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Population Dynamics of Spinycheek Lanternfish *Benthosema fibulatum* (Gilbert and Cramer 1897), Caught off the South-west Coast of India

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Abstract

Aspects of population dynamics of Spinycheek lanternfish *Benthosema fibulatum* (Gilbert and Cramer 1897), caught off the south-west coast of India were studied. The asymptotic length (L_∞) and growth constant (K) were estimated at 108 mm and 0.460 yr^{-1} respectively while t_{max} was worked out as 6 years. *Benthosema fibulatum* grows faster initially and attains a total length of 101.22 mm over 6 years. The coefficients of total mortality (Z), instantaneous natural mortality (M) and fishing mortality (F) were estimated as 2.32 yr^{-1}, 0.51 yr^{-1} and 1.81 yr^{-1} respectively. The exploitation rate (E) was estimated as 0.78 yr^{-1}. Size at first capture (L_c) was estimated as 62.84 mm TL. The relative yield per recruit reached maximum at an exploitation rate (E_{max}) of 0.772. Though there has been no targeted fishery for myctophids in the area of study, they constituted a significant proportion of bycatch of deep sea shrimp trawlers. *Benthosema fibulatum* stock may be unsustainable when fishery intensifies in future to meet demand from fish meal industry, unless proper action is taken to manage the stocks.

Keywords: *Benthosema fibulatum*, population dynamics, growth, south-west coast of India, Spinycheek lanternfish

Introduction

Myctophids are dominant representatives among mesopelagic communities and are known to be abundant in the world oceans with their largest concentrations in the Indian ocean (Gjosaeter 1984; Shilat and Valinassab 1998; Jayabalan 2011; Catul et al. 2011). The global biomass of mesopelagic fish was estimated at 948 million t (Gjosaeter and Kawaguchi 1980) and 999 million t (Lam and Pauly 2005). However, recent acoustic observations indicate the possible existence of higher biomass and demand further revisions of estimates (Irigoien et al. 2014).

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Most of the myctophids grow fast (Childress et al. 1980) and have a high rate of mortality (Gjosaeter and Kawaguchi 1980). However, information on aspects of population dynamics on myctophids is limited. The age and growth of *Benthosema glaciale* (Reinhardt 1837) has been reported (Halliday 1970; Gjosaeter 1981; Albikovskaya 1988; Garcia-Seoane 2013) while in another study Gartner (1991) estimated the growth rate of a subtropical species *Benthosema suborbital* (Gilbert 1913), inhabiting the eastern Gulf of Mexico. Giragosov and Ovcharov (1992) studied the growth of *Myctophum nitidulum* Garman 1899 of tropical Atlantic waters while Hayashi et al. (2001) determined the age of *Myctophum asperum* Richardson 1845, inhabiting Kuroshio waters.

Benthosema fibulatum (Gilbert and Cramer 1897), the spinycheek lantern fish inhabits between 100-1000 m depth. Several studies have reported the distribution of *B. fibulatum* in the Arabian Sea (Kinzer et al. 1993; Valinassab 2005; Valinassab et al. 2007; Karuppasamy et al. 2006, 2010). However, commercial fisheries targeting these myctophids are limited. They do not constitute targeted fishery in Indian waters, however, large quantities are caught as bycatch in deep-sea shrimp trawlers operating off the south-west coast (Boopendranath et al. 2009; Pillai et al. 2009; Sebastine et al. 2013). The commercial exploitation of mesopelagic resources may increase in the future due to the growing demand by various sectors including the aquaculture feed industry for the production of fish meal, fish oil and fish silage (Shaviklo 2012; Shaviklo and Rafipour 2013). The present account encompasses the results of studies on age, growth and stock dynamics of spinycheek lanternfish *Benthosema fibulatum* (Gilbert and Cramer 1897), inhabiting the south-west coast of India. The results of the study will be helpful for the development of suitable management models for the sustainable exploitation and utilisation of spinycheek lanternfish in the area.

Materials and Methods

A total of 453 specimens of *B. fibulatum* having total length ranging from 48 to 85 mm were collected from the bycatch of deep-sea shrimp trawlers operating off the south-west coast of India, during the period September 2009 to May 2012, barring the trawl ban period from 15 June to 31 July. The specimens were caught from the depth range of 300–400 m and stored in chilled condition until analysis. Length measurements were grouped into 5 mm class intervals. The growth parameters were estimated using ELEFAN I programme incorporated in the FAO-ICLARM Stock Assessment Tools (FiSAT) software (Gayanilo et al. 1996). The growth was described using von Bertalanffy growth formula (VBGF) (von Bertalanffy 1957) $L_t = L_\infty [1-e^{-k(t-t_0)}]$, where L_t is the fish length at t age (mm); L_∞ is the maximum asymptotic length a fish can theoretically reach; K is curvature growth constant per year; and t_0 is age at zero length. Best growth curve was identified by scan of K-values. The estimate of t_0 was worked out using von Bertalanffy plot (von Bertalanffy 1934) in which the results of the regression of –ln (1-Lt/L) against t was used to calculate t_0 following equation t_0=-a/b. The length based growth performance index (φ) was calculated following Pauly and Munro (1984). Life span was estimated following the equation: $t_{max} = 3/K$ (Pauly 1983a).

The total mortality (Z) and instantaneous rate of natural mortality (M) were estimated by length converted catch curve method (Pauly 1983b, 1984) and Pauly's empirical formula (Pauly 1980) respectively using FiSAT software. Fishing mortality was estimated as F = Z-M and the exploitation ratio (E) as E = F/Z. The probability of capture, relative yield per recruit and biomass per recruit were worked out using FiSAT software (Gayanilo et al. 1996).

Results

Growth parameters (L_∞ and K)

Length frequency data ranging from 48 to 85 mm total length (TL) were used for estimating growth parameters of *B. fibulatum* inhabiting the south-west coast of India. The growth parameters asymptotic length (L_∞) and growth constant (K) were estimated at 108 mm and 0.460 yr^{-1} respectively. The value of length at zero age (t_0) was estimated at -0.02. The restructured length frequency data of population of *B. fibulatum* and the superimposed growth curve fitted with highest levels of Rn is given in the Fig. 1. The von Bertalanffy Growth formula for *B. fibulatum* based on the parameters estimated in the present study can be expressed as, $L_t = 108^* [1 - e^{-0.460\,(t+0.02)}]$.

Growth and lifespan

The VBGF growth curve of *B. fibulatum* inhabiting the south-west coast of India is shown in Fig. 2. It appears that this species grows faster in the first year to attain 40.4 mm while the lengths attained at the end of 2nd to 6th years were 65.34 mm, 81.07 mm, 90.99 mm, 97.27 mm and 101.22 mm, respectively. The growth performance index (φ) was estimated as 3.73. The lifespan of *B. fibulatum* was estimated as 6 years based on empirical formula 3/K (Pauly 1983a).

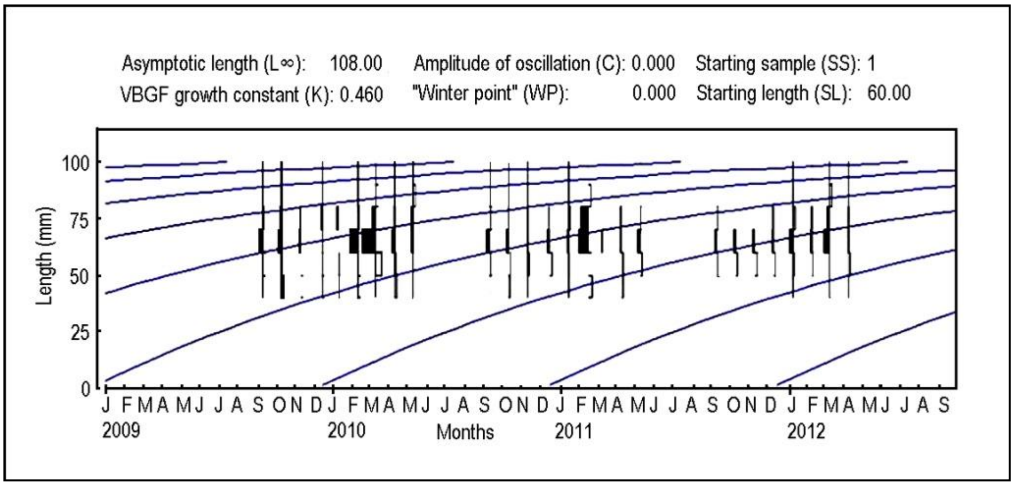

Fig. 1. The restructured length frequency data with super-imposed growth curve fitted at highest levels of Rn values, for *Benthosema fibulatum* inhabiting the south-west coast of India.

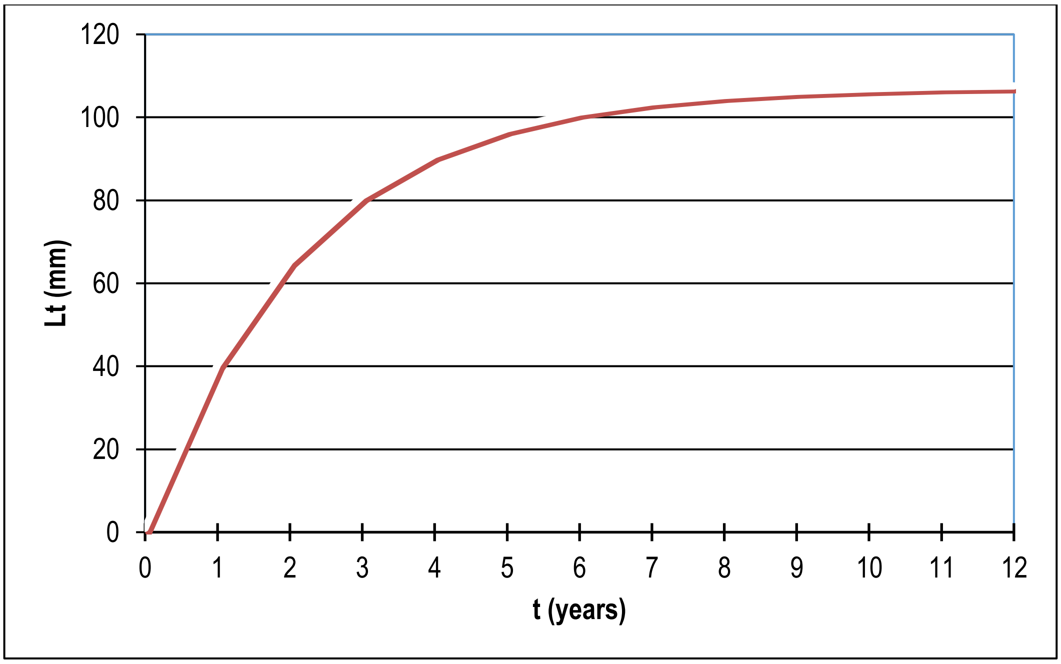

Fig. 2. von Bertalanffy **g**rowth curve of *Benthosema fibulatum* inhabiting the south-west coast of India.

Mortality estimation

The catch curve for mortality estimates of the population of *B. fibulatum* in the south-west coast of India is shown in the Fig. 3. The coefficient of total mortality using bycatch curve method was 2.32 yr^{-1}. The instantaneous natural mortality (M) estimated as per Pauly's empirical formula was 0.51 yr^{-1}. The fishing mortality coefficient (F) and exploitation rate (E) were 1.81 and 0.78 respectively.

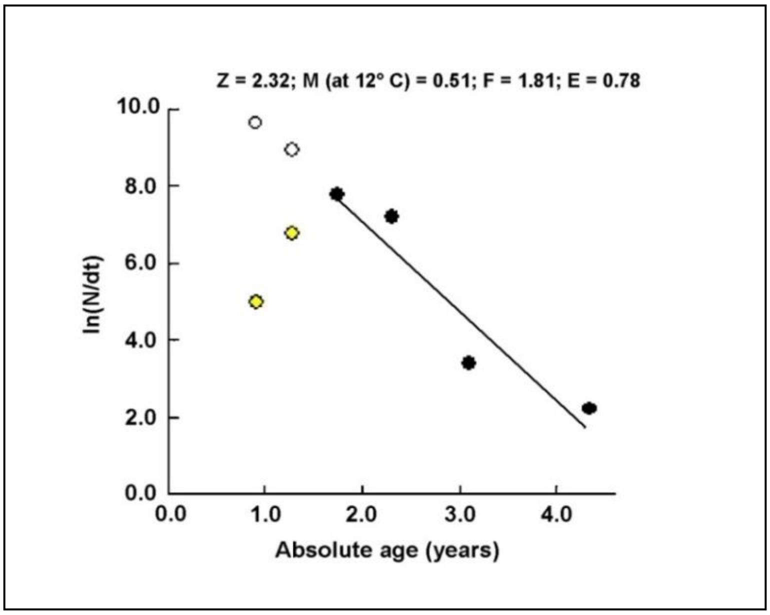

Fig. 3. Length converted catch curve of *Benthosema fibulatum* inhabiting south-west coast of India.

Probability of capture

Figure 4 shows the probabilities of capture with respect to *B. fibulatum* inhabiting the south-west coast of India. Size at first capture (L_c) of *B. fibulatum* was estimated as 62.84 mm. The probabilities of capture values were estimated at L_{25} = 58.61 mm, L_{50} = 62.84 mm and L_{75} = 67.06 mm respectively.

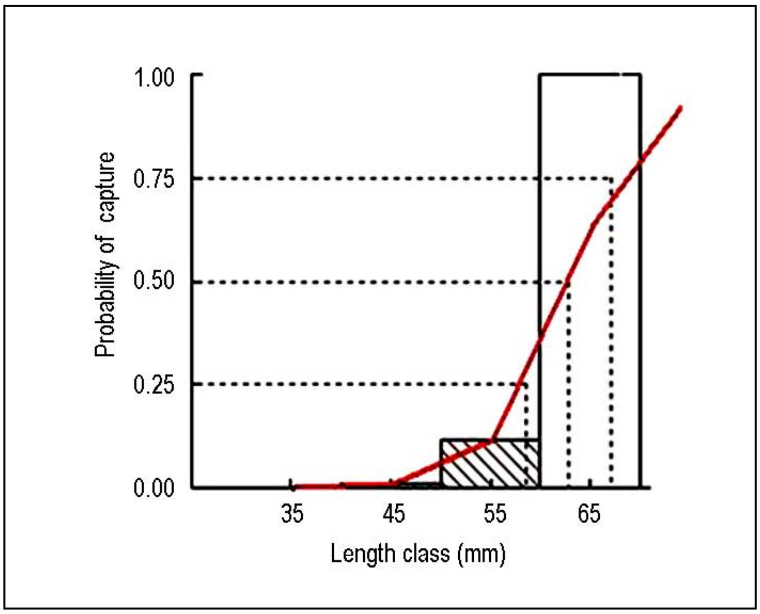

Fig. 4. Probability of capture of *Benthosema fibulatum* inhabiting the south-west coast of India.

Relative yield/recruit (Y/R) and biomass/recruitment (B/R)

The relative yield per recruit and biomass per recruit of *B. fibulatum* inhabiting the south-west coast of India are shown in Table 1 and Fig. 5. The L_{50}/L_{∞} and M/K values used for Y'/R analysis were 0.582 and 1.110, respectively. The exploitation rate at which the marginal increase in relative yield per recruit becomes 1/10th of its value at E=0 ($E_{0.1}$) was estimated at 0.658 while the exploitation rate at which the stock would be reduced to 50% of its unexploited biomass ($E_{0.5,}$) was estimated at 0.388. It could also be noted that the yield per recruit reaches a maximum at an exploitation rate (E_{max}) of 0.772.

Table 1. The details of Y'/R and B/R at various levels of exploitation rate (E) with respect to *Benthosema fibulatum* inhabiting the south-west coast of India (Parameters: E_{max}: 0.772 E-50: 0.388; E-10: 0.658; M/K: 1.110; L_c/L_{∞}: 0.587).

E	Y/R	B/R	E	Y/R	B/R
0.01	0.018	0.862	0.60	0.079	0.276
0.20	0.035	0.730	0.70	0.083	0.186
0.30	0.050	0.605	0.80	0.084	0.110
0.40	0.062	0.486	0.90	0.081	0.047
0.50	0.072	0.376	0.99	0.076	0.004

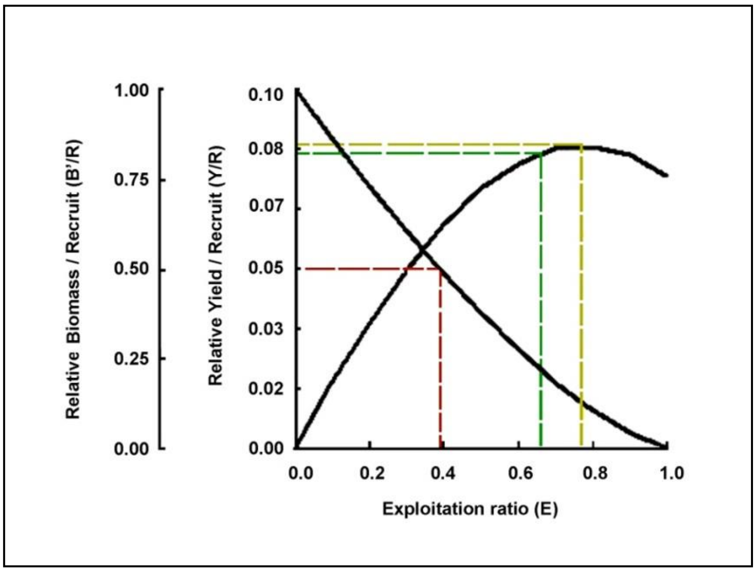

Fig. 5. Relative yields and biomass per recruit of *Benthosema fibulatum* inhabiting the south-west coast of India.

Discussion

The present results revealed that *B. fibulatum* undergoes a rapid growth initially and a slow growth in later stages which conforms to typical growth pattern in most myctophids (Smoker and Pearcy 1970; Filin 1997). The negative t_0 value worked out in the present study also indicated faster growth rate at the juvenile stage (Walford 1946). The total length of *B. fibulatum* recorded in the present study ranged from 48 to 85 mm. However, Hussain (1992) reported a maximum length of 102 mm in *B. fibulatum* inhabiting Northern Arabian Sea. The L_∞ value computed in the present study is greater than the L_{max} values reported by Hussain (1992). Maximum length of *B. pterotum*, another myctophid of eastern Arabian Sea has been reported as 56 mm (Karuppasamy et al. 2008).

In the present study, the maximum age of this species was deducted as 6 years as evidenced from 3/K (Pauly 1983). It has been reported that *B. glaceile*, a related species lives 4 to 8 years (Halliday 1970; Gjosaeter 1981; Albikovskaya 1988; Garcia-Seoane 2013). The L_∞ value in the present study is much higher than 75 mm and 83.06 mm as reported for *B. glaciale* (Gjosaeter 1973, 1981). The present estimate of growth parameter in *B. fibulatum* is comparable to 0.45 of *B. glaciale* (Gjosaeter 1973), though a low value of 0.20 was also reported in the latter species (Gjosaeter 1981).

In the present study, the lengths attained by the fish at the end of 1^{st} year to 6^{th} year revealed that growth is fast during the 1^{st} year of life, however, it decreased thereafter. It appeared that this species takes more than 6 years to reach L_{max} 102 mm. The growth of deep water species does not show much seasonal changes since they are less affected by seasonal hydrographic changes such as temperature and food availability, compared to shallow water species (Kawaguchi and Mauchline 1982). Availability of food and prevailing water temperature are two main factors affecting growth rates of deep sea fishes.

The abundance of *B. fibulatum* in Arabian Sea is generally in water column having low temperatures ranging from 10 to 14 ºC. The slower growth rate may be due to the low water temperatures prevailing in deep waters. Most myctophids undertake diurnal migration from a depth of minimum oxygen to the oxygen-rich surface layer at night for feeding (Kinzer et al. 1993; Klevjer et al. 2012; Dypvik et al. 2012; Dypvik and Kaartvedt 2013). They are known to swim at a speed of 3 to 5 $m.s^{-1}$ during ascending (Luo et al. 2000; Klevjer et al. 2012) and move almost twice as fast during descending (Klevjer et al. 2012). They constitute important food source for whales, seals, sea lions, seabirds, large pelagic fishes and other deep-sea fishes and also play an important role in oceanic energy dynamics (Gjosaeter and Kawaguchi 1980; Kozlov 1995; Robinson et al. 2010).

In the present study, the size at first capture of this fish was estimated as 62.84 mm. The results of lengths at age indicated that fish reaches this length at age of 2 years. Vipin (2016) has reported that this fish at first maturity attains a length of 46.88 mm at the age of 1+ year. It appears that the present exploited stock comprise of mainly reproductively mature individuals. In the present study, the value of Z was estimated at 2.32 yr^{-1}. Gjosaeter (1973) reported a total mortality rate (Z) of 0.74 in *B. glaciale* from Norwegian waters. The present estimate of instantaneous natural mortality was low at 0.51 yr^{-1} at 12 ºC. However, the M/K ratio in the present study was 1.11 which conforms to the normal range of 1 to 2.5 in most fishes (Beverton and Holt 1959). The mortality due to fishing (F) in *B. fibulatum* was 1.81 yr^{-1} which is higher than the natural mortality (M) of 0.51 yr^{-1} and the exploitation rate was 0.78 yr^{-1}. The results of the present study indicate that the current exploitation rate is close to the maximum. However, any targeted fishery exploitation may challenge the sustainability of this stock. In contrast, Sebastine et al. (2013) reported a low exploitation rate of 0.279 and fishing mortality of 0.47 for another myctophid *Diaphus watasei* Jordan and Starks 1904, inhabiting the same fishing area.

Though mesopelagic fish stocks are known to be abundant in the world oceans, only a few countries have commercial fisheries targeting myctophids. Recently, the Iran Fisheries Organization (Shilat) and the Iran Fisheries Research Organization (IFRO) investigated the feasibility of developing a commercial fishery for mesopelagic fish in the Oman Sea (Shaviklo 2012). There has been no targeted fishery for myctophids in the study area. However, these are caught as bycatch during deep-sea shrimp trawling operations and are generally discarded back into the sea (Boopendranath et al. 2009; Pillai et al. 2009; Sebastine et al. 2013), due to lack of market acceptance. The discarding of large quantities of this species could generate considerable ecological and environmental impact (Blanco et al. 2007).

Conclusion

Even though myctophids are not subjected to a targeted fishery, they constitute a significant proportion of deep-sea trawl catches in the south-west coast of India. *Benthosema fibulatum* is one of such myctophid which has largely been exploited along with deep sea trawl catches in the south-west coast of India, and is being exclusively discarded owing to lack of market acceptance.

The present study revealed that this fish lives for 6 years with comparatively slow growth. The present catch levels are sustainable, as the current exploitation rate is close to maximum. However, the stock of this species can become unsustainable when the fishery expands and intensifies in the future, particularly due to demand from fish meal industry. Thus, proper action should be taken to manage these stocks.

References

Albikovskaya, L.K. 1988. Some aspects of the biology and distribution of glacier lanternfish (*Benthosema glaciale*) over the slopes of Flemish Cap and eastern Grand Bank. NAFO Scientific Council Studies 12:37–42.

Beverton, F.J.H. and S.J. Holt. 1956. A review of methods for estimating mortality rate in fish populations, with special reference to source of bias in catch sampling. Rapports et process - verbaux des réunions CIEM. 140:67–83.

Blanco, M., C.G. Sotelo, M.J. Chapela and R.I. Perez-Martin. 2007. Towards sustainable and efficient use of fishery resources: present and future trends. Trends in Food Science and Technology 18:29–36.

Boopendranath, M.R., M.P. Remesan, T. Jose Fernandez, K. Pradeep, P.M. Vipin and Renju Ravi. 2009. Myctophids in the bycatch of deep sea shrimp trawlers. Fish Technology Newsletter 20:1–2.

Catul, V., M. Gauns and P.K. Karuppasamy. 2011. A review on mesopelagic fishes belonging to family Myctophidae. Reviews in Fish Biology and Fisheries 21:339–354.

Childress, J.J., S.M. Taylor, G.M. Cailliet and M.H. Price. 1980. Patterns of growth, energy utilization and reproduction in some meso- and bathypelagic fishes off southern California. Marine Biology 61:27–40.

Dypvik, E. and S. Kaartvedt. 2013. Vertical migration and diel feeding periodicity of the skinnycheek lanternfish (*Benthosema pterotum*) in the Red Sea. Deep-Sea Research Part I 72:9–16.

Dypvik, E., A. Rostad and S. Kaartvedt. 2012. Seasonal variations in vertical migration of glacier lanternfish, *Benthosema glaciale*. Marine Biology 159:1673–1683.

Filin, A.A. 1997. Growth, size and age composition of the *Notoscopelus kroeyerii* (Myctophidae). Journal of Ichthyology 37:27–32.

Garcia-Seoane, E. 2013. Ecology of the glacier lanternfish *Benthosema glaciale* (Reinhardt, 1837) with focus on the Flemish Cap. Ph.D. thesis. The University of Vigo, Galicia, Spain. 164 pp.

Gartner, J.V. Jr. 1991. Life histories of three species of lanternfishes (Pisces: Myctophidae) from the eastern Gulf of Mexico. II. Age and growth patterns. Marine Biology 111:21–27.

Gayanilo, F.C., P. Sparre and D. Pauly. 1996. FAO-ICLARM stock Assessment Tools (FISAT) User's guide. FAO Computerized Information Series (Fisheries), No. 6. FAO, Rome. 186 pp.

Giragosov, B. and Y. Ovcharov. 1992. Age and growth of the lantern fish *Myctophum nitidulum* (Myctophidae) from the tropical Atlantic. Journal of Ichthyology 32:34–42.

Gjosaeter, J. 1973. Age, growth and mortality of the myctophid fish, *Benthosem aglaciale* (Reinhardt), from western Norway. Sarsia 52:53–58.

Gjosaeter, J. 1981. Growth, production and reproduction of the myctophid fish *Benthosema glaciale* from western Norway and adjacent seas. *Fiskeridirektoratets havforskningsinstitutt*. 17:79–108.

Gjosaeter, J. 1984. Mesopelagic fish, a large potential resource in the Arabian Sea. Deep-Sea Research 31:1019–1035.

Gjosaeter, J. and K. Kawaguchi. 1980. A review of the world resources of mesopelagic fish. FAO Technical Report 193. FAO, Rome. 151 pp.

Kinzer, J., R.B. Schnack and K. Schulz. 1993. Aspects of horizontal distribution and diet of myctophid fish in the Arabian Sea with reference to the deep water oxygen deficiency. Deep Sea Research Part II, 40:783–800.

Halliday, R.G. 1970. Growth and vertical distribution of the glacier lanternfish, *Benthosema glaciale*, in the north western Atlantic. Journal of the Fisheries Research Board of Canada 27:105–126.

Hayashi, A., H. Watanabe, M. Ishida and K. Kawaguchi. 2001. Growth of *Myctophum asperum* (Pisces: Myctophidae) in the Kuroshio and transitional waters. Fisheries Science (Tokyo) 67:983–984.

Hussain, S.M. 1992. The reproductive biology of the lanternfish *Benthosema fibulatum* from the northern Arabian Sea. Fisheries Research 13:381–393.

Irigoien, X., T.A. Klevjer, A. Røstad, U. Martinez, G. Boyra, J.L. Acuna, A. Bode, F. Echevarria, J.I. Gonzalez-Gordillo, S. Hernandez-Leon, S. Agusti, D.L. Aksnes, C.M. Duarte and S. Kaartvedt. 2014. Large mesopelagic fishes biomass and trophic efficiency in the open ocean. Nature Communication 5:3271.

Jayabalan, N. 2011. FAO workshop on the status of shared fisheries resources in the northern Arabian Sea – Iran (Islamic republic of), Oman and Pakistan, Muscat, Oman, 13–15 December 2010. FAO Fisheries and Aquaculture Report No. 971:13–15.

Karuppasamy, P.K., K. Balachandran, S. George, S. Balu, V. Persi and N.G. Menon. 2008. Food of some deep sea fishes collected from the eastern Arabian Sea. Journal of Marine Biological Association of India 50:1–5.

Karuppasamy, P.K., K. Balachandran, S. George, S. Balu, V. Persis and N.G. Menon. 2006. A check list of fishes collected by IKMT from the DSL survey in the Indian EEZ of Arabian Sea. Indian Hydrobiology 9:311–316.

Karuppasamy, P.K., K. Muraleedharan, R. Dineshkumar and M. Nair. 2010. Distribution of mesopelagic micronecton in the Arabian Sea during the winter monsoon. Indian Journal of Marine Science 39:227–237.

Kawaguchi, K. and J. Mauchline. 1982. Biology of myctophid fishes (Family: Myctophidae) in the Rockall Trough, north-eastern Atlantic Ocean. Biological Oceanography 1:337–373.

Klevjer, T.A., D.J. Torres and S. Kaartvedt. 2012. Distribution and diel vertical movements of mesopelagic scattering layers in the Red Sea. Marine Biology 159:1833–1841.

Kozlov, A.N. 1995. A review of the trophic role of mesopelagic fish of the family Myctophidae in the Southern Ocean ecosystem. CCAMLR Science 2:71–77.

Lam, W.V.Y. and D. Pauly. 2005. Mapping the global biomass of mesopelagic fishes. Seas Around Us Project Newsletter 30:4.

Luo J, P. Ortner, D. Forcucci and S. Cummings. 2000. Diel vertical migration of zooplankton and mesopelagic fish in the Arabian Sea. Deep-Sea Research Part II 47:1451–1473.

Pauly, D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. Journal du Conseil/Conseil Permanent International pour l'Exploration de la Mer 39:175–192.

Pauly, D. 1983a. Some simple methods for the assessment of tropical fish stocks. FAO Fisheries and Aquaculture Technical Paper 234. 52 pp.

Pauly, D. 1983b. Length converted catch curves. A powerful tool for the fisheries research in the Tropics (Part-I). Fishbyte 1:9–13.

Pauly, D. 1984. Fish population dynamics in tropical waters: A manual for use with programmable calculators, Studies and Reviews 8. International Center for Living Aquatic Resources Management, Makati, Metro Manila. 325 pp.

Pauly, D. and J.L. Munro. 1984. Once more on the comparison of growth in fish and invertebrates. Fishbyte 2:1–21.

Pillai, N.G.K., K.K. Bineesh, M. Sebastine and K.V. Akhilesh. 2009. Lanternfishes (Myctophids): bycatch of deep sea shrimp trawlers operated off Kollam, south-west coast of India. Marine Fisheries Information Service Technical and Extension Series 202:1–4.

Robinson, C., D.K. Steinberg, T.R. Anderson. J. Arı´stegui, C.A. Carlson, J.R. Frost, J.F. Ghiglione, S. Herna´ndez-Leo´n, G.A. Jackson, R. Koppelmann, B. Quéguiner, O. Ragueneau, F. Rassoulzadegan, B.H. Robison, C. Tamburini, T. Tanaka, K.F. Wishner and J. Zhang. 2010. Mesopelagic zone ecology and biogeochemistry-a synthesis. Deep-Sea Research Part II 57:1504–1518.

Sebastine, M., K.K. Bineesh, E.M. Abdussamad and N.G.K. Pillai. 2013. Myctophid fishery along the Kerala coast with emphasis on population characteristics and biology of the headlight fish, *Diaphus watasei* Jordan & Starks, 1904. Indian Journal of Fisheries 60:7–11.

Seshappa, G. 1999. Recent studies on age determination of India, fishes using scales, otoliths and other hard parts. Indian Journal of Fisheries 46:1–11.

Shaviklo, A.R. and F. Rafipour. 2013. Surimi and surimi seafood from whole ungutted myctophid mince. LWT- Food Science and Technology 54:463–468.

Shaviklo, A.R. 2012. Developing value-added products from lanternfish. INFOFISH International 2 March:42–46.

Shilat, A.Z. and T. Valinassab. 1998. Trail fishing for lanternfishes (myctophids) in the Gulf of Oman (1989–1990). FAO Fisheries Circular No. 935. FAO, Rome. 66 pp.

Smoker, W. and W.G. Pearcy. 1970. Growth and reproduction of the lanternfish *Stenobrachius leucopsarus*. Journal of Fisheries Research Board of Canada 27:1265–1275.

Valinassab, T. 2005. Biomass distribution and pattern of myctophids in the Oman Sea. Iranian Journal of Fisheries Science 4:101–110.

Valinassab, T., G.J. Pierce and K. Johannesson. 2007. Lanternfish (*Benthosema pterotum*) resource as a target for commercial exploitation in the Oman Sea. Journal of Applied Ichthyology 23:573–577.

Vipin, P.M. 2016. Studies on selected myctophid fishes in Arabian Sea with respect to their status in deep sea trawl bycatch, length-weight relationship, reproductive biology and population dynamics. Ph.D. Thesis, Cochin University of Science and Technology, India. 217 pp.

von Bertalanffy, L. 1934. Unterschunger iiber die Gesetzlichkeiten des wachstums. 1. Allge meine Grundlagen der theorie. Wilhelm Roux' Archiv für Entwicklungsmechanik der Organismen 131:613–653.

von Bertalanffy, L. 1957. Quantitative laws in metabolism and growth. Quarterly Review of Biology 32:217–231.

Walford, L.A. 1946. A new graphic method of describing the growth of animals. Biological Bulletin 90:141–147.

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