | +       | R     |
| Sciaenidae       | Sciaenid sp.      | Colomontok| -         | +       | M     |
|                  | Johnius carutta   | Tombol    | -         | +       | M     |
|                  | Nibea artiflora   |           | -         | +       | M     | A     |
| Scombridae       | Scomberomorus     | Tengiri   | +         | -       | M     |
|                  | Scomber           |           | +         | -       | M     |
| Scorpaenidae     | Scorpaenidae      |           | -         | +       | M     |
| Serranidae       | Epinephelus tauvina| Kerapu balong | -     | -       | M     |
|                  | Chalanthias       |           | +         | -       | M     |
| Sillaginidae     | Sillago           | Bojor     | +         | +       | R     |
| Sparidae         | Spanus            |           | +         | -       | M     | A     |
|                  | Acanthropagrus    | Bekuku    | -         | +       | R     | A, B  |
| Stromateidae     | Pampus            | Dawah     | -         | -       | M     | B     |
| Synanceilida     | Inimicus jpanicus |           | +         | -       | M     |
| Syngnathidae     | Parasyngnathus sp.|           | +         | -       | M     |
|                  | Trachyrhamphus sp.|           | +         | -       | M     |
| Synodontidae     | Saurida tumbil    | Bloso     | +         | +       | R     |
|                  | Thrachicephalus sp.| Susur wedi | -     | +       | R     |
| Tetraodontidae   | Tetraodon reticulatus | Buntak kelapa | -     | +       | M     |
|                  | Arothron stelatus |           | -         | +       | M     | A     |
|                  | Takifuga sp.      |           | +         | -       | M     |
| Theraponiidae    | Therapon theraps  | Terongan  | -         | +       | M     |
| Trichiuridae     | Trichiurus        | Layur     | -         | +       | M     |
| Trygonidae       | Himanturas sp.    | Pari/Pe   | -         | +       | M     |
| Trypauchenidae   |                   |           |           |         |       |
Trypauchen sp. & Tungon & + & + & R \\
Uranoscopidae & Urocampus & + & - & M \\
Total & 64 & 65

Note. A (by Sulistiono dan Kohno, 1993), B (Pemda Tk. II Cilacap-LPPM, 1998), M (Migratory), R (Resident)

4. Conclusion

Based on above, we may conclude that SAL has an ecological role for maintaining the biodiversity of fish as a lot of fish whether at the stage of larvae and mature or both found at the lagoon. SAL is used as nursery ground for small fish as SAL provide protective shelter to avoid the predator. In addition, SAL as an estuary is rich of nutrient that are sufficient for both larvae and mature fish. For migratory fish SAL is a transitional environment for aclimatitation and adaptation before return to the saline or freshwater. The ecological role of SAL might be taken as the causal explanation why the fish biodiversity of fish at SAL is relatively high.

References

Affandi, R., Rahardjo, M.F., Sulistiono. 1995. Distribusi Juvenil Ikan Sidat, Anguilla spp. di Perairan Segara Anakan, Cilacap, Jawa Tengah. Jurnal Ilmu-ilmu Perairan dan Perikanan Indonesia 3, 27-38.

Balber, S. 1998. Reproductive Ecology and Life History of Terubuk (Tecnulosa macrura) in Bengkalis Estuary, Indonesian Terubuk Project, 2nd Coordination Meeting, Pekanbaru.

Bengen, D. G. 2000. Sinopsis Teknik Pengambilan Contoh dan Analisis Data Biofisik Sumberdaya Pesisir dan Lautan. Bogor. Pusat Kajian Sumberdaya Pesisir dan Lautan, fakultas Perikanan dan Ilmu Kelautan IPB, Bogor.

Bensam, P. 1987. On The Early Developmental Stages of A Few Fishes From Vellar Estuary. Journal of Marine Biology Assesment India 29 (257 – 272).

Delsman, H. C. 1926. Fish Eggs and Larvae From Java Sea. Treubia 8, 389-412.

Delsman, H. C. 1932. Fish Eggs and Larvae from Java Sea. Treubia. 14, 109 – 116.

Dando, P. R. 1984. Reproduction in Estuaries Fish, in Fish Reproduction : Strategy and Tactics. G.W. Potts and R. J. Wooton (eds). Academic Press, London.

Drake, P. and A. M. Arias 1991. Composition and Seasonal Fluctuation of the Ichtyoplankton Community in Shallow Tidal Channel of Cadiz Bay (S. W. Spain). Journal of Fish Biology, 39, 245 – 263.

Effendie, M. I. 1997. Biologi Perikanan. Yayasan Pustaka Nusantara, Yogyakarta.

Ekau, W., Westhaus-Ekau, P., Macedo, S.J., Dorrien, C.V. 2001. The Larva Fish Fauna of Canal de Santa Cruz – Estuary in Northeast Brazil. Tropical Oceanography 29: 1-12.

Harris, S.A., Cyrus, D.P., Beckley, L.E. 1999. The Larval Fish Assemblage in Nearshore Coastal Waters off the St Lucia Estuary, South Africa. Estuarine, Coastal and Shelf Science 49, 789-811.

Ida, H. 1972. Some Ecological aspect of Larval Fish in Waters off Central Japan. Bulletin of the Japanese Society of Scientific Fisheries 38, 981 – 994.

Jenkins, G., P. 1998. Composition, Seasonality and Distribution of Ichtyoplankton in Port Phillip Bay, Victoria. Australian Journal of Marine and Freshwater Research 37, 193 – 1207
Kawaroe M. 2001. Kontribusi ekosistem Mangrove Terhadap Struktur Komunitas Ikan di Pantai Utara Kabupaten Subang, Jawa Barat. Jurnal Pesisir dan Lautan 3, 12-25

Kidwai, S., Amjad, S. 2001. abundance and Distribution of Ichtyolarvae from Upper Pelagic Weters of The Northwestern Arabian Sea during Different Monsoon Periods, 1992-1994. ICES Journal of Marine Science 58, 714-724.

Kohno, H., Sulistiono. 1993. Ichtyofauna in Segara Anakan Lagoon. Ecological Assessment for Management Planning. IPB, Bogor.

Leis, J. M., Carson-Ewart, B.M. 2000. The Larvae of Indo-Pacific Coastal Fishes. An Identification Guide to Marine Fish Larvae. Brill, Leiden.

Legendre, P., Legendre, L. 1998. Numerical Ecology. Second English Edition. Elsevier Science, Amsterdam.

Magguran, A. E. 1988. Ecological Diversity and Its Measurement. Croom Helm, Sydney.

Merta, I. G., Girsang, E.S., Wagiyo, K., Suwarso., Herlisman. 2000. Kondisi Lingkungan Estuarin Bengkalis dalam Hubungannya dengan Kelimpahan Larva Ikan. Prosiding Seminar Hasil Penelitian Perikanan 1999/2000 : 11 – 23. Jakarta : Puslitbang Eksplorasi Laut dan Perikanan.

Moller, H., Dieckwisch, B. 1991. Larval Fish Production in The Tidal River Elbe 1985 – 1986. Journal of Fish Biology 38, 829 – 838.

Neira, F. J., Potter, I.C. 1994. The Larvae Fish Assemblage of the Normalup – Walwope Estuary. A Permanently Open Estuary on Southern Coast of Western Australia. Australia Journal of Marine and Freshwater Research 45, 1193 – 1207.

Nellen, W. 1973. Investigation on the Distribution of Fish Larvae and Plankton near and above the Great Meteor Seamount. Meteor Forsch- Ergebnisse 13, 47-69.

Nontji, A. 1987. Laut Nusantara. Penerbit Djambatan, Jakarta.

Nuryanto, A, & A. H. Susanto. 2010. Genetic variability of Polymesoda eros population in The Segara Anakan Cilacap. Biotropia 17, 22-30.

Nybakkken, J. W. 1992. Biologi Laut, Suatu Pendekatan Ekologis. Penerbit PT. Gramedia, Jakarta.

Pemerintah Daerah Tingkat II Cilacap-Lembaga Pengkajian dan Pengembangan Mangrove. 1998. Rancangan Sistem Pengelolaan Hutan Bakau di Kawasan Segara Anakan Kabupaten Dati II Cilacap-Jawa Tengah. Project Management Office Segara Anakan Cilacap (BKSAC), Cilacap.

Odum, E. P. 1998. Dasar-Dasar Ekologi. Gadjah Mada University Press, Yogyakarta.

Okiyama, M. 1988. An Atlas of The Early Stage Fishes in Japan. Tokyo University Press, Tokyo.

Romimohtarto, K., Juwana, S. 1998. Plankton Larva Hewan Laut. Pusat Penelitian dan Pengembangan Oseanologi LIPI, Jakarta.

Rositasari, R., Rahayu, S.K. 1995. Sifat-Sifat Estuari dan Pengelolaannya. Oseana 19, 21-31.

Russel, F. S. 1976. The Eggs and Planktonic Stages of British Marine Fishes. Academic Press, Amsterdam.

Saanin, Hasanuddin, 1995. Taksonomi dan Kunci Identifikasi Ikan 1, Penerbit Binacipta, Bogor.

Saanin, Hasanuddin, 1995. Taksonomi dan Kunci Identifikasi Ikan 2, Penerbit Binacipta, Bogor.

Setijanto., Sahri, A.S. 2000. Segregasi Niche Tropik dan Divergensi Morphologi Komunitas Ikan di Muara Sungai Donan, Segara Anakan. Fakultas Biologi, Universitas Jenderal Soedirman, Purwokerto, Laporan Penelitian, (tidak dipublikasikan).

Subiyanto., Hirata, I., Senta, T. 1993. Larval Settlement of Japanese Flounder on Sandy Beaches of the Yatsushiro Sea, Japan. Nippon Suisan Gakkaishi 59, 1121-1128.

Subiyanto., Ruswahyuni., Cahyono, D.G. 2008. Composition And Distribution Of Fish Pelagic Larvae In East Pelawangan Estuary, Segara Anakan, Cilacap, Jurnal Saintek Perikanan 4,62 – 68.
Suharti, S. R. 1996. Pengembangan Rancangan Sampling Secara Acak (Random Sampling Design) untuk Menentukan Pola Kelimpahan. Oseana 21, 19-24.

Thomascik, T., Mah, A. J., Nontji, A., Mousa, M. K. 1997. The Ecology of Indonesian Seas. Part II. Periplus Editions (HK) Ltd. Singapore.

Tominaga, O., Watanobe, M., Hanyu, M., Domon, K., Watanabe, Y., Takahashi, T. 2000. Distribution of Movement of Larvae, Juvenile, and Young of the Pointhead Founder Hipoglossoides pinetorum in Isikari Bay and Vicinity, Hokaido. Fisheries Science 66, 442 – 451.

Yamashita, Y., Aoyama, T. 1984. Ichtyoplankton in Outsuchi Bay on Northeastern Honsu with Reference to The Time-Space Segregation of Their Habitats. Bulletin of The Japanese Society of Scientific Fisheries 50, 189 – 198.