2. REVIEW OF LITERATURE

Successful utilization of marine resources depends on the exact information of their occurrence, relative abundance and distribution and also the influence of environmental characteristics in a particular place. The novel dimensions added to marine research e.g., the use of remote sensing facilities, GIS, seasats, manned submersibles and others have significantly enhanced the quality of marine studies.

Estuaries are defined as semi-enclosed bodies of water, situated at the interface between land and ocean, where seawater is measurably diluted by the inflow of freshwater (Hobbie, 2000). The term “estuary,” derived from the Latin word *aestuarium*, means marsh or channel (Merriam-Webster, 1979). Based on salinity estuaries are defined as semi-enclosed coastal bodies of water that have a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage (Pritchard, 1967).

Estuaries have been aptly referred to as the “doorways between Oceans and land masses”. It has also been recognized that such regions which are more or less inorganic connection with the Sea from an integral part of the overall marine environment (Tampi, 1968).

Importance of estuaries is well documented in many parts of the world as breeding and nursery grounds for a wide variety of fishes,
crabs and prawns. Even though estuaries provide a uneven environmental conditions due to changes in salinity, most of the fish species have establish them to be extremely advantageous areas in which to spawn, develop, and grow during early stages of life; productivity tends to be high. Estuarine environments are among the highly productive on earth, producing more organic matter each year than comparably-sized areas of forest, grassland or agricultural land and also have significant commercial value with providing economic benefits for tourism, fisheries and recreational activities (Hossain et al., 2012). The protected coastal waters of estuaries also support important public infrastructure, serving as harbors and ports for shipping and transportation.

Tropical estuaries with microhabitats like mangroves, mud flats, marshes, reed swamps, shell beds, etc. and varied salinity conditions are good places for fishery potentials (Breine et al., 2011). These supporting ecosystems serve as potential nursery grounds because of their richness in productivity, providing shelter and conduciveness of physico-chemical characteristics etc., Most of the marine fishes uses estuarine and mangrove environment as nursery and feeding ground for their young once and sub-adults. The root entanglement of mangroves protects the fishes from predation and fishing by humans (Dando, 1984).
Most of the marine organisms have complex life histories that include divergent stages that depend on different marine habitats (Leis et al., 1996). The majority of marine fishes spawn 10,000 eggs to 1,000,000 tiny eggs (less than 1 mm) which hatch into larvae that drift in ocean currents for 1 week to several months. For some species these nursery habitats are the same habitats as their adults, but for most of the species nursery habitats are different (Jones et al., 1999 and Leis et al., 1996). Nursery grounds are usually found near the shore (shallow water) and may be estuaries, sea grass, mud flats and mangroves (Munro et al., 1973).

Ichthyoplanktonology as a part of discipline in ichthyology concerns pelagic early life stages of fishes including eggs, larvae and partly juvenile stages (Yuksek and Gucu, 1994). The data about the early stages of fishes are informative on the ichthyology, fisheries oceanography, aquaculture and ecology in some respects such as the researching of fish communities, identifying of spawning season and ground, estimating of stock biomass, examining of recruitment (Reay, 1984; Palomera and Perttierra, 1993; Begg, 2005 and Govoni, 2005). Thus, the importance of the ichthyoplankton surveys results from the fact that they can provide mentioned data faster, cheaper and reliable. Research into the distribution and abundance of ichthyoplankton is likely to improve our understanding of the interrelationships between fish species during their early life stages, as well as an understanding
of adult spawning patterns (Nonaka et al., 2000). Changes in the patterns of distribution and abundance of larvae reflect changes in both the distributional range of the adult fish and features of their reproductive strategies such as timing; location of spawning (Doyle et al., 1993). The relationship between spatial and temporal distribution of ichthyoplankton in relation to geographical and oceanographic conditions is important from ecological and economic perspectives (Itziar Alvarez et al., 2015).

Fish eggs and larvae are most of the commercially important species of the temperate seas. The only exception is the work of Delsman (1922-1938) who elucidated the early life histories of a number of fishes from Java Sea. The above work remains a standard one of reference even today. Following this, many publications have emanated from India, adding to the knowledge on finfish eggs, larvae and juveniles of many species in estuarine and marine species.

Contributions on the subject relating to the early developmental stages of marine fishes are meager. The erstwhile of Madras Presidency Fisheries Department pioneered the study on development of marine fishes of India (Hornell, 1910; Hornell and Nayudu, 1923). Later, several publications to the knowledge of eggs and larvae of different commercial fishes and breeding biology were made by the Department which gave several contributions on these aspects (John, 1939; Chidamabaram and Venkatraman, 1946; Chacko, 1950).
Chacko (1950) gave the salient features of the eggs and larvae of 16 species of fishes collected from the vicinity off Kurusadai Island, based on the observations of Delsman (1925-1938). It has been, however, noticed that there are some variations in the descriptions given by Chacko and by Delsman. Publications of Nair (1946; 1957), John (1951) and Bapat (1955) are very useful sources of information concerning the marine finfish eggs of India and their early developmental stages.

Vijayaraghavan (1957) have worked in details about the descriptions and the methods of collection, hatching of eggs rearing and feeding habits of the various species during their larval, juvenile and adult stages of fishes collected from Madras Coast. Ravish Chandra (1964) and Kowtal (1967) have reported on the distribution and abundance of fish eggs and larvae in Hoogly and Chilka Lake, East coast of India. A very preliminary report on the density of fish eggs and larvae of the Indian Ocean in general has been analyzed by Peter (1967).

Published information on the eggs and early developmental stages of Indian half-beaks is rather very less. Vijayaraghavan (1957) made some observations on the eggs and young stages of *Hemiramphus far* collected from Madras coastal waters. Sudarsan (1966) reported a bunch of eggs attached to seaweeds which were collected from the beach at Mandapam (Gulf of Mannar). The eggs
were hatched in the laboratory and the larval development was followed for a few days. On the basis of the characters observed, the eggs and larvae are provisionally assigned to the Hemiramphid fish *Hyporamphus quoyi*.

Venkataramanujam (1975) described the eggs, larvae, post-larvae and juveniles of about forty species of marine and estuarine fishes belonging to 36 families and including life history and larval development of fishes collected from Portonovo coastal waters. Similar studies of Venkataramanujam and Ramamoorthi (1974) have dealt with seasonal abundance and distribution of fish eggs and larvae collected from the same localities. This seasonal observation was of first time in Indian waters.

Krishnamurthy and Prince Jayaseelan (1981) studied the early developmental stages of fishes from Pichavaram Mangrove forest with special reference to the physico-chemical characteristics and the collected fish species were 79 belonging to 34 families and 56 genera. Bensam, (1984) analyzed development and systematics of 25 species belonging to 16 and 13 families. Of these, 15 species have been dealt with for the first time and the other cases relate to early life history stages which are either not yet described following from Indian waters or from Porto Novo.

The fishes of the family Carangidae are one of the commercial importances constituting 3.1% of the total marine catches in India.
Thangaraja (1985) investigated eggs from Carangids collected from Vellar estuary. They were reared in the laboratory and identified as *Selaroides leptolepis*, *Carangoides malabaricus*, *Scomberioides tol*, *Decapterus russelli* and *Aлепes djeddaba*. The larvae were reared in laboratory observations for identification purposes.

The Vellar estuary in Porto-Novo abounds in early life stages of fishes. Bensam (1987) described and identified a few early developmental stages of *Polynemus sextardius*, *Sillago sihama*, *Gerres oblongus*, *Gerres settiferus*, *Terapon jarbua*, *Lates calcarifer* and *Siganus javus* from Vellar estuary. This study gives illustrations and brief descriptions of most of these stages of fishes and many of them were of the first time. Salient features of taxonomic value are mentioned along with comparison and contrast with similar stages of allied species described.

Siraimetan and Marichamy (1988) observed gross quantitative variations of fish eggs and larvae in planktons of the inshore waters with reference to environmental conditions and general inter-relationship of zooplankton organisms. Information on the meroplanktonic component of the estuarine and nearshore biotopes is very essential for aquaculture practices. Ayyakkannu (1989) pointed diel variations and relative abundance of larvae in Coleroon estuarine complex on the east coast with a view to assess the larval resources.
The influence of environmental parameters to the densities of larval forms were analyzed statistically and discussed.

Manickasundaram *et al.,* (1990) analyzed hydrographical parameters such as temperature, salinity, pH, rainfall and dissolved oxygen influencing fish eggs and larvae, their identification and their seasonal abundance patterns from Coleroon estuarine complex. Thangaraja (1995) studied distributional fluctuations of fish eggs and larvae collected in different zones of Vellar estuary during low tide and high tide, day and night and new-moon and full-moon periods. The influence of hydrographical parameters such as rainfall, atmospheric and surface water temperature and surface salinity on the availability of fish eggs was highly significant. A significant correlation in the distribution of eggs and larvae with season reiterates the well known fact of seasonal influence of organism.

Coral beds serve as nursery grounds for many young commercially important fishes and shrimps. Krishnamurthy and Subramanian (1999) investigated natural organization of meroplankton to understand the distribution, frequency of occurrence and species dominance along the Southeast coast of India. Chandrasekaran (2000) discussed the relationship between plankton and finfish and shell fish juveniles from Pichavaram mangrove waterways.
Sundaramanickam (2002) studied the distribution of finfish larvae in relation to hydrographical parameters in Parangipettai coast and adjacent waters. Rajasegar et al., (2005) reported the distribution and abundance of fish eggs and larvae in Arasalar estuary. The finfish eggs and larvae collected were identified. Environmental parameters such as temperature, salinity, pH and dissolved oxygen were also recorded.

Brinda and Bragadeeswaran (2005) studied the occurrence of some cultivable juvenile fishes in relation to the rainfall, surface water temperature, salinity, dissolved oxygen and pH of water in Vellar estuary. The influence of hydrographical parameters to the finfishes and its abundance was discussed.

An extensive work was carried out Sundaramanickam et al., (2007) about the impact of tsunami on the distribution, abundance and species composition of finfish eggs and larvae from Parangipettai coast, Southeast coast of India. Enamul Hoq and Nazhrul Islam (2007) documented the composition of fish population, as well as examined the effect of lunar cycle, seasonal and Physico-chemical parameters on the distribution and abundance of fish species in Sundarban Mangrove waters. Vital aspects the identifying the spawning grounds of sound producing marine fishes and the planktonic finfish eggs and larvae was studied at Parangipettai coastal waters (Veerappan et al., 2009).
Ichthyoplankton species distribution and abundance in the coastal waters of Kodiakkarai and Arukkatuthurai were documented by Azhagar et al., (2009). Brinda et al., (2010) observed the diversity of finfish juveniles in Vellar estuary. Species richness, species evenness and juvenile density influencing Physico-chemical characteristics such as water temperature, salinity, dissolved oxygen and pH were also studied. Arockiamary et al., (2011) surveyed different types of finfish eggs in Vellar estuary in relation to physio-chemical parameters. The seasonal variations and distribution of Engraulidae fish eggs collected in the same locality (Arockiamary et al., 2011).

Arunava Mukherjee et al., (2012) investigated the juvenile fish diversity in the mangrove dominated estuary whether; Sundarban mangrove habitat operates as nursery ground for juvenile fin fish species are worked on seasonal variations in density and species composition of juvenile fish communities in mangrove mudflats. Fish communities in the different habitats of mangroves were compared on the basis of species richness, abundance and variation of juvenile fish species. Balakrishnan et al., (2015) studied on the distribution, diversity and abundance of fish eggs and larvae from Coleroon estuary seasonally.

The first major account of the quantitative distribution of fish eggs and larvae of the Indian Ocean was given in the Planktonic atlas (IOBC, 1969) based on the zooplankton collections of the International
Indian Ocean Expedition (1970). The details of methodology and the procedure for the analysis and interpretation are followed by Lalithambika Devi et al., (1996) on spatial, seasonal and day and night variations of fish eggs and larvae of Andaman and Nicobar region collected during cruises of Sagar Sampada.

Occurrence of eel eggs in the Indian coastal waters has been recorded only on few occasions, probably owing to their relative abundance is meager. Bensam (1966) gave an account of the early developmental stages of Muraenid species, collected from Cannaore, South west coast of India. *Opisthopterus tardoore*, the long finned herring, is one of the commercially valuable Clupeiform fishes in the Indian waters. Bensam (1967) reared embryonic development and early larval stages were identified from Cannaore, Southwest coast of India.

In the late fifties and sixties, the erstwhile Indo-Norwegian Project, in collaboration with the Central Marine Fisheries Research Institute played a vital role in the survey of ichthyoplankton, off the Southwest coast of India, particularly in the Lakshadweep area (Silas, 1974). Flat fishes, though they form only a relatively small percentage of the total fish population, still occupy a significant position in the list of highly preferred food fishes. Balakrishnan and Lalithambikadevi (1974) has stated the occurrence of larvae of some flat fishes from Cochin backwaters. Lalithambikadevi (1993) studied the distribution
of larvae of flatfishes in the same area in relation to hydrographical conditions.

The most intensive and systematic effort in ichthyoplankton surveys in earlier times in Indian waters has been put in along the Southwest coast of India by the UNDP/FAO Pelagic Fishery Project, Cochin (Anon, 1974). Silas (1974) described in detail studies on different larval stages of Indian mackerel and mapped their distribution and abundance off the South West Coast of India and the Laccadives Sea, based on materials from cruises of R.V. Varuna in 1964. Rengarajan and David Raj (1979) investigated the composition of fish eggs and larvae, their quantitative abundance and seasonal fluctuations in relation to certain environmental factors in the Cochin backwaters and this information has created proper understanding of seed resources and their exploitation.

Exhaustive information is available on the fish eggs and larvae from the polluted and unpolluted environments off Bombay based on data obtained from a few stations as reported by Gajbhiye et al., (1982). Premalatha (1988) described the distribution and abundance of Carangid fish larvae from South West coast of India. George (1979) dealt with the distribution and abundance of fish eggs and larvae particularly the latter and the pelagic fisheries of the Southwest coast of India.
Lalithambikadevi (1999) reported 23 species belonging to 9 genera from the Indian Ocean, their regional, seasonal as well as diurnal variations. The biodiversity of 23 species in relation to environmental parameters such as temperature, salinity, dissolved oxygen and nutrients was reported by Lalithambikadevi (2000).

Ronald (2001) worked on distribution of the eggs and larvae of finfish and shellfish in the coastal waters of Dakshina Kannada and observed the seasonal variations of temperature, salinity and dissolved oxygen at the confluence of Nethravati-Gurupur estuary. Rajesh et al., (2015) analyzed seasonal abundance and composition of finfish and shellfish seeds in the mangroves of Gangoli estuary off west coast of India.

Though, many works are available on the abundance and distribution of finfish eggs and larvae in Indian waters. In east coast of India, Gulf of Mannar and Palk bay (Velappan Nair, 1952; Bapat, 1955) Madras coast (Vijayaraghavan, 1957); Orissa coast (Jones and Pantulu, 1958); Waltair coast (Ganapati and Raju, 1961); Vellar estuary (Venkataramanujam and Ramamoorthy, 1972; Thangaraja, 1995) Coleroon estuary (Manickasundaram et al., 1987); Parangipettai and Cudalore coast (Sundaramanickam et al., 2007) Tuticorin coast (Marichamy and Siraimeetan, 1984); Sundarban mangroves (Enamul Hoq and Nazrul Islam, 2007), in west coast of India (George, 1979; David Raj and Ramamirtham, 1981); Bombay waters (Bal and
Pradhan, 1951); Vizhinjam coast (Rani Mary George, 1988); Kadinamkulam estuary (Bensam and Tamachandrakarthak, 1967); Cochin backwater (Rengarajan and David Raj, 1979; Lalithambikadevi, 1993).

The highly productive nature of estuarine habitats and their role as nursery areas to fish in early life stages are well documented for temperate estuarine habitats (Elliott and Savidge, 1990; Ketchum, 1969; Drake and Arias, 1991a; Szedlmayer and Able, 1996; Whitfield, 1999; Blaber, 2000; Shackell and Frank, 2000) and tropical estuarine habitats (Raynie and Shaw, 1994; Sanvicente-Anorve et al., 2002; Harris et al., 2001; Cowley and Whitfield, 2001; Franco-Gordo et al., 2003).


Faria et al., (2006) analyzed detailed characterization of the ichthyoplankton community and its spatial-temporal dynamics in the Guadiana estuary and adjacent coastal zone, an area that is poorly characterized. Pattrick et al., (2007) studied the estuarine larval fish in the South African subtropical/warm-temperate biogeographic boundary region and aimed to provide information on the
composition, abundance, distribution and seasonality of larval fishes in this estuary.

Primo et al., (2012) studied the high-frequency sampling, in which diel cycles were sampled seasonally, at neap and spring tide cycle, combined with spatial sampling inside the estuary. The main objectives of this study were, to understand how lunar-associated tidal cycles influence entrance of fish larvae into the estuary; to identify how this influence varies seasonally; and to determine the extent to which this influence affects up-estuary transport and spatial distribution inside the estuary. Sutherland et al., (2012) described the spatio-temporal dynamics of the larval fish assemblage in the Sundays Estuary over a two-year period and identified the species composition, abundance, distribution and seasonality of the larval fish community in the estuary and relate this to the physico-chemical variability within the system.

Bucater et al., (2013) compared the composition of the larval fish assemblage at two temporal scales; months (August–November) and diel (day/night) in the Murray Mouth during a severe drought when waterflow over the barrages was negligible. The hypothesis that there would be an increase in water temperature and a decrease in dissolved oxygen (DO) through months, but that salinity would not vary. We tested the hypothesis that larval fish assemblages would vary at both time scales (e.g. monthly and diel) and that those differences
would be driven by small-bodied species that are tolerant of high salinity was also tested.

Deapananda *et al.*, (2013) investigated the distribution and abundance of finfish larvae in the coastal waters of Southern Sri Lanka, with particular reference to the importance of Rekawa mangrove forest as a refugee for early life stages of fishes. This study was undertaken to investigate the abundance and distribution of finfish larvae in coastal waters off the Rekawa area.

Many studies were made involving planktonic communities and evaluating the effects of dredging in aquatic ecosystems. Maltez *et al.*, (2014) studied ichthyoplankton assemblage adjacent to the port of Aratu, Todos of Santos Bay (TSB), Baiha, Brazil, before, during and after the dredging activity. The correlation between the fish larvae assemblage structure and oceanographic variables, water quality and nutrients was examined in an attempt to understand the possible effects caused by dredging process. Katsuragawa *et al.*, (2014) investigated larval fish distribution, and compared the spatial changes in larval fish assemblages in Southeastern Brazilian Bight (SBB) under the influence of spring and autumn oceanographic conditions.

Kent *et al.*, (2013) described the trends in fish egg and larval abundance in Western Port and Bass Strait over a 15 month period, and investigated the variation based on distance from shore. Community level analyses were conducted to identify spatial
differences in community structure between a tidal bay environment and offshore sites and with distance from offshore sites and identify seasonal changes in the larval assemblages of Western Port and Bass Strait.

Mohamed et al., (2014) determined the composition of juvenile fish communities inhabiting mangrove swamps in the Egyptian Red Sea and evaluated the importance of these swamps as nursery areas for the economically important fishes and how mangroves could support the life history of reef fishes. Sichum et al., (2013) provided baseline information of different shallow marine habitats in the Gulf of Thailand by comparing the diversity and abundance of juveniles and small sized fishes and determining if these fish assemblage patterns are related to water quality variables.

Daniela Giordano et al., (2014) studied community structure in terms of species composition, abundance and spatial distribution of fish larvae in a wide coastal area of Sicily facing the Southeastern Tyrrhenian Sea, extending for 2300 km² from Cape Cefalu to the west, to Cape Rasocolmo in the east. Hasan Huseyin Satilmis et al., (2014) evaluated the ichthyoplankton assemblages in an ecological perspective. For this purpose, seasonal changes of the species composition, richness and diversity of ichthyoplankton assemblages were investigated by using horizontal and vertical ichthyoplankton samplings.
Renata Roque Porcaro (2014) analyzed the spatial and temporal distribution patterns of the Sciaenidae larvae and evaluated the influence of abiotic and biotic factors in the Santos estuarine system and on the adjacent continental shelf and discussed the about the importance of the study area to early life stages of some Sciaenidae species. Seagrass beds and mangrove are places where species are known to use as habitats during their larval and juvenile stage. The stages of fishes inhabit this environment for at least few month and this may be due to high food productivity and less predation pressure. Even though the importance of seagrass bed as nursery areas for fish is well documented but many of the studies have focused on adult and juveniles rather than on larval stages. Ara et al., (2013) analyzed fish larval density and composition among the river, estuary, mangrove, seagrass and outside seagrass beds of the South western coastal waters of Johor, Peninsular Malaysia.

Ichthyoplankton are meroplankton, a planktonic stage that is highly sensitive to environmental changes. The spatial distribution of ichthyoplankton assemblages is closely related to oceanographic features. These features act as mechanisms of enrichment, concentration and retention of larval fish, affecting their survival and production. Chen et al., (2014) investigated the species composition, spatial distributions of fish larval assemblages and abundance of
larval fish in the East China Sea. Moreover, the factors responsible for larval abundance were determined.

The recruitment of larvae through an estuarine mouth and subsequent transport up an estuary are critical for successful completion of the life cycle. Patrrick and Strydom, (2014) investigated the influence of the diel and tidal cycle on larval and juvenile fish directional movement using fyke nets over spring tides in two warm- temperate permanently open South African estuaries. Various movement patterns exhibited by different species as well as the mechanisms of transport resulting from these movements were analysed. Katsuragawa et al., (2014) investigated larval fish distribution and compared the spatial changes in larval fish assemblages in Southeastern Brazilian Bight (SBB) under the influence of spring and autumn oceanographic conditions. Camilla Nunes Garbini et al., (2014) has stated composition, abundance and density in horizontal and vertical distribution of flatfish larvae in southeastern Brazilian waters.

Selma Pacariz et al., (2014) reported that no specific analyses of how the transport is related to egg density or direct effects of vertical mixing, as eggs are only transported at the neutrally buoyant levels. In this study the focus is on the density dependence of transport and sedimentation patterns using a model where eggs can be mixed vertically and thus become positively or negatively buoyant.
Shallow estuarine zones are important for recruitment and refuge areas in larval and juvenile fishes. Frias and Carranza, (2014) described the effects of season, moon phase, diel variations, and their interactions on the abundance and richness of fish early stage assemblages in the estuarine environments within the CWBR. Therefore, four tropical estuarine habitats (coastal zone, mangroves, river, and submerged aquatic vegetation) of the CWBR were used as a model, considering the influential physico-chemical parameters.

Jimenez et al., (2014) analyzed the composition of the larval fish community in a highly diverse area but lacked to acquire knowledge on the larval distribution of the most important fish species; and to understand how local oceanographic features influence the abundance and distribution of these larvae. The study also described the distribution of the main spawning grounds and the hydrographic scenario in which they develop.

Munk et al., (2014) investigated the species specificity of distributions and for recognized communities, the influence of the horizontal stratification in salinity and temperature was detected. Further, the series of observations to ascertain annual variability and long-term trends in the ichthyoplankton abundances were made. Kwak and Park, (2014) examined the temporal and spatial variation in species composition and abundance of ichthyoplankton in Masan Bay
and determined the relationships between environmental factors and ichthyoplankton abundance.

Mangroves are important nursery area for early life history of finfishes and shell fishes, researches on the early stages of fishes and their biology and ecology in the world is very rare. Abu El-Regal and Ibrahim (2014) determined the composition of juvenile fish communities inhabiting mangrove swamps in the Egyptian Red Sea, to evaluate the importance of these swamps as nursery areas for the economically important fishes and how mangroves could support the life history of reef fishes.

Salt marshes are recognized as important nurseries and feeding grounds for many finfish and shellfish species. Goncalves et al., (2015) investigated spatial and temporal variations of the larval fish community in a salt marsh sub-tidal creek of the estuary and the effects of the environmental factors on larval fish occurrence using a decision tree (DT) model.

Zhang et al., (2015) surveyed at four springs in 1999, 2001, 2004 and 2007 and aimed to provide detailed characterizations of the ichthyoplankton assemblage in springs, examined the long-term dynamics of spring ichthyoplankton assemblages, and evaluated the influence of environmental factors on the spatial distribution and inter-annual variations of ichthyoplankton assemblages associated with the Yangtze estuary.
Nazli Demirel (2015) focused on the distributional patterns of fish eggs and larvae in the Golden Horn estuary. In this study two main objectives were specified, determination of the ichthyoplankton density and distribution, and analysis of the dynamics of the ichthyoplankton in relation to environmental variables. For this purpose, seasonal and regional changes of the ichthyoplankton assemblages were observed. Environmental parameters were considered to determine environmental status in different parts of the Golden Horn estuary. Differences in the environmental status and influence on the ichthyoplankton assemblage were discussed.

The most common nekton life cycle of fishes inhabiting estuaries involves offshore spawning with the production of a large number of small pelagic eggs, and recruitment to estuaries as larvae or early juveniles (Acha et al., 1999). Therefore, the exchange between the ocean and estuaries is a key issue to coastal scientists because many species of fish move between the continental shelf and estuaries during their early life. Moreover, this movement is indeed crucial for successful completion of the life cycle of several species sustaining commercial coastal fisheries. Bruno et al., (2014) investigated the fish larvae recruitment patterns from the sea to a very shallow temperate wind-dominated choked lagoon. In order to do so, the patterns in fish larvae abundance and distribution in Mar Chiquita Lagoon inlet channel and adjacent coastal area were explored, and hypothesized
that in this context of low tidal influence, other factors such as wind force may be regulating fish larvae dynamics and Particularly the onshore winds are strongly related to fish larvae recruitment into Mar Chiquita inlet channel grounds for many finfish and shell fish species.

Rodríguez et al., (2015) described the composition and structure of the LFC off the NW Iberian peninsula, and analyzed the influence of abiotic factors (depth, sea surface salinity, sea surface temperature, geostrophic velocity and dynamic height) and biotic factors (micro-and meso-zooplankton biomass) on the horizontal distribution of fish larvae and in determining the horizontal structure of LFC, during the winter mixing period. The study initiated that fish larvae are good tracers of the hydrography of the region on a short time scale during the winter mixing period.

Strydom (2015) has reviewed estuarine ichthyoplankton research in temperate South Africa and conducted a comparative cross-system analysis on species composition, diversity, abundance, and seasonality, including density relationships with physico-chemical variables and hydrodynamic features of 25 estuaries sampled in temperate South Africa since 1998. This work has highlights a holistic overview of larval fish dynamics in temperate estuaries.

Colegrove et al., (2015) investigated the effects of hypoxia and other environmental variables on the density, composition, horizontal
and vertical distribution of fish larvae along the Oregon and Washington coasts during three summers: 2008, 2009 and 2010. The study focused on the shelf system (<100-m depth) and locations of previous coastal hypoxic events, which are seasonal phenomena with a peak intensity during summer.

Zengguang et al., (2015) described the composition and relative abundance of fish eggs and larvae in Haizhou Bay and its adjacent waters, as well as the environmental factors that determine these patterns, to study the spatial patterns of ichthyoplankton of fishes that use the area as reproductive grounds.

The diversity of the ichthyofauna, its spatial and temporal distribution and abundance considering a salinity and longitudinal gradient in order to identify patterns along the internal portion of the Amazon Estuary was analysed by Mourao et al., (2015). The importance of the area as reproduction and nursery grounds was also investigated. This study might provide guidelines for the development of conservation and/or management strategies for the local fish fauna, considering the ecological and social-economic importance of the area.

Tsai et al., (2015) observed and described the fish community structure in a mangrove forest of Puzih river estuary in subtropical Taiwan with emphasis on seasonal and diel variations.

Tulin Coker and Bulent Cihangir (2015) assessed the ichthyoplankton status in Mediterranean waters of the TRNC as of
July 1998 (summer season) to produce maps on the diversity, abundance and distribution of fish species at the 40 stations.

Rezagholinejad et al., (2016) analyzed to improve the knowledge of the fish larval assemblage changes influenced by different habitats and abiotic factors in the mangrove estuarine area of Marudu bay, Sabah, Malaysia.

Correct identification of finfish eggs and larvae to the species level can let us understand which species are spawning where and when, their hatching and nursery grounds, and their possible migration routes in their life history. The information is very important for ecological monitoring, environmental impact assessment, fishery compensation, resource management, smuggling prevention and establishing marine protected areas (Moura et al., 2008; Valdez et al., 2010).

Conventionally, marine finfish eggs are identified by visual characteristics such as the presence, number and size of oil globules, size of perivitelline space, yolk homogeneity and embryo pigmentation (Russel, 1976). Traditionally, larval fish identification has always used morphological characters, such as the body shape, pigmentation, meristic counts and measurements. However, these characters are not enough to identify every species, especially those rare and cryptic species (Matarese et al., 2011). In the early life history of fishes, many
species share the same morphology, and their morphometric measurements are often duplicated (Victor et al., 2009).

Taxonomy, the science dedicated to discovering, describing, naming, and identifying species and other taxa, has been the subject of many debates (Lee, 2002, Blaxter and Floyd, 2003; Prendini, 2005; Meier et al., 2006; Carvalho et al., 2008) that centre on the use of revolutionary ideas (Hebert et al., 2003 and Tautz et al., 2003) that can help it overcome the “taxonomic crisis” of the last decades (Wilson, 1985). This crisis is mainly characterized by a lack of specialists in several groups and geographic areas, and by insufficient funding for taxonomic work (Godfray, 2002; Mallet and Willmott, 2003);

information technology, (Tautz et al., 2003, Hebert et al., 2003), the development of investment funds (Wheeler, 2007) and increased utilization of cyber tools (Pyle et al., 2008, La Salle et al., 2009). Among those applications, DNA barcoding has been particularly most successful in the identification and delimitation of new species from various groups (Hebert et al., 2003; Hebert et al., 2004; Ward et al., 2005; Cywinska et al., 2006; Hajibabaei et al., 2006a; Smith et al., 2007, Borisenko et al., 2008; Kerr et al., 2009). This method has received increased acceptance because it is simple and affordable (Padial and De La Riva, 2007).
DNA barcoding in which a short nucleotide sequence of mitochondrial genome will act as a DNA barcode for species identification of eukaryotes, in particular, animals. This technology has proven to be a rapid tool for precise identification of biological specimens. DNA barcoding works under the principle that inter-species variations are greater than the intra-species variations, allowing one to differentiate the species using nucleotide sequences (Hebert et al., 2004).

Six-fifty nucleotide bases of 5’ cytochrome c oxidase subunit-I gene (COI) have been accepted as a universal barcode to delineate animal life of this planet. By harnessing the advances in electronics and genetics, barcoding is going to help investigators to quickly recognize known species and to retrieve information about them. This technique will speed up the discovery of many species yet to be named. Thus, this technology will provide a vital new tool for appreciating and managing the earth’s immense and changing biodiversity (Buhay, 2009).

Taxonomic identification and validation using DNA barcoding is greatly enhanced by comprehensive and easily accessible sequence databases. GenBank is a universal database of all publicly available DNA sequences, with over 240,000 named species at present (www.ncbi.nlm.nih.gov; Benson et al., 2007). In addition, the Barcode of Life Data Systems (BOLD) is another database which focuses on
species identification by collecting the COI and ITS gene sequences of an organism (http://www.barcodinglife.org), with over 48,000 species formally described (BOLD, 2008).

To augment the database in particular regions, on-site collection and identification of specimens, followed by obtaining sequence information are necessary, this could then form the baseline for biodiversity analysis and species identification for specimens of interest. By means of Polymerase Chain Reaction (PCR) and DNA sequencing of COI and 16S rRNA genes, sequences of finfish eggs and larval stages of different morphotypes can be matched with those of the known finfish adults for species identification.

Molecular methods have been used to identify larval and juvenile fish and have revealed a cryptic fish species. Many successful nationwide studies on ichthyofaunal diversity have been undertaken using this method for both marine and freshwater fishes (Carvalho et al., 2011; de Oliveira Ribeiro et al., 2012; Mabragana et al., 2011; Wang et al., 2012). These studies have resolved several cases of crypticism and diagnosed many latent species (Carvalho et al., 2011; Pereira et al., 2011).

Shao et al., (2002) has pointed out that only molecular identification can guarantee identification of fish eggs to the species level and can be applied to larval fish identification, too. The
application of DNA barcoding to larval fish identification has become popular in recent years.

Ko et al., (2013) by having different larval fish taxonomists identified the same larval fish specimens independently, using traditional morphological characters. Then, DNA barcoding technique was used to identify their species names and calculated how accurate was previous identification and discussed some larval fish identification problems.

Species composition and distributions of all larval fishes collected at eight stations located in close proximity to frontal zones in the subtropical convergence zone of the Sargasso sea (STCZ) using a combination of DNA barcoding and morphological identification techniques were investigated by Ayala et al., (2016).

Giordano et al., (2008) analysed new methods to sequence DNA from larval fish samples fixed in formalin solution and reported protocols and success rates for amplifying and sequencing regions of the genomic 28S ribosomal RNA and mitochondrial 16S rDNA.

Burghart et al., (2014) compared the community compositions of planktonic fish eggs and larvae that were collected simultaneously, testing the hypothesis that the composition of the planktonic larval fish community proportionately reflects the composition of the planktonic fish egg community. Genetic methods were used to identify individual eggs, and thereby preserve the quantitative aspects of
genome-based community analysis. This comparison was conducted in a small embayment that has restricted hydrodynamic connectivity to other coastal waters, and described the connectivity between egg and larval stages using a circulation model.

Baldwin et al., (2011) identified genetic lineages of *Apogon* derived from DNA barcoding data of Western Central Atlantic fishes; matched early life stages of Belize *Apogon* to adults using the barcoding data; described diagnostic morphological features of larval and juvenile *Apogon* identified in this study; provided comparative sections to help distinguish early-life stages of *Apogon* spp. from one another; and provided color photographs of larvae and juveniles to highlight distinctive color patterns that are lost upon conventional preservation. Additionally comments were made on the potential utility of early life stages of western Atlantic *Apogon* in phylogenetic studies of the genus.

I-Shiung Chen et al., (2013) documented the real species diversity from coastal samples of larval fish communities via recent research based on the proof of mitochondrial DNA COI sequences in the Dongsha Island, South China Sea for detecting the reproduction characteristics of marine fishes in the coral-reef habitats.

Song et al., (2014) reported the morphology of juvenile *Chromis mirationis*, and compared the characteristics of juvenile *C. mirationis*
with those of juvenile *Chromis notata*, as there two species were found to be closely related by molecular analyses.

DNA barcodes will play an increasingly important role in the identification of fish larvae and eggs, besides from their role in species discovery and identification. Egg-based identifications can play a major role in fisheries management (Fox *et al.* 2005). Baldwin *et al.* (2009) described the early stages of six species in two genera (*Phaeoptyx* and *Astrapogon*) and Victor (2007; 2008) and Victor *et al.* (2009) described larvae and adults of two new species of *Coryphopterus* and *Lutjanus cyanopterus* from the Caribbean.

Pegg *et al.*, (2006) analyzed that planktonic larvae captured a shallow coral reef study site on the Great Barrier Reef (GBR) around spring-summer new moon periods using light trap or net capture devices. Larvae were identified to the genus or species level by comparison with a phylogenetic tree of tropical marine fish species using mtDNA *HVR1* sequence data. Further analysis showed that within-species *HVR1* sequence variation was typically 1-3%, whereas between-species variation for the same genus ranged up to 50%, supporting the suitability of *HVR1* for species identification.

Valdez-Moreno *et al.*, (2010) studied the ability of barcodes to distinguish marine species from the Yucatan coastline, connected finfish eggs and larvae to adults by using barcodes and assessed how
correct identifications could aid fisheries management and conservation.

Matarese et al., (2011) performed DNA barcoding techniques to determine that the “mystery black larva” is *Zesticelus profundorum*, the Flabby Sculpin, a rare deepwater member of the family Cottidae. The results of this work have enhanced the methods for long-term monitoring of species diversity, abundance, and distribution, and give us the potential for real-time at-sea identification.

Kwun et al., (2013) studied the Mugilid juveniles collected by scoop net in October 2012 from the southern coastal waters of Jeju Island. Among the specimens collected, *Oedalechilus labiosus* (Valenciennes, 1836) and *Ellochelon vaigiensis* (Quoy and Gaimard, 1825) were identified using molecular methods. Only two species of *Oedalechilus* Fowler, 1903 and a single species of *Ellochelon* Whitley, 1930 are recognized worldwide. In this study, two unrecorded mugilid species from Jeju Island were reported.

Kolangi-Miandare et al., (2013) identified *Syngnathus abaster* using morphometric, meristic characteristics and preparing primary DNA barcoding documents as well as comparing the documented DNA sequences of the Syngnathidae family, despite the fact that the information about phylogenetic relationships and genetic markers of Pipefish are very rare. Soo Jeong Lee and Jin Koo Kim (2014) compared morphological and molecular information on eggs, larvae,
and adults of hairtail fish from Korea with that of *Trichirus lepturus* from the Atlantic Ocean, reviewed the taxonomic status of the hairtail.

Mitochondrial DNA provides a potential tool for studying population and phylogenetic analysis and different genes of mitochondrial genome are used for phylogeny analysis at different levels of taxa, family, species and individual’s level. Ramanadevi and Thangaraj (2013) reported the phylogenetic analysis based on the updated nucleotide sequence data from GenBank for the four regions of the mitochondrial genome (Cytb, CO1, 16S rRNA and 12S rRNA) to assess the pattern of species relationship and also to examine the rates and types of nucleotide substitutions among the Tenpounder fish species. Thirumaraiselvi *et al.*, (2015) identified some dominant fish larvae in Vellar estuary up to species level using CO1 gene and find the phylogenetic relationship among them.

Bernal *et al.*, (2014) assessed the validity of morphological larval identifications using two mitochondrial markers, CO1 or 12S rRNA, to accurately associate larvae and adults of the same species for the most abundant and frequent mesopelagic fishes of the western Mediterranean. Additionally, it was of interest to determine the similarity of congeneric taxa and infer the most external relationships under the resolution threshold of one mtDNA marker.

Gregory Neils Puncher *et al.*, (2015) described how larvae collected from the Strait of Sicily, Western Ionian Sea and Levantine
Sea were acquired from three different institutions for genomic analysis within ICCAT’s Atlantic wide research programme for bluefin tuna (GBYP). All larvae had been provisionally identified as *Thunnus thynnus* by technicians using morphology-based methods. All larvae were barcoded using a 650bp fragment of the CO1 gene and identified to species in an effort to assess the accuracy of identification and compared the effectiveness of various methods used for associating sample sequences to reference or voucher sequences. The overall effectiveness of the Neighbour-Joining tree approach and compare two methods used for distance matrix construction (p-distance vs. K2P) was reviewed. Finally, a character-based key which uses unique genetic characteristics in much the same way astaxonomic keys that identify organisms based on diagnostic morphological features was developed.

Pappalardo *et al.*, (2015) studied the utility of the DNA barcoding approach as a molecular technique for the identification of Myctophidae larval stages caught during oceanographic surveys carried out in the Sicilian Channel (Strait of Sicily) as part of the European project “Distribution, biology and biomass estimates of the Sicilian channel anchovy”. Furthermore, a preliminary analysis of intraspecific COI genetic variation among Atlantic Ocean, Balearic Sea and Sicilian Channel samples of five lantern fish species was tentatively assessed to show the effectiveness of the COI barcode
sequences in discriminating the geographic origin of larvae. Lewis et al., (2016) compared the species identifications; those produced from morphological versus molecular analyses of eggs, in terms of species diversity and taxonomic resolution and evaluated the feasibility of incorporation of DNA barcoding into long-term, regional-scale ichthyoplankton monitoring programs.