Chapter 1.

Introduction
1.1. General Introduction

Fish forms a vital source of food and is man's most important single source of high-quality protein, providing 16% of the animal protein consumed by the world's population (FAO, 2000). Fish consumption is on the increase in many countries and in India, fisheries has emerged as a major industry with an annual turnover of more than Rs.220 billion, accounting for 1.4% of the total GDP (Ayyappan and Biradar, 2000). Marine fisheries has emerged as one of the largest industries in the country employing about 10 million people in 3,651 fishing villages along the 8,129 km coastline of India earning a foreign exchange value of over Rs.7250 crores in 2005-06. The emphasis of coastal fisheries development in India since independence was to increase fish production through improving and increasing the techniques and efficiency of fishing and by offering welfare measures to the fishers. This paved the way for increasing the marine fish production from 0.5 million tonnes (mt) in 1950 to 2.6 mt in 2005-06. Of this 66% was landed by mechanized vessels, 26% by motorized units and 8% by non-motorized units. Fishing down marine food webs along Indian coast indicate that present exploitation patterns are unsustainable and reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fishes (Vivekanandan et al., 2005). To ensure sustainable marine fisheries and to effectively manage the fish stocks, it has became increasingly necessary to understand the impact of fishing on fish. Such studies should include understanding of interspecific relationship among fish and also with other organisms in their environment. In order to understand the functioning within marine habitats, it is necessary to describe the trophic interactions in the habitats and then to quantify them where possible. To achieve these goals, interactions between the different components within marine ecosystems have to be acknowledged, understood and quantified (Cury et al., 2003). Trophic interactions may change with time and may be affected by fishing pressure (Alonso et al., 2002), making it necessary to periodically monitor them by conducting diet studies.

India has an EEZ of 2.02 million km² and is endowed with a rich variety of demersal fishery resources. The growth of demersal fishery in India during the post independence era is significant. The exploited demersal finfish resources
increased from 0.75 mt in 1985 and registered a peak of 1.35 mt in 1998 but
decreased to 1.15 mt in 2004 (Srinath et al., 2006). About 700 species of finfishes
are recorded from the Indian sea bottom of which about 250 are common to the
demersal fisheries. Species richness of demersals is more off the east coast than
off the west coast (Bensam, 2000). The important demersal finfish groups are:
croakers, elasmobranchs, threadfinbreams, catfishes, major perches (rockcords,
snappers, pigfacebreams, and other perches), silverbellies, pomfrets and
flatfishes. They inhabit a wide range of habitats such as sandy, muddy to rocky
and coral grounds as well as from shallow coastal waters to deep continental
slope, from all geographical regions and through all the seasons in the
subcontinent, at varying temporal and spatial diversities (Bensam, 2000).

Karnataka state with a coastline of 300 km along the southwest coast of
India is one of the frontline states in the country in marine fisheries development
(Mohamed et al., 1998). Its contribution to annual marine fish production of India
has varied between 6% and 14%. Pelagic and demersal finfishes, prawns and
cephalopods are landed at 28 landing centers along the coast. Mechanised crafts
employing purse seines and trawls contributed more than 95% to the landings.
The principal gears used in the state are trawl net, purse seine, gillnet, longline
and a variety of artisanal gears. Around 1,500 trawlers operate along this coast.
Mangalore and Malpe fish landing centres account for more than 60% of the
total marine fish landings of Karnataka. The trawlers land 56% of the total catch.
Demersal fishes formed the significant fishery in trawls. The trawl fleet in the
state is distinctly of two types, a single day fishing fleet (SDF) consisting of small
(overall length (OAL): 30'-32') coastal trawlers and multi-day fishing fleet
(MDF) consisting of larger (OAL: 36'-52') trawlers operating in the 30-150 m
depth zones (Zacharia et al., 1996). The demersal fishes landed along the
Karnataka coast ranged from 31,100 tonnes in 1985 to 78,800 tonnes in 2004
(Srinath et al., 2006). The important resources landed by trawlers include
threadfin breams, carangids, anchovies, flatfishes, lizardfishes, seerfishes,
cephalopods, shrimps, stomatopods and crabs. Mohamed et al. (1998) studied the
exploitation status of marine fisheries along the coastal Karnataka.

Among the exploited demersal resources, the elasmobranchs are landed in
all the maritime states of India. Sharks (61.4%), skates (5.7%) and rays (33%) are
the major components of elasmobranchs in the fishery (CMFRI, 2005). It
contributed 9% to the total demersal fish landings in the country. In Karnataka, sharks contributed 80% to elasmobranch catch. Sharks play an important role in the trophic structure of world's marine ecosystem (Cortes, 1999). Many sharks are large and abundant marine consumers and as such are likely to influence the aquatic communities in which they exist (Bowen, 1997). Little is known about the feeding behaviour and diet of sharks in India. The works of Aiyar and Natini (1938), Sarangahar (1943) and Nair and Appukuttan (1973) are too limited and there is complete lack of quantitative data on the food of sharks.

Perches occur all along the Indian coast. Perches contribute almost 30% to the total marine fish production in the country (CMFRI, 2005). Groupers especially rockcods form the major component of perches in the catch. Karnataka contributed 6.4% of the total perch catch in the country with an average landing of 1,538t. A review of the Indian publications indicates that study of diet of rockcods in India is scanty and information given by Prabhu (1954), Premalatha (1989) and Tessy (1994) on different species of rockcods are some of the significant records.

The fishes of the family Nemipteridae (Order: Perciformes), which are popularly called threadfin breams, are distributed in the tropical and subtropical seas. Threadfin breams formed about 17.8% of the total marine demersal fish landings of India (CMFRI, 2005). *Nemipterus* spp form an important demersal fishery resource along the Karnataka coast accounting 19, 812 t, of the total marine landing of the state (CMFRI, 2005). Nemipterids are one of the midlevel carnivores along the Indian coast (Vivekanandan et al., 2006). Qualitative and some of the quantitative description of diet of different species of Nemipterids along the Indian coast was recorded by Kuthalimgam (1965), Krishnamurthy (1971), Muthiah and Pillai (1979), Mohan and Velayudhan (1985) and Rao and Rao (1991).

Silverbellies of the family Leiognathidae are an important group of small to moderate sized finfishes. In India, mechanization and modernization of fishing equipments and methods in the last few decades have made it technically feasible to increase the harvest of leiognathids manifold. They formed 8% of total marine demersal fish landings in the country (CMFRI, 2005). *Leiognathus bindus, L. splendens* and *Secutor insidiator* are the most dominant species accounting for nearly 70-80%. The feeding habit studies by many Indian workers are qualitative
in nature (Chacko, 1944; Venkataraman, 1960; Basheeruddin and Nayar, 1962; Jayabalan and Ramamoorthi, 1985).

Sciaenids contributed 18% to the total marine demersal fish landing in India (CMFRI, 2005). More than 30 species under 14 genera of the family Sciaenidae are distributed in the Indian waters with Otolithes cuvieri being the most abundant species in Indian waters (CMFRI, 2003). In India, many authors have recorded the food and feeding habits of croakers (Jacob, 1948; Bapat and Bal, 1952; Suseelan and Nair, 1969; Jayaprakash, 1974; Lal Mohan, 1984 and Manojkumar, 2003).

Pomfrets are one of the most delicious food fish available along Indian coast. Pomfrets are represented by the silver pomfret (*Pampus argenteus*; 62.5%), black pomfret *Parastromateus niger*; 34.5%) and Chinese pomfret (*Pampus chinensis*; 2.98%). They contributed 6% of the total marine demersal landings in the India (CMFRI, 2005). The observations of Kulkarni (1958), Rao (1964) and Pati (1978) on the diet provide information on the feeding pattern of pomfrets along the Indian coast.

The bullseye’s or big eye (family Priacanthidae) is one of the major non-conventional fish resources, which of late has assumed significance as an emerging demersal fish in the commercial landings. The contribution of bullseye’s to the total marine landing was low ranging between 0.1% and 3% at various centres. Four species of priacanthids namely (*Priacanthus hamrur*, *P. macracanthus*, *P. tayenus* and *P. blochii*) are reported from the Indian seas. *P. hamrur* (Forsskal) formed the most dominant species in the commercial landings (CMFRI, 2005). Philip (1998), Rao (1984) and Zacharia et al. (1991) have reported feeding behavior of priacanthids in India.

Flatheads are one of the important demersal fish resources of southern Karnataka. They form 2.11% of total landings along this coast. The spotfin flathead, *Grammoplites suppositus* is the most important and most abundant species in the trawl catches of Karnataka. Rao (1964) and George et al. (1968) have briefly described the diet of flatheads along the Indian coast.

Fishes belonging to the families Bothidae (flounders), Cynoglossidae (tongue soles), Psettodidae (Indian halibut) and Soleidae (Soles) are popularly known as flatfishes. Flatfishes belonging to 11 genera and 25 species contribute to minor and major fisheries along the Indian coast. The flatfish landings have
increased consistently during the past few years and reached 36,202 t and accounted for 5.4% total marine demersal fish landings (CMFRI, 2005). Among all the species of flatfishes occurring along the Indian coast, it is only the tongue sole, *Cynoglossus macrostomus* that has formed a major fishery for several years, especially along the southwest coast. Jayaprakash (2000), Seshappa and Bhimachar (1955), Datta and Das (1983) and Kuthalimgam (1957) have reported the diet of flatfishes in India.

The white fish *Lactarius lactarius* is distributed all along the Indian coast. Trawlers and the indigenous drift gill netters are the major gears. The resource contributed 0.2% to the total marine production in India. In Karnataka, its landing ranged from 836 t in 1985 to 678 t in 2004 (Srinath et al., 2006). The quantitative description of the diet of whitefish was given by Zacharia (2003) from the Karnataka coast.

The present study has been taken up to understand the trophic interaction among these demersal fishes for the management of multispecies fishery. The present study defines trophic guilds to characterize the trophic interactions to assess the potential for competition based upon patterns of resource use. The study also explores the utility of the guild concept as a tool for understanding and managing the complex demersal food web along the Karnataka coast.

1.2. Scope of the study

Fishing has become one of the most widespread anthropogenic activities on the marine ecosystem. The fishery resources are under constant threat of overexploitation in addition to natural and predation losses. In India, fisheries management based on ecosystem approach is in its infancy and needs a detailed study of various trophic components. In the modern ecosystem based fisheries analysis, fish diet analysis has become the core subject that will decipher the trophic relations in an ecosystem. Trophic interactions within ecosystems play a large role in multispecies modelling; hence diet and feeding data are of primary importance. Fish food habit studies also helps in understanding some of the higher level trophic relations in an ecosystem and is an important mechanism for gaining knowledge on feeding ecology and a means to explore interactions between predators and prey (Hall et al., 1995; Garvey et al., 1998; Vander Zanden et al., 2000).
Studies on the food and feeding habits of marine fishes are not a new practice in India. However, the methods followed to study the stomach analysis of most of these fishes were qualitative in nature and the quantitative information available are inadequate to explain the complex food chain interaction between them. A review of dietary, food habit, and food consumption studies of Indian marine fishes reveals lack of consistent methodological approach and application of statistical tests to analyze results. In the last fifty years, the major Indian fisheries journals like Indian Journal of Fisheries and Journal of Marine Biological Association of India published 120 papers on the food and feeding habits of marine fishes. With the exception of a few researchers, most of them have used the traditional numerical methods to evaluate the relative importance of different preys. There is urgent need for the quantitative assessment of food habits as this assessment forms an important aspect of fisheries management and successful management enables us to effectively manage prey resources (DeVries and Stein, 1990). Moreover, the knowledge on the relative importance of different prey items can guide management efforts aimed at increasing fish production.

As the role of predators in controlling lower trophic level populations has been observed as a major structuring factor in benthic marine communities (Shears and Babcock, 2002), the trophic analysis of commercially important demersal finfish species was conducted in the present study. Trophic guilds formed by the union of fishes with similar feeding habits and the highly impacted prey groups due to predation were delineated in the present study.

The present study is aimed at understanding the variation of trophic level with ontogeny. Trophic level has been widely used to understand the functional position of fishes in the food web. Many recent researchers have used constant trophic levels for fish groups/species for ecosystem modeling and for detecting fishing down marine food web (Christensen, 1993; Vivekanandan et al., 2005). As most of the predators have ontogenetic (Figueiredo et al., 2005; Cortes, 1999; Vander Zanden and Rasmussen, 1996), seasonal and location specific feeding habits, assigning constant trophic levels may lead into erroneous results in trophic modeling.

In the present study, special attention has been given to the study of predator and prey relations. Knowledge on the size of prey is essential in order to
identify their potential impact on prey survival and their role in structuring populations at lower trophic levels. This is particularly important for any ecosystem approach to fisheries management where knowledge of interactions is critical. From a behavioral standpoint, relative body sizes of prey and predator can have significant effects on predator feeding success.

The present study is expected to aid construction of mass-balance models like ECOPATH for modelling benthic ecosystems of Karnataka and to understand the energy transfer and trophic interactions.