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Cephalopod: Squid Biology, Ecology and Fisheries in Indian waters

Anusha J.R., Albin T. Fleming

ABSTRACT
This short review summarizes the current status of the squid fisheries in Indian waters. It primarily considers the historical classification and biological characteristics of squid within the context to Indian squid varieties. Squid is an economically important cephalopod in India represented mainly by *Loligo duvauceli, Sepioteuthis lessoniana,* and *Doryteuthis* species. Among the squids, the Indian squid (*Loligo duvauceli*) is the dominant species, catching about 97% all over the country per year. The squid fish plays a major role in balancing the marine ecosystem. Generally, the temperature changes, ocean acidification and climatic changes are likely to affect marine ecosystems and their associated fisheries, adding to the challenges of managing fisheries sustainably. The proposed changes responded quickly in the squids and act as ecosystem indicators of environmental change by minimum growth rate and maximum production. Since, the increase in ocean temperatures can cause faster growth and shorter life spans of squid. In addition, briefly reviews the methods of exploitation of squid along with the current squid populations, fishing methods, export, utilization and marketing. India's squid fishing fleet accounted for 3% of the global squid production and makes up approximately 5–7% of U.S. squid imports. The processed squid meat has been exported in global level from the maritime states to Japan, US, EU, UAE, Italy and France through the major ports such as Kochi, Kollam, Tuticorin, Mumbai and Visakhapatnam. A brief analysis of the current status of the Indian squid fisheries and considers the potential for future development are provided in conclusion.

Keywords: Cephalopod, Squid, Ecosystem, Fisheries, Global Utilization.

1. Introduction

India is one of the major fish producing country in the world which holds second and third position in aquaculture and fisheries. Indian fisheries sector has high potentials for domestic nutritional security, employment generation, rural development, gender mainstreaming as well as export earnings. This sector has been witnessing a steady growth since First Five Year Plan. Indian fisheries contribute overall production of 4.39% to that of the global output. After declaration of the Exclusive Economic Zone (EEZ) in 1977, the oceanic resources available to India are estimated at 2.02 million sq. km, comprising 0.86 million sq. km (42.6% of the total) on the west coast, 0.56 million sq. km (27.7%) on the east coast and 0.60 million sq. km (29.7%) around the Andaman and Nicobar Islands (Fig. 1). These resources are one of the main sources of livelihood for the rural people around the coastal region. Considering the output of the sector, it can provide livelihood for over 90 lakhs at subsistence level of annual income. It was estimated that 14 million people are engaged in fishing, aquaculture and ancillary activities currently. Hence, the fisheries sector of India is an important player in the overall socio-economic development. After 1947, it came into focus as blue revolution to promote fisheries production in order to ensure food security and social as well as economic development of fishers through subsidization of various assets. By generating income and employment for local people along the coasts, the marine fishery sector significantly develop the economy of the country. Most of the marine ecosystem concern to India is in coastal ecosystem. The modern research on marine biodiversity is established in most of the region in the country acts for saving the marine resources. The exploitation of marine fisheries resources in India has increased due to development in fishing gear. The invertebrates are the highly developed group and occupy a leading place among the exploited marine fishery resource of India. Cephalopods, which have gained great grandness in recent years due to the increasing, demand in the export trade.

contributed on cephalopod resources, biology, population dynamics and information on specific aspects of cephalopod stocks in last few decades [11, 12, 13, 14, 15].

3. Classification and Biology of Squid

The classification of recent taxa of the molluscan Class, Cephalopoda [16] includes the squids which come under the Order Teuthoidea, which are further distinguished based on their eyes. If the eyes are covered by a transparent cornea which comes under the Suborder Myopsida or exposed were placed in another suborder Oegopsida. The two families of squid, the Ommastrephidae and the Loliginidae, are extensively exploited. The loliginids are distinguished by a membrane covering the eye, which in Ommastrephids is slit exposing the lens to the sea. Loliginid squid, occur sporadically which are coastal and can only support local fisheries, they yield a higher quality meat than the Ommastrephids. The family Loliginidae includes many species that are important in trophic systems, fisheries, environmental and biomedical studies.

The squids, in common with the other coleoid cephalopods, are semelparous and generally shortlived [17]. Most commercially exploited species exist a short life span of approximately one year at the end of which there is a single spawning event followed by death. The coleoids evolved from their molluscan ancestors through the process of progenesis [18]. The juvenile of coleoids characteristics with full sexual maturity are features of their physiological energetic [19]. The short life span and semelparous lifestyle of the squid and other coleoid cephalopods distinguishes the fish species that are exploited commercially [20]. These characteristics have particular problems for the management of the fisheries, the spawners of one generation have reproduced and died, it is almost impossible to assess the potential recruitment strength and stock size of the next generation. Hence, recommended that squid and other cephalopod fisheries should be managed by effort limitation and assessed in real-time [21, 22].

The squid and cuttle fish together are commonly known as decapods; the members of both orders have ten suckered appendages to the head. These consist of arms and one pair of tentacles, which are often more than twice the length of the arms [23]. The size of the squid ranges from 6 to 28 cm mantle length. It is characterized by a relatively short, stout mantle. Fins are rhombic, broad, short, just over 50% of mantle length. Tentacular clubs expanded forming large median manual suckers eleven times larger than marginals, with 14 to 17 short, sharp teeth around ring. Arm suckers of female of about equal size on second and third arms, rings smooth proximally, toothed with about 7 broad, blunt teeth distally but male has 9 to 11 broad tooth. It is squared to round, truncate teeth in the distal two or three of ring with rows of large papillae, some with minute suckers on tip; ventral rows larger, turned outward, comb-like; an oval photophore on each side of rectum and ink sac and a chitionus internal shell known as the 'pen or gladius' embedded under the mantle, mid- dorsally. This species feeds on fishes and squids. Squid are often highly fecund with more than 0.5 million egg [24, 25, 26]. The potential fecundity of the giant form of squid ranged between 2 million and 5 million eggs and the holding capacity of the oviducts was approximately 300,000 eggs [27]. Indirect evidences suggested that *S. oualaniensis* might be a multiple spawner [28, 29]. Kore and Joshi (1975) [15] also observed that there was a decreased feeding activity during the spawning period. Squid have been reported to change their feeding habitat with growth in size. Cannabalism increased among the largest animals. Planktonic feeding was dominant in the smallest squid, whereas larger squid are Euphausiid feeding [30]. Size (DML) of *L. duvauceli, S. pharaonis S. aculeata and C. indicus* were 20-309 mm, 70-299 mm, 40-129 mm and 30-199 mm respectively. Fecundity of *L. duvauceli* ranged between 740-14,924 eggs. The feeding strategy of squid is entirely different from other fishes. They use their tentacles and oral arms for prey capture. The toxic saliva termed 'cephalotoxin' cause paralyzing and respiratory distress sometimes even kill their prey. The squids are adept in their ability with fast growth, short life span and semelparity [31]. They have versatile character to capture, subdue and consume a wide variety of prey and they feed voraciously to maintain the active associated lifestyle [32]. In case of squid, the gladius is quite variable within and among the species and formally used to distinguish the genus, it's only important at specific level [33]. The gladius could be highly adaptive in response to differences in swimming behavior. The generic systematizes of the Loliginidae include spermatophore deposition site, presence of suckers on the buccal lappets, adult chromatophore patterns, and presence of a longitudinal mid-ventral ridge on the mantle may also varies in specific range of species [34]. The subsequent analyses of DNA sequences [35] have indicated that a holophyletic classification requires recognition of generic-level species groups defined primarily on distributional characteristics, towards consensus on the genera of this family.

Among the squids, the Indian squid (*Loligo duvauceli* Orbigny, 1848) is the dominant species, catching about 97% from Indian waters. The most common Indian squid distributed in Indo-Pacific ocean periphery, including the Red Sea and the Arabian Sea, extending from Mozambique to the South China and the Philippines Sea, northward to Taiwan (Fig. 2a). The biology of *Loligo duvauceli* (Fig. 2b) was studied by Silas et al. (1986) [36] and Rao (1988) [12]. The report reveals that the males and females are found to be in equal proportion. It matures from the size ranges of 4 to 28 cm for males and 4 to 18 cm in females. Juveniles of squids are less than 4 cm in size. Females were dominant during January, March, May and December, whereas males were dominant in other months. The overall male to female ratio was 1: 1.3 [37]. The length- weight relationship and the morphometric character of the Loligo squid varies with geographical locations [38]. The seasonal growth, stock recruitment relationship, predictive yield and exploitation of *L. duvauceli* was studied by Sunilkumar (1997) [39], Mohamad (1997) [40] and Nirmala *et al*. (2003) [41]. The purpleback squid (*Sthenoteuthis oualaniensis* Lesson, 1830), is widely distributed in the equatorial and tropical waters of Indo-Pacific Ocean. It occupies throughout the tropical and temperature waters of both the northern and southern hemispheres [42, 43]. Siboa squid, *Doryteuthis sibogae* Adam, 1954 is a neritic species distribution from Indonasian waters and Formosan waters of Bay of Bengal upto the South-eastern Arabian sea [2]. It is forming a notable fishery along Thoothukudi (India) coast throughout the year with peak from June to November. It is a prolonged breeder as matured and almost round the year. Females attained maturity earlier than males [44].

were followed these days. Restrictions exist on the use of otter trawls, including minimum mesh sizes. This otter trawls are sometimes make contact with the seafloor, thus damage or alter the habitat and disturbs the marine ecosystem. Biodiversity conservation and management is essential for the future development of marine resources [69].

6. Squid Fishing Methods

In India, the squid fishes were catch by a common known method, Squid jigging [70]. Squids were attracted to artificial light and they aggregate close to the illuminated area. They are also easily attracted to fast moving bait or bait like object. Squid jigging operation take advantage of this behavior of squids [71]. Lines carrying jigs are vertically hawled through the congregation of squids. Squids get entangled in the jigs and fall on the deck when the jigs are inverted. The ommastrephid squid are almost exclusively caught using jigs armed with barbless hooks which are fished in series on lines using automatic machines [72]. The squid are attracted towards the jigs at night with incandescent, metal halide lamps suspended on cables above the deck of the vessel. Small coastal vessels may use a single lamp while the large industrial vessels operate with 150 or more lamps which are typically 2 kW each. The lamps mostly emit white light but small numbers of green lamps are often interspersed in the arrays [73]. Some industrial vessels will also operate one or two underwater lamps which are raised through the water column, and dimmed, as the squids were attracted towards the vessel. Jiggers typically deploy a large parachute drogue to prevent drifting downwind while fishing, thus enabling the jig lines to operate close to the vertical. The major fisheries for loliginids mostly use trawls which operate during daytime when the squids were concentrated near the seabed. Conventional otter trawls fish on the bottom but over rough ground pelagic trawls may be fished just off the seabed to avoid fouling the gear. Trawls designed for squid fishing generally have a higher head rope than would be usual for finfish. Outside the major fisheries a wide variety of gear including jigs, traps, nets etc. are used to catch loliginid squid [74, 75]. While comparing the oceanic squid fishing method's efficiency, gillnet catch rates were relatively higher, followed by mechanized jigging in larger vessel. Dermal resources of Fishery Survey of India (FSI) revealed the existence of potential grounds for cephalopod all along the India Coast. Squid jigging method was introduced by FSI for the exploration of the squid resources. Matsya Sugundhi is the vessel name of squid jigging used since from the end of 1980s. The vessel Matsya Sugundhi conducted jigging for neritic squids between lat 8N and 17N in the depth range 25-200 m and for the oceanic squids between lat. 10N–14N in area beyond 500 m depth. Based on the Fishery Survey of India, the fish catch was about 96213 kg using 823 hauls.

7. Methods of Exploitation of squid

Various investigations on cephalopod biology centre on the commercially exploited species such as the Palk Bay squid, *Sepioteuthis lessoniana* [76], *L. duvauceil* [2, 15, 77, 79], *Sepia pharaonis, S. aculeata, Sepiella inermis* [79] and *Octopus dollfusi* [80]. Although, about 40 per cent of the world's cephalopod catches are taken by squid jigging and 25 per cent by trawling, in India, cephalopods are principally caught by bottom trawlers operating upto 200 m depth zones. Among the Cephalopods, 48% squids and 44% cuttlefish were catch during the year 2011 (Fig. 3). While, most of the catch is brought to us by-catch from the shrimp and fish trawls employed by the trawlers. There is a targeted fishery for cuttlefishes during the post monsoon period of September - December using off bottom high opening trawls along the southwest and northwest coast. Prior to the seventies traditional gears like shore seines, boat seines, hooks and lines and spearing were the principal gear employed to capture cephalopods. Experimental squid jigging has been tried with Japanese expertise along the west coast by GOI vessels with considerable success [81]. Current cephalopod fishing effort is above optimum precautionary targets for several regions [82, 83]. Mesh size regulations and vessel restrictions are the only major protections employed for fishery stocks. In recent years, trawl licenses have been withheld and gear conversions have been encouraged to help rationalize the trawl fleet.

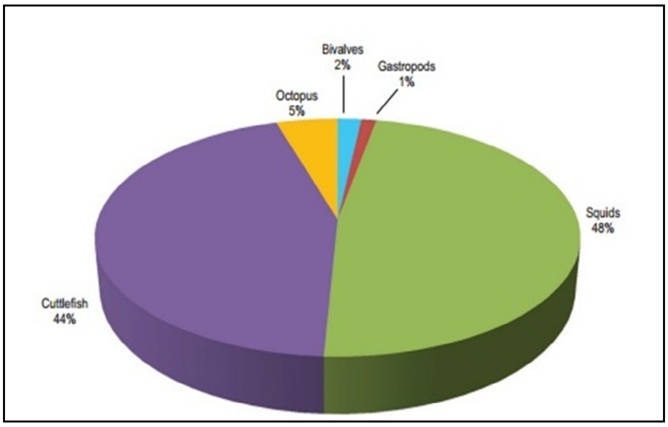

Fig 3: Molluscus fish landings in India during 2011-2012 (CMFRI Annual report)

8. Region wise exploitation of Squid Catch

Squid catches have increased substantially worldwide and this has highlighted the fact that their populations are highly variable. In India, from January to March and October to December was the most productive period of squid species. Along the upper east and west coast the above mentioned months was the most productive, while in southern region such as Karnataka, Kerala, Tamil Nadu and Andhra Pradesh equal productivity was evaluated in July to September. Region-wise and resource-wise estimates of marine fish

New trends were rising in the recent years all over the world for processing of squid. It can be processed in canned, dried and smoked forms. In India, freezing is the predominant method for the adopted for export. The major frozen items in the case of loliginida are squid whole, whole cleaned, tubes, rings, fillet, tentacles, peeled whole, stuffed and wings tray packed. Among the 44 varieties, the frozen squid whole and frozen squid whole cleaned contributed more than 60 per cent to the exports. In spite of upsurge in the demand for ready-to-eat and ready-to-cook products in international and domestic markets, our export of value-added squid product such as frozen squid rings breaded and frozen squid stuffed is less than a percent.

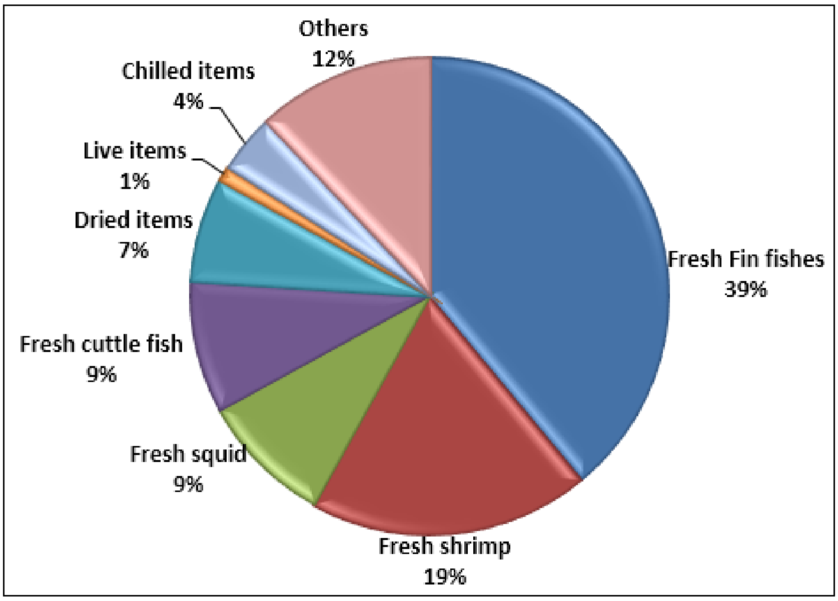

Fig 5: Major seafood items exported during the year 2009-2010 (Data from MPEDA records)

Table 2: Squid products exported from India to various countries

Items exported	Origin	Market
Fillet	Tuticorin	Japan
Wings	Tuticorin	Japan
Whole (Cleaned)	Kollam and Veraval	USA & European Union
Whole	Kollam and Mangalore	Spain & UAE
Whole (Cleaned)	Mumbai	Italy
Rings blanched IQF	Kochi	Italy & France
Tentacles blanched IQF	Kochi	Italy

10. Conclusion

India's coastal marine fisheries are open access. An inter-ministerial empowered committee looks after management and development of fisheries in the EEZ. Management varies by state and includes some seasonal or area closures and gear restrictions for trawls. In India, the fisheries research is coordinated by the Indian Council of Agricultural Research (ICAR), an autonomous organization under the Ministry of Agriculture, the Agricultural Universities, and institutes under the Ministry of Agriculture (FAO India profile, 2012). The conflict between the resources used by humans and the marine concertion is ubiquitous and increasing throughout the world. Ecosystem based management is not in practice, but there is a high emphasis by management on conservation and protecting marine biodiversity. Global estimates of consumption of squid as well as other cephalopods by higher predators have projected that they far exceed global or regional catches by the commercial fisheries; although, due to variability in cephalopod populations, this estimate must be taken with caution (FAO, 2005) [84]. As a result, squid fisheries are urged to proceed following precautionary principles in fishery. The ecological impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems. Squids are dioecious, with a life expectancy generally ranging from a few months to 1-2 years, usually ending in a single terminal spawning event. However, the physiology and ecology of most squid species is still poorly understood. Internationally, squid fisheries have increased dramatically over the last 25 years. As demand for marine resources increases, squid can provide a high protein alternative to fish stocks, particularly in those regions where other fish stocks may have become reduced by overfishing [85]. Commercial squid fishing operations are maintained by several countries in coastal waters worldwide. Biodiversity monitoring surveys are needed to assess and track fisheries impacts; some area and seasonal closures are in place to aid in biodiversity conservation for economically valuable living resources.

11. Acknowledgement

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3. Classification and Biology of Squid

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The squids, in common with the other coleoid cephalopods, are semelparous and generally shortlived [17]. Most commercially exploited species exist a short life span of approximately one year at the end of which there is a single spawning event followed by death. The coleoids evolved from their molluscan ancestors through the process of progenesis [18]. The juvenile of coleoids characteristics with full sexual maturity are features of their physiological energetic [19]. The short life span and semelparous lifestyle of the squid and other coleoid cephalopods distinguishes the fish species that are exploited commercially [20]. These characteristics have particular problems for the management of the fisheries, the spawners of one generation have reproduced and died, it is almost impossible to assess the potential recruitment strength and stock size of the next generation. Hence, recommended that squid and other cephalopod fisheries should be managed by effort limitation and assessed in real-time [21, 22].

The squid and cuttle fish together are commonly known as decapods; the members of both orders have ten suckered appendages to the head. These consist of arms and one pair of tentacles, which are often more than twice the length of the arms [23]. The size of the squid ranges from 6 to 28 cm mantle length. It is characterized by a relatively short, stout mantle. Fins are rhombic, broad, short, just over 50% of mantle length. Tentacular clubs expanded forming large median manual suckers eleven times larger than marginals, with 14 to 17 short, sharp teeth around ring. Arm suckers of female of about equal size on second and third arms, rings smooth proximally, toothed with about 7 broad, blunt teeth distally but male has 9 to 11 broad tooth. It is squared to round, truncate teeth in the distal two or three of ring with rows of large papillae, some with minute suckers on tip; ventral rows larger, turned outward, comb-like; an oval photophore on each side of rectum and ink sac and a chitionus internal shell known as the 'pen or gladius' embedded under the mantle, mid- dorsally. This species feeds on fishes and squids. Squid are often highly fecund with more than 0.5 million egg [24, 25, 26]. The potential fecundity of the giant form of squid ranged between 2 million and 5 million eggs and the holding capacity of the oviducts was approximately 300,000 eggs [27]. Indirect evidences suggested that *S. oualaniensis* might be a multiple spawner [28, 29]. Kore and Joshi (1975) [15] also observed that there was a decreased feeding activity during the spawning period. Squid have been reported to change their feeding habitat with growth in size. Cannabalism increased among the largest animals. Planktonic feeding was dominant in the smallest squid, whereas larger squid are Euphausiid feeding [30]. Size (DML) of *L. duvauceli, S. pharaonis S. aculeata and C. indicus* were 20-309 mm, 70-299 mm, 40-129 mm and 30-199 mm respectively. Fecundity of *L. duvauceli* ranged between 740-14,924 eggs. The feeding strategy of squid is entirely different from other fishes. They use their tentacles and oral arms for prey capture. The toxic saliva termed 'cephalotoxin' cause paralyzing and respiratory distress sometimes even kill their prey. The squids are adept in their ability with fast growth, short life span and semelparity [31]. They have versatile character to capture, subdue and consume a wide variety of prey and they feed voraciously to maintain the active associated lifestyle [32]. In case of squid, the gladius is quite variable within and among the species and formally used to distinguish the genus, it's only important at specific level [33]. The gladius could be highly adaptive in response to differences in swimming behavior. The generic systematizes of the Loliginidae include spermatophore deposition site, presence of suckers on the buccal lappets, adult chromatophore patterns, and presence of a longitudinal mid-ventral ridge on the mantle may also varies in specific range of species [34]. The subsequent analyses of DNA sequences [35] have indicated that a holophyletic classification requires recognition of generic-level species groups defined primarily on distributional characteristics, towards consensus on the genera of this family.

Among the squids, the Indian squid (*Loligo duvauceli* Orbigny, 1848) is the dominant species, catching about 97% from Indian waters. The most common Indian squid distributed in Indo-Pacific ocean periphery, including the Red Sea and the Arabian Sea, extending from Mozambique to the South China and the Philippines Sea, northward to Taiwan (Fig. 2a). The biology of *Loligo duvauceli* (Fig. 2b) was studied by Silas et al. (1986) [36] and Rao (1988) [12]. The report reveals that the males and females are found to be in equal proportion. It matures from the size ranges of 4 to 28 cm for males and 4 to 18 cm in females. Juveniles of squids are less than 4 cm in size. Females were dominant during January, March, May and December, whereas males were dominant in other months. The overall male to female ratio was 1: 1.3 [37]. The length- weight relationship and the morphometric character of the Loligo squid varies with geographical locations [38]. The seasonal growth, stock recruitment relationship, predictive yield and exploitation of *L. duvauceli* was studied by Sunilkumar (1997) [39], Mohamad (1997) [40] and Nirmala *et al*. (2003) [41]. The purpleback squid (*Sthenoteuthis oualaniensis* Lesson, 1830), is widely distributed in the equatorial and tropical waters of Indo-Pacific Ocean. It occupies throughout the tropical and temperature waters of both the northern and southern hemispheres [42, 43]. Siboa squid, *Doryteuthis sibogae* Adam, 1954 is a neritic species distribution from Indonasian waters and Formosan waters of Bay of Bengal upto the South-eastern Arabian sea [2]. It is forming a notable fishery along Thoothukudi (India) coast throughout the year with peak from June to November. It is a prolonged breeder as matured and almost round the year. Females attained maturity earlier than males [44].

were followed these days. Restrictions exist on the use of otter trawls, including minimum mesh sizes. This otter trawls are sometimes make contact with the seafloor, thus damage or alter the habitat and disturbs the marine ecosystem. Biodiversity conservation and management is essential for the future development of marine resources [69].

6. Squid Fishing Methods

In India, the squid fishes were catch by a common known method, Squid jigging [70]. Squids were attracted to artificial light and they aggregate close to the illuminated area. They are also easily attracted to fast moving bait or bait like object. Squid jigging operation take advantage of this behavior of squids [71]. Lines carrying jigs are vertically hawled through the congregation of squids. Squids get entangled in the jigs and fall on the deck when the jigs are inverted. The ommastrephid squid are almost exclusively caught using jigs armed with barbless hooks which are fished in series on lines using automatic machines [72]. The squid are attracted towards the jigs at night with incandescent, metal halide lamps suspended on cables above the deck of the vessel. Small coastal vessels may use a single lamp while the large industrial vessels operate with 150 or more lamps which are typically 2 kW each. The lamps mostly emit white light but small numbers of green lamps are often interspersed in the arrays [73]. Some industrial vessels will also operate one or two underwater lamps which are raised through the water column, and dimmed, as the squids were attracted towards the vessel. Jiggers typically deploy a large parachute drogue to prevent drifting downwind while fishing, thus enabling the jig lines to operate close to the vertical. The major fisheries for loliginids mostly use trawls which operate during daytime when the squids were concentrated near the seabed. Conventional otter trawls fish on the bottom but over rough ground pelagic trawls may be fished just off the seabed to avoid fouling the gear. Trawls designed for squid fishing generally have a higher head rope than would be usual for finfish. Outside the major fisheries a wide variety of gear including jigs, traps, nets etc. are used to catch loliginid squid [74, 75]. While comparing the oceanic squid fishing method's efficiency, gillnet catch rates were relatively higher, followed by mechanized jigging in larger vessel. Dermal resources of Fishery Survey of India (FSI) revealed the existence of potential grounds for cephalopod all along the India Coast. Squid jigging method was introduced by FSI for the exploration of the squid resources. Matsya Sugundhi is the vessel name of squid jigging used since from the end of 1980s. The vessel Matsya Sugundhi conducted jigging for neritic squids between lat 8N and 17N in the depth range 25-200 m and for the oceanic squids between lat. 10N–14N in area beyond 500 m depth. Based on the Fishery Survey of India, the fish catch was about 96213 kg using 823 hauls.

7. Methods of Exploitation of squid

Various investigations on cephalopod biology centre on the commercially exploited species such as the Palk Bay squid, *Sepioteuthis lessoniana* [76], *L. duvauceil* [2, 15, 77, 79], *Sepia pharaonis, S. aculeata, Sepiella inermis* [79] and *Octopus dollfusi* [80]. Although, about 40 per cent of the world's cephalopod catches are taken by squid jigging and 25 per cent by trawling, in India, cephalopods are principally caught by bottom trawlers operating upto 200 m depth zones. Among the Cephalopods, 48% squids and 44% cuttlefish were catch during the year 2011 (Fig. 3). While, most of the catch is brought to us by-catch from the shrimp and fish trawls employed by the trawlers. There is a targeted fishery for cuttlefishes during the post monsoon period of September - December using off bottom high opening trawls along the southwest and northwest coast. Prior to the seventies traditional gears like shore seines, boat seines, hooks and lines and spearing were the principal gear employed to capture cephalopods. Experimental squid jigging has been tried with Japanese expertise along the west coast by GOI vessels with considerable success [81]. Current cephalopod fishing effort is above optimum precautionary targets for several regions [82, 83]. Mesh size regulations and vessel restrictions are the only major protections employed for fishery stocks. In recent years, trawl licenses have been withheld and gear conversions have been encouraged to help rationalize the trawl fleet.

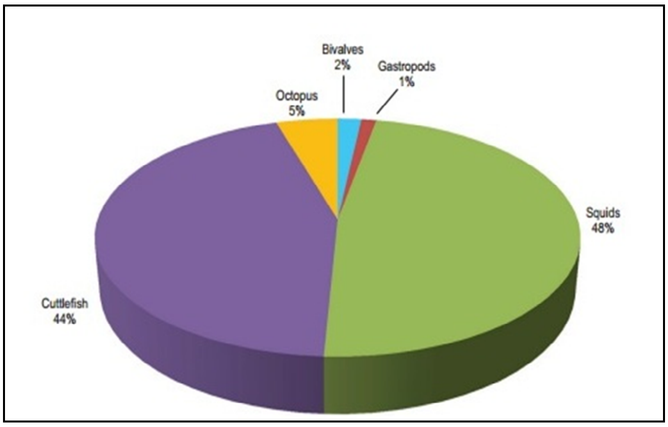

Fig 3: Molluscus fish landings in India during 2011-2012 (CMFRI Annual report)

8. Region wise exploitation of Squid Catch

Squid catches have increased substantially worldwide and this has highlighted the fact that their populations are highly variable. In India, from January to March and October to December was the most productive period of squid species. Along the upper east and west coast the above mentioned months was the most productive, while in southern region such as Karnataka, Kerala, Tamil Nadu and Andhra Pradesh equal productivity was evaluated in July to September. Region-wise and resource-wise estimates of marine fish

New trends were rising in the recent years all over the world for processing of squid. It can be processed in canned, dried and smoked forms. In India, freezing is the predominant method for the adopted for export. The major frozen items in the case of loliginida are squid whole, whole cleaned, tubes, rings, fillet, tentacles, peeled whole, stuffed and wings tray packed. Among the 44 varieties, the frozen squid whole and frozen squid whole cleaned contributed more than 60 per cent to the exports. In spite of upsurge in the demand for ready-to-eat and ready-to-cook products in international and domestic markets, our export of value-added squid product such as frozen squid rings breaded and frozen squid stuffed is less than a percent.

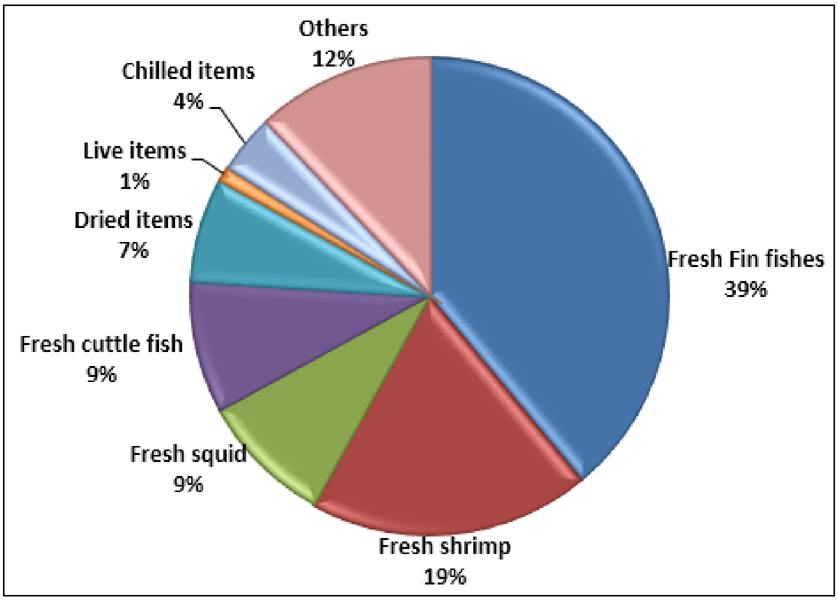

Fig 5: Major seafood items exported during the year 2009-2010 (Data from MPEDA records)

Table 2: Squid products exported from India to various countries

Items exported	Origin	Market
Fillet	Tuticorin	Japan
Wings	Tuticorin	Japan
Whole (Cleaned)	Kollam and Veraval	USA & European Union
Whole	Kollam and Mangalore	Spain & UAE
Whole (Cleaned)	Mumbai	Italy
Rings blanched IQF	Kochi	Italy & France
Tentacles blanched IQF	Kochi	Italy

10. Conclusion

India's coastal marine fisheries are open access. An inter-ministerial empowered committee looks after management and development of fisheries in the EEZ. Management varies by state and includes some seasonal or area closures and gear restrictions for trawls. In India, the fisheries research is coordinated by the Indian Council of Agricultural Research (ICAR), an autonomous organization under the Ministry of Agriculture, the Agricultural Universities, and institutes under the Ministry of Agriculture (FAO India profile, 2012). The conflict between the resources used by humans and the marine concertion is ubiquitous and increasing throughout the world. Ecosystem based management is not in practice, but there is a high emphasis by management on conservation and protecting marine biodiversity. Global estimates of consumption of squid as well as other cephalopods by higher predators have projected that they far exceed global or regional catches by the commercial fisheries; although, due to variability in cephalopod populations, this estimate must be taken with caution (FAO, 2005) [84]. As a result, squid fisheries are urged to proceed following precautionary principles in fishery. The ecological impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems. Squids are dioecious, with a life expectancy generally ranging from a few months to 1-2 years, usually ending in a single terminal spawning event. However, the physiology and ecology of most squid species is still poorly understood. Internationally, squid fisheries have increased dramatically over the last 25 years. As demand for marine resources increases, squid can provide a high protein alternative to fish stocks, particularly in those regions where other fish stocks may have become reduced by overfishing [85]. Commercial squid fishing operations are maintained by several countries in coastal waters worldwide. Biodiversity monitoring surveys are needed to assess and track fisheries impacts; some area and seasonal closures are in place to aid in biodiversity conservation for economically valuable living resources.

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Cephalopod: Squid Biology, Ecology and Fisheries in Indian waters

Anusha J.R., Albin T. Fleming

ABSTRACT
This short review summarizes the current status of the squid fisheries in Indian waters. It primarily considers the historical classification and biological characteristics of squid within the context to Indian squid varieties. Squid is an economically important cephalopod in India represented mainly by *Loligo duvauceli, Sepioteuthis lessoniana,* and *Doryteuthis* species. Among the squids, the Indian squid (*Loligo duvauceli*) is the dominant species, catching about 97% all over the country per year. The squid fish plays a major role in balancing the marine ecosystem. Generally, the temperature changes, ocean acidification and climatic changes are likely to affect marine ecosystems and their associated fisheries, adding to the challenges of managing fisheries sustainably. The proposed changes responded quickly in the squids and act as ecosystem indicators of environmental change by minimum growth rate and maximum production. Since, the increase in ocean temperatures can cause faster growth and shorter life spans of squid. In addition, briefly reviews the methods of exploitation of squid along with the current squid populations, fishing methods, export, utilization and marketing. India's squid fishing fleet accounted for 3% of the global squid production and makes up approximately 5–7% of U.S. squid imports. The processed squid meat has been exported in global level from the maritime states to Japan, US, EU, UAE, Italy and France through the major ports such as Kochi, Kollam, Tuticorin, Mumbai and Visakhapatnam. A brief analysis of the current status of the Indian squid fisheries and considers the potential for future development are provided in conclusion.

Keywords: Cephalopod, Squid, Ecosystem, Fisheries, Global Utilization.

1. Introduction

India is one of the major fish producing country in the world which holds second and third position in aquaculture and fisheries. Indian fisheries sector has high potentials for domestic nutritional security, employment generation, rural development, gender mainstreaming as well as export earnings. This sector has been witnessing a steady growth since First Five Year Plan. Indian fisheries contribute overall production of 4.39% to that of the global output. After declaration of the Exclusive Economic Zone (EEZ) in 1977, the oceanic resources available to India are estimated at 2.02 million sq. km, comprising 0.86 million sq. km (42.6% of the total) on the west coast, 0.56 million sq. km (27.7%) on the east coast and 0.60 million sq. km (29.7%) around the Andaman and Nicobar Islands (Fig. 1). These resources are one of the main sources of livelihood for the rural people around the coastal region. Considering the output of the sector, it can provide livelihood for over 90 lakhs at subsistence level of annual income. It was estimated that 14 million people are engaged in fishing, aquaculture and ancillary activities currently. Hence, the fisheries sector of India is an important player in the overall socio-economic development. After 1947, it came into focus as blue revolution to promote fisheries production in order to ensure food security and social as well as economic development of fishers through subsidization of various assets. By generating income and employment for local people along the coasts, the marine fishery sector significantly develop the economy of the country. Most of the marine ecosystem concern to India is in coastal ecosystem. The modern research on marine biodiversity is established in most of the region in the country acts for saving the marine resources. The exploitation of marine fisheries resources in India has increased due to development in fishing gear. The invertebrates are the highly developed group and occupy a leading place among the exploited marine fishery resource of India. Cephalopods, which have gained great grandness in recent years due to the increasing, demand in the export trade.

contributed on cephalopod resources, biology, population dynamics and information on specific aspects of cephalopod stocks in last few decades [11, 12, 13, 14, 15].

3. Classification and Biology of Squid

The classification of recent taxa of the molluscan Class, Cephalopoda [16] includes the squids which come under the Order Teuthoidea, which are further distinguished based on their eyes. If the eyes are covered by a transparent cornea which comes under the Suborder Myopsida or exposed were placed in another suborder Oegopsida. The two families of squid, the Ommastrephidae and the Loliginidae, are extensively exploited. The loliginids are distinguished by a membrane covering the eye, which in Ommastrephids is slit exposing the lens to the sea. Loliginid squid, occur sporadically which are coastal and can only support local fisheries, they yield a higher quality meat than the Ommastrephids. The family Loliginidae includes many species that are important in trophic systems, fisheries, environmental and biomedical studies.

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Among the squids, the Indian squid (*Loligo duvauceli* Orbigny, 1848) is the dominant species, catching about 97% from Indian waters. The most common Indian squid distributed in Indo-Pacific ocean periphery, including the Red Sea and the Arabian Sea, extending from Mozambique to the South China and the Philippines Sea, northward to Taiwan (Fig. 2a). The biology of *Loligo duvauceli* (Fig. 2b) was studied by Silas et al. (1986) [36] and Rao (1988) [12]. The report reveals that the males and females are found to be in equal proportion. It matures from the size ranges of 4 to 28 cm for males and 4 to 18 cm in females. Juveniles of squids are less than 4 cm in size. Females were dominant during January, March, May and December, whereas males were dominant in other months. The overall male to female ratio was 1: 1.3 [37]. The length- weight relationship and the morphometric character of the Loligo squid varies with geographical locations [38]. The seasonal growth, stock recruitment relationship, predictive yield and exploitation of *L. duvauceli* was studied by Sunilkumar (1997) [39], Mohamad (1997) [40] and Nirmala *et al*. (2003) [41]. The purpleback squid (*Sthenoteuthis oualaniensis* Lesson, 1830), is widely distributed in the equatorial and tropical waters of Indo-Pacific Ocean. It occupies throughout the tropical and temperature waters of both the northern and southern hemispheres [42, 43]. Siboa squid, *Doryteuthis sibogae* Adam, 1954 is a neritic species distribution from Indonasian waters and Formosan waters of Bay of Bengal upto the South-eastern Arabian sea [2]. It is forming a notable fishery along Thoothukudi (India) coast throughout the year with peak from June to November. It is a prolonged breeder as matured and almost round the year. Females attained maturity earlier than males [44].

were followed these days. Restrictions exist on the use of otter trawls, including minimum mesh sizes. This otter trawls are sometimes make contact with the seafloor, thus damage or alter the habitat and disturbs the marine ecosystem. Biodiversity conservation and management is essential for the future development of marine resources [69].

6. Squid Fishing Methods

In India, the squid fishes were catch by a common known method, Squid jigging [70]. Squids were attracted to artificial light and they aggregate close to the illuminated area. They are also easily attracted to fast moving bait or bait like object. Squid jigging operation take advantage of this behavior of squids [71]. Lines carrying jigs are vertically hawled through the congregation of squids. Squids get entangled in the jigs and fall on the deck when the jigs are inverted. The ommastrephid squid are almost exclusively caught using jigs armed with barbless hooks which are fished in series on lines using automatic machines [72]. The squid are attracted towards the jigs at night with incandescent, metal halide lamps suspended on cables above the deck of the vessel. Small coastal vessels may use a single lamp while the large industrial vessels operate with 150 or more lamps which are typically 2 kW each. The lamps mostly emit white light but small numbers of green lamps are often interspersed in the arrays [73]. Some industrial vessels will also operate one or two underwater lamps which are raised through the water column, and dimmed, as the squids were attracted towards the vessel. Jiggers typically deploy a large parachute drogue to prevent drifting downwind while fishing, thus enabling the jig lines to operate close to the vertical. The major fisheries for loliginids mostly use trawls which operate during daytime when the squids were concentrated near the seabed. Conventional otter trawls fish on the bottom but over rough ground pelagic trawls may be fished just off the seabed to avoid fouling the gear. Trawls designed for squid fishing generally have a higher head rope than would be usual for finfish. Outside the major fisheries a wide variety of gear including jigs, traps, nets etc. are used to catch loliginid squid [74, 75]. While comparing the oceanic squid fishing method's efficiency, gillnet catch rates were relatively higher, followed by mechanized jigging in larger vessel. Dermal resources of Fishery Survey of India (FSI) revealed the existence of potential grounds for cephalopod all along the India Coast. Squid jigging method was introduced by FSI for the exploration of the squid resources. Matsya Sugundhi is the vessel name of squid jigging used since from the end of 1980s. The vessel Matsya Sugundhi conducted jigging for neritic squids between lat 8N and 17N in the depth range 25-200 m and for the oceanic squids between lat. 10N–14N in area beyond 500 m depth. Based on the Fishery Survey of India, the fish catch was about 96213 kg using 823 hauls.

7. Methods of Exploitation of squid

Various investigations on cephalopod biology centre on the commercially exploited species such as the Palk Bay squid, *Sepioteuthis lessoniana* [76], *L. duvauceil* [2, 15, 77, 79], *Sepia pharaonis, S. aculeata, Sepiella inermis* [79] and *Octopus dollfusi* [80]. Although, about 40 per cent of the world's cephalopod catches are taken by squid jigging and 25 per cent by trawling, in India, cephalopods are principally caught by bottom trawlers operating upto 200 m depth zones. Among the Cephalopods, 48% squids and 44% cuttlefish were catch during the year 2011 (Fig. 3). While, most of the catch is brought to us by-catch from the shrimp and fish trawls employed by the trawlers. There is a targeted fishery for cuttlefishes during the post monsoon period of September - December using off bottom high opening trawls along the southwest and northwest coast. Prior to the seventies traditional gears like shore seines, boat seines, hooks and lines and spearing were the principal gear employed to capture cephalopods. Experimental squid jigging has been tried with Japanese expertise along the west coast by GOI vessels with considerable success [81]. Current cephalopod fishing effort is above optimum precautionary targets for several regions [82, 83]. Mesh size regulations and vessel restrictions are the only major protections employed for fishery stocks. In recent years, trawl licenses have been withheld and gear conversions have been encouraged to help rationalize the trawl fleet.

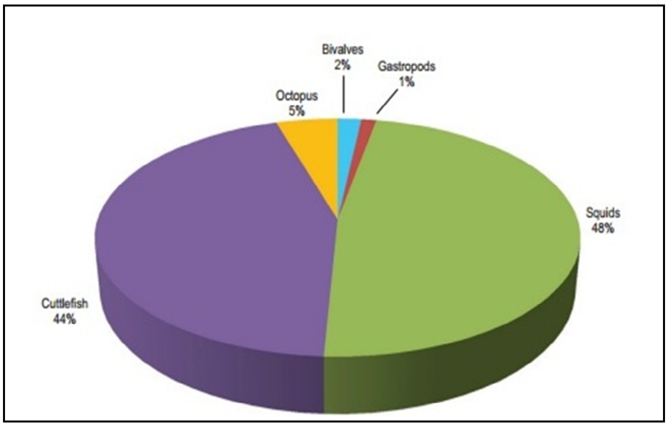

Fig 3: Molluscus fish landings in India during 2011-2012 (CMFRI Annual report)

8. Region wise exploitation of Squid Catch

Squid catches have increased substantially worldwide and this has highlighted the fact that their populations are highly variable. In India, from January to March and October to December was the most productive period of squid species. Along the upper east and west coast the above mentioned months was the most productive, while in southern region such as Karnataka, Kerala, Tamil Nadu and Andhra Pradesh equal productivity was evaluated in July to September. Region-wise and resource-wise estimates of marine fish

New trends were rising in the recent years all over the world for processing of squid. It can be processed in canned, dried and smoked forms. In India, freezing is the predominant method for the adopted for export. The major frozen items in the case of loliginida are squid whole, whole cleaned, tubes, rings, fillet, tentacles, peeled whole, stuffed and wings tray packed. Among the 44 varieties, the frozen squid whole and frozen squid whole cleaned contributed more than 60 per cent to the exports. In spite of upsurge in the demand for ready-to-eat and ready-to-cook products in international and domestic markets, our export of value-added squid product such as frozen squid rings breaded and frozen squid stuffed is less than a percent.

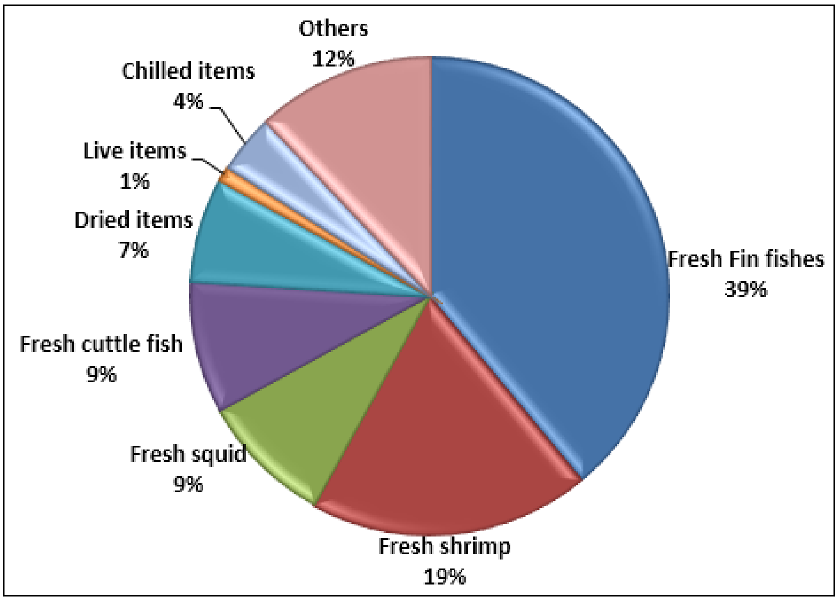

Fig 5: Major seafood items exported during the year 2009-2010 (Data from MPEDA records)

Table 2: Squid products exported from India to various countries

Items exported	Origin	Market
Fillet	Tuticorin	Japan
Wings	Tuticorin	Japan
Whole (Cleaned)	Kollam and Veraval	USA & European Union
Whole	Kollam and Mangalore	Spain & UAE
Whole (Cleaned)	Mumbai	Italy
Rings blanched IQF	Kochi	Italy & France
Tentacles blanched IQF	Kochi	Italy

10. Conclusion

India's coastal marine fisheries are open access. An inter-ministerial empowered committee looks after management and development of fisheries in the EEZ. Management varies by state and includes some seasonal or area closures and gear restrictions for trawls. In India, the fisheries research is coordinated by the Indian Council of Agricultural Research (ICAR), an autonomous organization under the Ministry of Agriculture, the Agricultural Universities, and institutes under the Ministry of Agriculture (FAO India profile, 2012). The conflict between the resources used by humans and the marine concertion is ubiquitous and increasing throughout the world. Ecosystem based management is not in practice, but there is a high emphasis by management on conservation and protecting marine biodiversity. Global estimates of consumption of squid as well as other cephalopods by higher predators have projected that they far exceed global or regional catches by the commercial fisheries; although, due to variability in cephalopod populations, this estimate must be taken with caution (FAO, 2005) [84]. As a result, squid fisheries are urged to proceed following precautionary principles in fishery. The ecological impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems. Squids are dioecious, with a life expectancy generally ranging from a few months to 1-2 years, usually ending in a single terminal spawning event. However, the physiology and ecology of most squid species is still poorly understood. Internationally, squid fisheries have increased dramatically over the last 25 years. As demand for marine resources increases, squid can provide a high protein alternative to fish stocks, particularly in those regions where other fish stocks may have become reduced by overfishing [85]. Commercial squid fishing operations are maintained by several countries in coastal waters worldwide. Biodiversity monitoring surveys are needed to assess and track fisheries impacts; some area and seasonal closures are in place to aid in biodiversity conservation for economically valuable living resources.

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Cephalopod: Squid Biology, Ecology and Fisheries in Indian waters

Anusha J.R., Albin T. Fleming

ABSTRACT
This short review summarizes the current status of the squid fisheries in Indian waters. It primarily considers the historical classification and biological characteristics of squid within the context to Indian squid varieties. Squid is an economically important cephalopod in India represented mainly by *Loligo duvauceli, Sepioteuthis lessoniana,* and *Doryteuthis* species. Among the squids, the Indian squid (*Loligo duvauceli*) is the dominant species, catching about 97% all over the country per year. The squid fish plays a major role in balancing the marine ecosystem. Generally, the temperature changes, ocean acidification and climatic changes are likely to affect marine ecosystems and their associated fisheries, adding to the challenges of managing fisheries sustainably. The proposed changes responded quickly in the squids and act as ecosystem indicators of environmental change by minimum growth rate and maximum production. Since, the increase in ocean temperatures can cause faster growth and shorter life spans of squid. In addition, briefly reviews the methods of exploitation of squid along with the current squid populations, fishing methods, export, utilization and marketing. India's squid fishing fleet accounted for 3% of the global squid production and makes up approximately 5–7% of U.S. squid imports. The processed squid meat has been exported in global level from the maritime states to Japan, US, EU, UAE, Italy and France through the major ports such as Kochi, Kollam, Tuticorin, Mumbai and Visakhapatnam. A brief analysis of the current status of the Indian squid fisheries and considers the potential for future development are provided in conclusion.

Keywords: Cephalopod, Squid, Ecosystem, Fisheries, Global Utilization.

1. Introduction

India is one of the major fish producing country in the world which holds second and third position in aquaculture and fisheries. Indian fisheries sector has high potentials for domestic nutritional security, employment generation, rural development, gender mainstreaming as well as export earnings. This sector has been witnessing a steady growth since First Five Year Plan. Indian fisheries contribute overall production of 4.39% to that of the global output. After declaration of the Exclusive Economic Zone (EEZ) in 1977, the oceanic resources available to India are estimated at 2.02 million sq. km, comprising 0.86 million sq. km (42.6% of the total) on the west coast, 0.56 million sq. km (27.7%) on the east coast and 0.60 million sq. km (29.7%) around the Andaman and Nicobar Islands (Fig. 1). These resources are one of the main sources of livelihood for the rural people around the coastal region. Considering the output of the sector, it can provide livelihood for over 90 lakhs at subsistence level of annual income. It was estimated that 14 million people are engaged in fishing, aquaculture and ancillary activities currently. Hence, the fisheries sector of India is an important player in the overall socio-economic development. After 1947, it came into focus as blue revolution to promote fisheries production in order to ensure food security and social as well as economic development of fishers through subsidization of various assets. By generating income and employment for local people along the coasts, the marine fishery sector significantly develop the economy of the country. Most of the marine ecosystem concern to India is in coastal ecosystem. The modern research on marine biodiversity is established in most of the region in the country acts for saving the marine resources. The exploitation of marine fisheries resources in India has increased due to development in fishing gear. The invertebrates are the highly developed group and occupy a leading place among the exploited marine fishery resource of India. Cephalopods, which have gained great grandness in recent years due to the increasing, demand in the export trade.

contributed on cephalopod resources, biology, population dynamics and information on specific aspects of cephalopod stocks in last few decades [11, 12, 13, 14, 15].

3. Classification and Biology of Squid

The classification of recent taxa of the molluscan Class, Cephalopoda [16] includes the squids which come under the Order Teuthoidea, which are further distinguished based on their eyes. If the eyes are covered by a transparent cornea which comes under the Suborder Myopsida or exposed were placed in another suborder Oegopsida. The two families of squid, the Ommastrephidae and the Loliginidae, are extensively exploited. The loliginids are distinguished by a membrane covering the eye, which in Ommastrephids is slit exposing the lens to the sea. Loliginid squid, occur sporadically which are coastal and can only support local fisheries, they yield a higher quality meat than the Ommastrephids. The family Loliginidae includes many species that are important in trophic systems, fisheries, environmental and biomedical studies.

The squids, in common with the other coleoid cephalopods, are semelparous and generally shortlived [17]. Most commercially exploited species exist a short life span of approximately one year at the end of which there is a single spawning event followed by death. The coleoids evolved from their molluscan ancestors through the process of progenesis [18]. The juvenile of coleoids characteristics with full sexual maturity are features of their physiological energetic [19]. The short life span and semelparous lifestyle of the squid and other coleoid cephalopods distinguishes the fish species that are exploited commercially [20]. These characteristics have particular problems for the management of the fisheries, the spawners of one generation have reproduced and died, it is almost impossible to assess the potential recruitment strength and stock size of the next generation. Hence, recommended that squid and other cephalopod fisheries should be managed by effort limitation and assessed in real-time [21, 22].

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Among the squids, the Indian squid (*Loligo duvauceli* Orbigny, 1848) is the dominant species, catching about 97% from Indian waters. The most common Indian squid distributed in Indo-Pacific ocean periphery, including the Red Sea and the Arabian Sea, extending from Mozambique to the South China and the Philippines Sea, northward to Taiwan (Fig. 2a). The biology of *Loligo duvauceli* (Fig. 2b) was studied by Silas et al. (1986) [36] and Rao (1988) [12]. The report reveals that the males and females are found to be in equal proportion. It matures from the size ranges of 4 to 28 cm for males and 4 to 18 cm in females. Juveniles of squids are less than 4 cm in size. Females were dominant during January, March, May and December, whereas males were dominant in other months. The overall male to female ratio was 1: 1.3 [37]. The length- weight relationship and the morphometric character of the Loligo squid varies with geographical locations [38]. The seasonal growth, stock recruitment relationship, predictive yield and exploitation of *L. duvauceli* was studied by Sunilkumar (1997) [39], Mohamad (1997) [40] and Nirmala *et al*. (2003) [41]. The purpleback squid (*Sthenoteuthis oualaniensis* Lesson, 1830), is widely distributed in the equatorial and tropical waters of Indo-Pacific Ocean. It occupies throughout the tropical and temperature waters of both the northern and southern hemispheres [42, 43]. Siboa squid, *Doryteuthis sibogae* Adam, 1954 is a neritic species distribution from Indonasian waters and Formosan waters of Bay of Bengal upto the South-eastern Arabian sea [2]. It is forming a notable fishery along Thoothukudi (India) coast throughout the year with peak from June to November. It is a prolonged breeder as matured and almost round the year. Females attained maturity earlier than males [44].

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In India, the squid fishes were catch by a common known method, Squid jigging [70]. Squids were attracted to artificial light and they aggregate close to the illuminated area. They are also easily attracted to fast moving bait or bait like object. Squid jigging operation take advantage of this behavior of squids [71]. Lines carrying jigs are vertically hawled through the congregation of squids. Squids get entangled in the jigs and fall on the deck when the jigs are inverted. The ommastrephid squid are almost exclusively caught using jigs armed with barbless hooks which are fished in series on lines using automatic machines [72]. The squid are attracted towards the jigs at night with incandescent, metal halide lamps suspended on cables above the deck of the vessel. Small coastal vessels may use a single lamp while the large industrial vessels operate with 150 or more lamps which are typically 2 kW each. The lamps mostly emit white light but small numbers of green lamps are often interspersed in the arrays [73]. Some industrial vessels will also operate one or two underwater lamps which are raised through the water column, and dimmed, as the squids were attracted towards the vessel. Jiggers typically deploy a large parachute drogue to prevent drifting downwind while fishing, thus enabling the jig lines to operate close to the vertical. The major fisheries for loliginids mostly use trawls which operate during daytime when the squids were concentrated near the seabed. Conventional otter trawls fish on the bottom but over rough ground pelagic trawls may be fished just off the seabed to avoid fouling the gear. Trawls designed for squid fishing generally have a higher head rope than would be usual for finfish. Outside the major fisheries a wide variety of gear including jigs, traps, nets etc. are used to catch loliginid squid [74, 75]. While comparing the oceanic squid fishing method's efficiency, gillnet catch rates were relatively higher, followed by mechanized jigging in larger vessel. Dermal resources of Fishery Survey of India (FSI) revealed the existence of potential grounds for cephalopod all along the India Coast. Squid jigging method was introduced by FSI for the exploration of the squid resources. Matsya Sugundhi is the vessel name of squid jigging used since from the end of 1980s. The vessel Matsya Sugundhi conducted jigging for neritic squids between lat 8N and 17N in the depth range 25-200 m and for the oceanic squids between lat. 10N–14N in area beyond 500 m depth. Based on the Fishery Survey of India, the fish catch was about 96213 kg using 823 hauls.

7. Methods of Exploitation of squid

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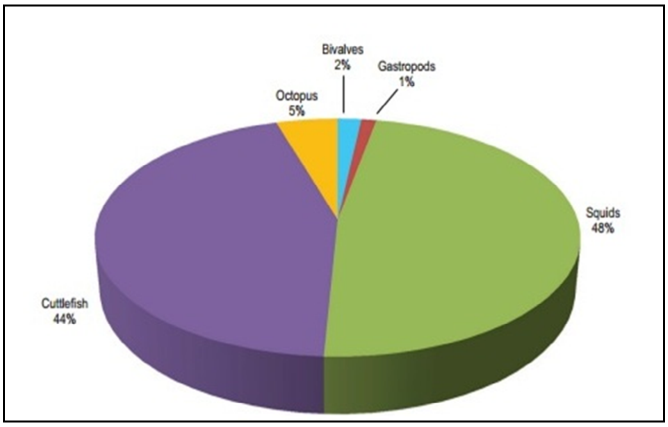

Fig 3: Molluscus fish landings in India during 2011-2012 (CMFRI Annual report)

8. Region wise exploitation of Squid Catch

Squid catches have increased substantially worldwide and this has highlighted the fact that their populations are highly variable. In India, from January to March and October to December was the most productive period of squid species. Along the upper east and west coast the above mentioned months was the most productive, while in southern region such as Karnataka, Kerala, Tamil Nadu and Andhra Pradesh equal productivity was evaluated in July to September. Region-wise and resource-wise estimates of marine fish

New trends were rising in the recent years all over the world for processing of squid. It can be processed in canned, dried and smoked forms. In India, freezing is the predominant method for the adopted for export. The major frozen items in the case of loliginida are squid whole, whole cleaned, tubes, rings, fillet, tentacles, peeled whole, stuffed and wings tray packed. Among the 44 varieties, the frozen squid whole and frozen squid whole cleaned contributed more than 60 per cent to the exports. In spite of upsurge in the demand for ready-to-eat and ready-to-cook products in international and domestic markets, our export of value-added squid product such as frozen squid rings breaded and frozen squid stuffed is less than a percent.

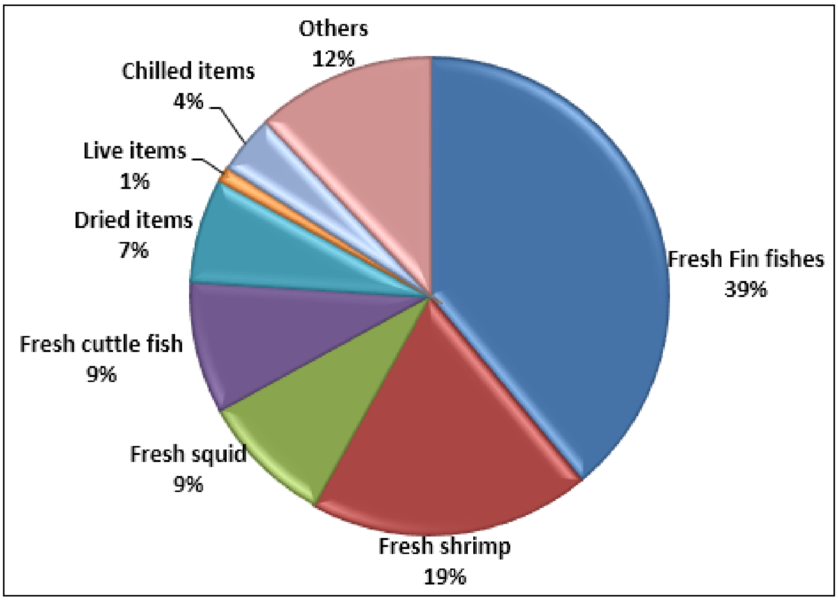

Fig 5: Major seafood items exported during the year 2009-2010 (Data from MPEDA records)

Table 2: Squid products exported from India to various countries

Items exported	Origin	Market
Fillet	Tuticorin	Japan
Wings	Tuticorin	Japan
Whole (Cleaned)	Kollam and Veraval	USA & European Union
Whole	Kollam and Mangalore	Spain & UAE
Whole (Cleaned)	Mumbai	Italy
Rings blanched IQF	Kochi	Italy & France
Tentacles blanched IQF	Kochi	Italy

10. Conclusion

India's coastal marine fisheries are open access. An inter-ministerial empowered committee looks after management and development of fisheries in the EEZ. Management varies by state and includes some seasonal or area closures and gear restrictions for trawls. In India, the fisheries research is coordinated by the Indian Council of Agricultural Research (ICAR), an autonomous organization under the Ministry of Agriculture, the Agricultural Universities, and institutes under the Ministry of Agriculture (FAO India profile, 2012). The conflict between the resources used by humans and the marine concertion is ubiquitous and increasing throughout the world. Ecosystem based management is not in practice, but there is a high emphasis by management on conservation and protecting marine biodiversity. Global estimates of consumption of squid as well as other cephalopods by higher predators have projected that they far exceed global or regional catches by the commercial fisheries; although, due to variability in cephalopod populations, this estimate must be taken with caution (FAO, 2005) [84]. As a result, squid fisheries are urged to proceed following precautionary principles in fishery. The ecological impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems. Squids are dioecious, with a life expectancy generally ranging from a few months to 1-2 years, usually ending in a single terminal spawning event. However, the physiology and ecology of most squid species is still poorly understood. Internationally, squid fisheries have increased dramatically over the last 25 years. As demand for marine resources increases, squid can provide a high protein alternative to fish stocks, particularly in those regions where other fish stocks may have become reduced by overfishing [85]. Commercial squid fishing operations are maintained by several countries in coastal waters worldwide. Biodiversity monitoring surveys are needed to assess and track fisheries impacts; some area and seasonal closures are in place to aid in biodiversity conservation for economically valuable living resources.

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Cephalopod: Squid Biology, Ecology and Fisheries in Indian waters

Anusha J.R., Albin T. Fleming

ABSTRACT
This short review summarizes the current status of the squid fisheries in Indian waters. It primarily considers the historical classification and biological characteristics of squid within the context to Indian squid varieties. Squid is an economically important cephalopod in India represented mainly by *Loligo duvauceli, Sepioteuthis lessoniana,* and *Doryteuthis* species. Among the squids, the Indian squid (*Loligo duvauceli*) is the dominant species, catching about 97% all over the country per year. The squid fish plays a major role in balancing the marine ecosystem. Generally, the temperature changes, ocean acidification and climatic changes are likely to affect marine ecosystems and their associated fisheries, adding to the challenges of managing fisheries sustainably. The proposed changes responded quickly in the squids and act as ecosystem indicators of environmental change by minimum growth rate and maximum production. Since, the increase in ocean temperatures can cause faster growth and shorter life spans of squid. In addition, briefly reviews the methods of exploitation of squid along with the current squid populations, fishing methods, export, utilization and marketing. India's squid fishing fleet accounted for 3% of the global squid production and makes up approximately 5–7% of U.S. squid imports. The processed squid meat has been exported in global level from the maritime states to Japan, US, EU, UAE, Italy and France through the major ports such as Kochi, Kollam, Tuticorin, Mumbai and Visakhapatnam. A brief analysis of the current status of the Indian squid fisheries and considers the potential for future development are provided in conclusion.

Keywords: Cephalopod, Squid, Ecosystem, Fisheries, Global Utilization.

1. Introduction

India is one of the major fish producing country in the world which holds second and third position in aquaculture and fisheries. Indian fisheries sector has high potentials for domestic nutritional security, employment generation, rural development, gender mainstreaming as well as export earnings. This sector has been witnessing a steady growth since First Five Year Plan. Indian fisheries contribute overall production of 4.39% to that of the global output. After declaration of the Exclusive Economic Zone (EEZ) in 1977, the oceanic resources available to India are estimated at 2.02 million sq. km, comprising 0.86 million sq. km (42.6% of the total) on the west coast, 0.56 million sq. km (27.7%) on the east coast and 0.60 million sq. km (29.7%) around the Andaman and Nicobar Islands (Fig. 1). These resources are one of the main sources of livelihood for the rural people around the coastal region. Considering the output of the sector, it can provide livelihood for over 90 lakhs at subsistence level of annual income. It was estimated that 14 million people are engaged in fishing, aquaculture and ancillary activities currently. Hence, the fisheries sector of India is an important player in the overall socio-economic development. After 1947, it came into focus as blue revolution to promote fisheries production in order to ensure food security and social as well as economic development of fishers through subsidization of various assets. By generating income and employment for local people along the coasts, the marine fishery sector significantly develop the economy of the country. Most of the marine ecosystem concern to India is in coastal ecosystem. The modern research on marine biodiversity is established in most of the region in the country acts for saving the marine resources. The exploitation of marine fisheries resources in India has increased due to development in fishing gear. The invertebrates are the highly developed group and occupy a leading place among the exploited marine fishery resource of India. Cephalopods, which have gained great grandness in recent years due to the increasing, demand in the export trade.

contributed on cephalopod resources, biology, population dynamics and information on specific aspects of cephalopod stocks in last few decades [11, 12, 13, 14, 15].

3. Classification and Biology of Squid

The classification of recent taxa of the molluscan Class, Cephalopoda [16] includes the squids which come under the Order Teuthoidea, which are further distinguished based on their eyes. If the eyes are covered by a transparent cornea which comes under the Suborder Myopsida or exposed were placed in another suborder Oegopsida. The two families of squid, the Ommastrephidae and the Loliginidae, are extensively exploited. The loliginids are distinguished by a membrane covering the eye, which in Ommastrephids is slit exposing the lens to the sea. Loliginid squid, occur sporadically which are coastal and can only support local fisheries, they yield a higher quality meat than the Ommastrephids. The family Loliginidae includes many species that are important in trophic systems, fisheries, environmental and biomedical studies.

The squids, in common with the other coleoid cephalopods, are semelparous and generally shortlived [17]. Most commercially exploited species exist a short life span of approximately one year at the end of which there is a single spawning event followed by death. The coleoids evolved from their molluscan ancestors through the process of progenesis [18]. The juvenile of coleoids characteristics with full sexual maturity are features of their physiological energetic [19]. The short life span and semelparous lifestyle of the squid and other coleoid cephalopods distinguishes the fish species that are exploited commercially [20]. These characteristics have particular problems for the management of the fisheries, the spawners of one generation have reproduced and died, it is almost impossible to assess the potential recruitment strength and stock size of the next generation. Hence, recommended that squid and other cephalopod fisheries should be managed by effort limitation and assessed in real-time [21, 22].

The squid and cuttle fish together are commonly known as decapods; the members of both orders have ten suckered appendages to the head. These consist of arms and one pair of tentacles, which are often more than twice the length of the arms [23]. The size of the squid ranges from 6 to 28 cm mantle length. It is characterized by a relatively short, stout mantle. Fins are rhombic, broad, short, just over 50% of mantle length. Tentacular clubs expanded forming large median manual suckers eleven times larger than marginals, with 14 to 17 short, sharp teeth around ring. Arm suckers of female of about equal size on second and third arms, rings smooth proximally, toothed with about 7 broad, blunt teeth distally but male has 9 to 11 broad tooth. It is squared to round, truncate teeth in the distal two or three of ring with rows of large papillae, some with minute suckers on tip; ventral rows larger, turned outward, comb-like; an oval photophore on each side of rectum and ink sac and a chitionus internal shell known as the 'pen or gladius' embedded under the mantle, mid- dorsally. This species feeds on fishes and squids. Squid are often highly fecund with more than 0.5 million egg [24, 25, 26]. The potential fecundity of the giant form of squid ranged between 2 million and 5 million eggs and the holding capacity of the oviducts was approximately 300,000 eggs [27]. Indirect evidences suggested that *S. oualaniensis* might be a multiple spawner [28, 29]. Kore and Joshi (1975) [15] also observed that there was a decreased feeding activity during the spawning period. Squid have been reported to change their feeding habitat with growth in size. Cannabalism increased among the largest animals. Planktonic feeding was dominant in the smallest squid, whereas larger squid are Euphausiid feeding [30]. Size (DML) of *L. duvauceli, S. pharaonis S. aculeata and C. indicus* were 20-309 mm, 70-299 mm, 40-129 mm and 30-199 mm respectively. Fecundity of *L. duvauceli* ranged between 740-14,924 eggs. The feeding strategy of squid is entirely different from other fishes. They use their tentacles and oral arms for prey capture. The toxic saliva termed 'cephalotoxin' cause paralyzing and respiratory distress sometimes even kill their prey. The squids are adept in their ability with fast growth, short life span and semelparity [31]. They have versatile character to capture, subdue and consume a wide variety of prey and they feed voraciously to maintain the active associated lifestyle [32]. In case of squid, the gladius is quite variable within and among the species and formally used to distinguish the genus, it's only important at specific level [33]. The gladius could be highly adaptive in response to differences in swimming behavior. The generic systematizes of the Loliginidae include spermatophore deposition site, presence of suckers on the buccal lappets, adult chromatophore patterns, and presence of a longitudinal mid-ventral ridge on the mantle may also varies in specific range of species [34]. The subsequent analyses of DNA sequences [35] have indicated that a holophyletic classification requires recognition of generic-level species groups defined primarily on distributional characteristics, towards consensus on the genera of this family.

Among the squids, the Indian squid (*Loligo duvauceli* Orbigny, 1848) is the dominant species, catching about 97% from Indian waters. The most common Indian squid distributed in Indo-Pacific ocean periphery, including the Red Sea and the Arabian Sea, extending from Mozambique to the South China and the Philippines Sea, northward to Taiwan (Fig. 2a). The biology of *Loligo duvauceli* (Fig. 2b) was studied by Silas et al. (1986) [36] and Rao (1988) [12]. The report reveals that the males and females are found to be in equal proportion. It matures from the size ranges of 4 to 28 cm for males and 4 to 18 cm in females. Juveniles of squids are less than 4 cm in size. Females were dominant during January, March, May and December, whereas males were dominant in other months. The overall male to female ratio was 1: 1.3 [37]. The length- weight relationship and the morphometric character of the Loligo squid varies with geographical locations [38]. The seasonal growth, stock recruitment relationship, predictive yield and exploitation of *L. duvauceli* was studied by Sunilkumar (1997) [39], Mohamad (1997) [40] and Nirmala *et al*. (2003) [41]. The purpleback squid (*Sthenoteuthis oualaniensis* Lesson, 1830), is widely distributed in the equatorial and tropical waters of Indo-Pacific Ocean. It occupies throughout the tropical and temperature waters of both the northern and southern hemispheres [42, 43]. Siboa squid, *Doryteuthis sibogae* Adam, 1954 is a neritic species distribution from Indonasian waters and Formosan waters of Bay of Bengal upto the South-eastern Arabian sea [2]. It is forming a notable fishery along Thoothukudi (India) coast throughout the year with peak from June to November. It is a prolonged breeder as matured and almost round the year. Females attained maturity earlier than males [44].

were followed these days. Restrictions exist on the use of otter trawls, including minimum mesh sizes. This otter trawls are sometimes make contact with the seafloor, thus damage or alter the habitat and disturbs the marine ecosystem. Biodiversity conservation and management is essential for the future development of marine resources [69].

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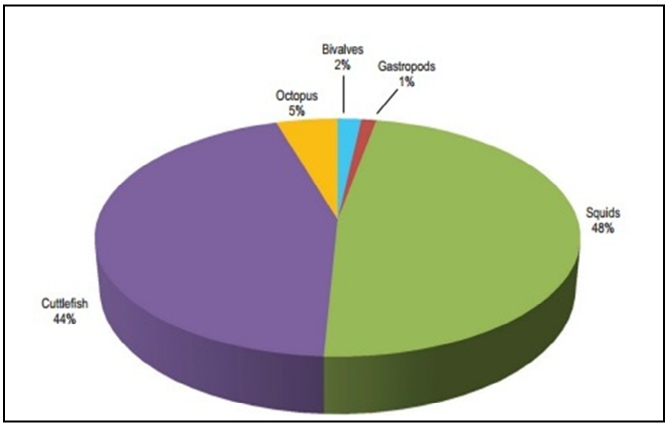

Fig 3: Molluscus fish landings in India during 2011-2012 (CMFRI Annual report)

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Squid catches have increased substantially worldwide and this has highlighted the fact that their populations are highly variable. In India, from January to March and October to December was the most productive period of squid species. Along the upper east and west coast the above mentioned months was the most productive, while in southern region such as Karnataka, Kerala, Tamil Nadu and Andhra Pradesh equal productivity was evaluated in July to September. Region-wise and resource-wise estimates of marine fish

New trends were rising in the recent years all over the world for processing of squid. It can be processed in canned, dried and smoked forms. In India, freezing is the predominant method for the adopted for export. The major frozen items in the case of loliginida are squid whole, whole cleaned, tubes, rings, fillet, tentacles, peeled whole, stuffed and wings tray packed. Among the 44 varieties, the frozen squid whole and frozen squid whole cleaned contributed more than 60 per cent to the exports. In spite of upsurge in the demand for ready-to-eat and ready-to-cook products in international and domestic markets, our export of value-added squid product such as frozen squid rings breaded and frozen squid stuffed is less than a percent.

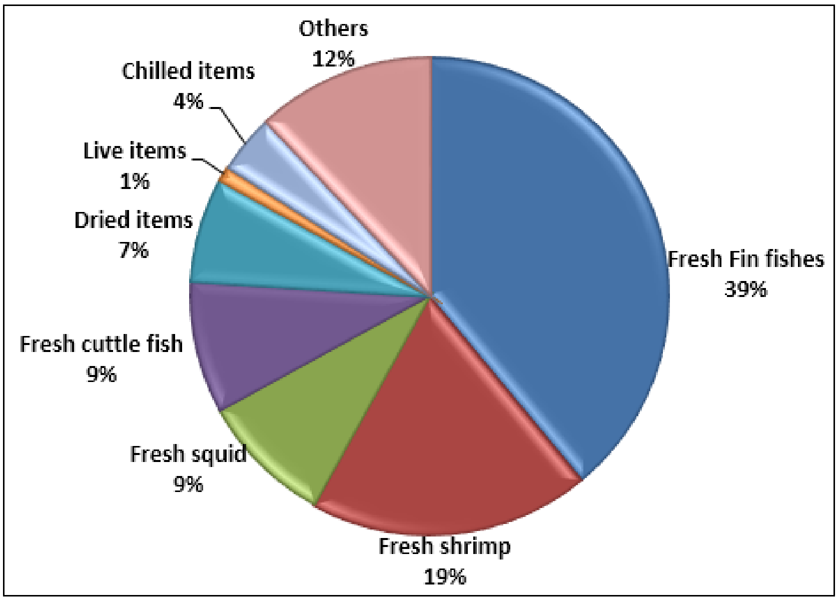

Fig 5: Major seafood items exported during the year 2009-2010 (Data from MPEDA records)

Table 2: Squid products exported from India to various countries

Items exported	Origin	Market
Fillet	Tuticorin	Japan
Wings	Tuticorin	Japan
Whole (Cleaned)	Kollam and Veraval	USA & European Union
Whole	Kollam and Mangalore	Spain & UAE
Whole (Cleaned)	Mumbai	Italy
Rings blanched IQF	Kochi	Italy & France
Tentacles blanched IQF	Kochi	Italy

10. Conclusion

India's coastal marine fisheries are open access. An inter-ministerial empowered committee looks after management and development of fisheries in the EEZ. Management varies by state and includes some seasonal or area closures and gear restrictions for trawls. In India, the fisheries research is coordinated by the Indian Council of Agricultural Research (ICAR), an autonomous organization under the Ministry of Agriculture, the Agricultural Universities, and institutes under the Ministry of Agriculture (FAO India profile, 2012). The conflict between the resources used by humans and the marine concertion is ubiquitous and increasing throughout the world. Ecosystem based management is not in practice, but there is a high emphasis by management on conservation and protecting marine biodiversity. Global estimates of consumption of squid as well as other cephalopods by higher predators have projected that they far exceed global or regional catches by the commercial fisheries; although, due to variability in cephalopod populations, this estimate must be taken with caution (FAO, 2005) [84]. As a result, squid fisheries are urged to proceed following precautionary principles in fishery. The ecological impacts of removing squid from the coastal systems are not known, however, squid are known to serve both as influential predators and critical prey for shelf ecosystems. Squids are dioecious, with a life expectancy generally ranging from a few months to 1-2 years, usually ending in a single terminal spawning event. However, the physiology and ecology of most squid species is still poorly understood. Internationally, squid fisheries have increased dramatically over the last 25 years. As demand for marine resources increases, squid can provide a high protein alternative to fish stocks, particularly in those regions where other fish stocks may have become reduced by overfishing [85]. Commercial squid fishing operations are maintained by several countries in coastal waters worldwide. Biodiversity monitoring surveys are needed to assess and track fisheries impacts; some area and seasonal closures are in place to aid in biodiversity conservation for economically valuable living resources.

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