EXECUTIVE SUMMARY

ICHTHYOFAUNAL DIVERSITY AND FISHERY STATUS OF SUTRAPADA

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BY

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One of the most diverse biodiversity is aquatic which covers around 3/4th of the total earth's surface. It includes our rivers and streams, ponds and lakes, oceans and bays, and swamps and marshes, and their associated animals. Aquatic habitats provide the food, water, shelter, and space essential for the survival of aquatic animals and plants. The aquatic ecosystem can be broadly classified into Marine and Freshwater.

Fishes are the largest group of vertebrates, which exhibit a remarkable diversity of morphological attributes and biological adaptations. Fishes are classified as Agnathan (Jawless fishes) there are around 50 species of class Chondrichthyes fish (cartilaginous like sharks and rays) they consist of about 600 species in total whereas Osteichthyes (bony fishes) are dominant with 30,000 species and most of them are ray fined category. Globally, ichthyofaunal diversity comprises approximately half of the total members of the subphylum Vertebrata with 35,797 valid fish species (Fricke *et al.*, 2021). Among teleost fishes, many species spend their lives in freshwater while majority of fishes are marine water inhabitants. In India, ichthyofauna account for 9.7 percent of the global population, among which the marine fishes alone account for 7.4 percent (Eschmeyer & Fong, 2014). Day (1899 a, b) reported 1418 species of fish belonging to 342 genera from British India. Recent findings have increased number of valid fish species in India with an estimation of 3231 species of freshwater, brackish water, and marine species (Gopi & Mishra, 2015). Out of the total fish diversity, marine water consists of 2443 species, freshwater consists of 675 species (Gopi & Mishra, 2015) and brackish water comprises approximately 113 species (Sarkar *et al.*, 2012).

The Gujarat state has coastline of about 1640 km consisting of 173 landing centers. In 1973, Ramachandran published a list of marine and freshwater fishes of Gujarat. Later, identification and description of marine and freshwater fishes have been carried out by the Gujarat Fisheries Aquatic Science Research Institute. Patel and Chhaya (1979) published a field key to the identification of fishes in Gujarat. According to Dulvy *et. al.,* (2003) within the fish population, there is a high genetic diversity present and that may be helping them to protect themselves against various environmental stresses and the spread of diseases. Fish and fisheries are an important sector in most of the developing and developed countries of the world from the standpoint of income and employment generation. The role of fisheries in the Indian economy is gaining momentum because of the introduction of advanced techniques to increase the yield per unit area of water and due to its role in earning foreign exchange. Apart from this, the twin problems of

unemployment and malnourishment in the rural sphere in India can be simultaneously addressed by proper and planned utilization of available local resources through the involvement of local people (Datta and Kundu, 2007).

The marine contribution of Saurashtra is the major portion in Gujarat state, with coastline contribution; it has around 50% of coastline and accounts for more than 90% of the fish production in Gujarat State (Barad, 2012). The introduction of mechanized boats with inboard engines started in 1956, at first at Veraval. In Gujarat mainly there is gill net fishing and fishing craft are mechanised boats, traditional craft (Plank-built boats) with IBM and OBM and FRP dugout canoes. Out of 179 villages, 29% were in Kutch, 23% in Valsad, 12% in Junagadh, 11% in Jamnagar and 8% in Surat. The rest of the district's accounts for less than 7% of the villages each (Balan *et al*; 1987).

Sutrapada is one of the fishing villages, a municipality in Gir-Somnath district in the state of Gujarat. Sutrapada is located 92 km distance from its district main city Junagadh and 14 km from Somnath. This place is known for the GHCL plant, the largest "Soda ash" producing company in the world. Here the fishing is one of the major occupations for local people; about 300 families are engaged in fishing as well as fishery activities. All the fishermen have settled near the landing center and the village is known as Sutrapada Bunder which is about 1 km away from the main Sutrapada village. About 272 families are engaged in fishing and fishery allied activities. Occupation analysis showed that 90.5% of the respondents had fishery as the only occupation, 5.4% fishery main and non-fishery as subsidiary occupation, and 4.1% non-fishery main and fishery as subsidiary occupation. They have very limited information and infrastructure (Sehara, *et. al.,* 1986).

Ichthyofaunal diversity refers to variety of fish species. India is one of the 17 mega biodiversity countries of the world, with only 2.5% of the land area. Among the fish diversity-rich areas in the marine waters of India, the Andaman and Nicobar archipelago shows the highest number of species, 1431, followed by the east coast of India with 1121 species and the west coast with 1071. As many as 91 species of endemic marine fishes are known to occur in the coastal waters of India. In the last 20 years (1990–2009), 2,701 new species of marine fishes have been described based on *Catalogue of Fishes* entries, of these, over 97 % are recognized as valid.

Marine fisheries are very important to the economy and well-being of coastal communities, providing food security, job opportunities, income, and livelihoods as well as traditional cultural identity. They produced 80 million tonnes of fish in 2009 and directly employed 34 million people in fishing operations in 2008 (FAO, 2010). Fish and fishery products are a vital and affordable source of high-quality protein, especially in the world's poorest nations in 2008, fish supplied more than 3 billion people with at least 15 percent of their average animal protein intake (FAO, 2010). Biswal *et. al.,* (2017) worked out social wellbeing and common management failure in small-scale bag net fishery in Gir Somnath, Gujarat. Thomas and Hridayanathan (2003) in their work catch analysis in small mesh gill nets has suggests that small mesh gill netting can be encouraged as a selective fishing method with the restraint use of 30 and 32-mm meshes. Gill nets contribute a significant portion of fish production in Gujarat fisheries sector. Silas et al. (1984) studied the drift gillnet fishery off Cochin. Sehara and Karbhari (1989a) undertook a study during 1986-87 to measure the economic efficiency of OBM units operating gill nets in northwest coast i.e., Kochra Nivti in Sindhudurg district of Maharashtra and Dhamlej in Junagadh district of Gujarat. Sehara and Karbhari (1989b) made a study on gillnet fishing by mechanized boats and profitability at selected centers in Maharashtra. Data and Dan (1992) worked out economics of gillnet fishing in west Bengal. Mohamad and Khan (1986) estimated the catch of gillnet fishery off Veraval coast during 1979-82. groups of fishes landed by gillnet along Veraval coast during 1982-90. Two types of crafts, wooden or FRP dugout canoes (Out Board Engine) and plank-built boats (In Board Engine) were selected for the study. Gillnet fisheries of India was studied by Luther et al. (1997). Data on state wise fish landings by gillnets provided by the Fishery Resources Assessment Division (FRAD) of the CMFRI for the years 1989-92 were analysed to study production trends, state wise contribution, catch, catch per effort and species composition. Sehara and Karbhari (1991) studied socioeconomics of trawl fishery in Saurashtra. Two main landing centers at Porbandar were used for study.

As per the Central Marine Fisheries Research Institute report Gujarat is top fish producing state in India, this highest landing rank was maintained by Gujarat since from last 4 years constantly (CMFRI, 2017). They reported that in the year of 2016 landings of Gujarat state was 0.77 mt, which contributed around 21.32% to the total fish landings of India. In Gujarat, the Gir-Somnath district contributes the maximum landings of marine fishes, i.e., 0.34 lakh tones approx.

The marine biodiversity conservation in India requires such mitigatory steps such as assessment of its status, identification of hotspots and threats to them. Sutrapada coast is one of such coastal zones where a huge gap exists in the knowledge on the biodiversity of the Ichthyofauna. Sutrapada is one of the important fish-landing centers. Sutrapada fishing center requires to be attended with scientific approach for fish diversity, fishing operation and socio-economic status of fisherman community. The present study will be helpful in the management and conservation of the commercially and ecologically important fishes.

AIM:

To study the diversity of fishes and fishery of Sutrapada

OBJECTIVES:

1. Species and genetic diversity of fishes
2. Status of fisheries of Sutrapada
3. Socio-economic status of fisherman

The Coastline of India is approximate 7500 km long, 200 nautical mile wide Exclusive Economic Zone (EEZ), harbouring a vast extent of coastal and marine habitats. The coastline consists of headlands, rocky shores, sandy shores, barrier beaches, bays, marshy lands, and offshore Islands. Among the eight maritime states of India, Gujarat state has the longest coastline of about 1,650 km length (about 22% of Indian coastline) having about 210 marine fishing villages and the almost same amount of fish landing centers on the western coast of India.

Sutrapada Bandar is one of the fishing villages in Gir-Somnath Dist. of Gujarat. It is situated 19 km away from Veraval – one of the major fish landings canters of Gujarat. Occupation analysis showed that 90.5% of the respondents had fishery as the only occupation, 5.4% fishery main and non-fishery as subsidiary occupation, and 4.1% non-fishery main and fishery as subsidiary occupation. They have very limited information and infrastructure (Sehara *et. al.,* 1986). Therefore, Sutrapada is selected to study the ichthyofaunal diversity and fishery aspects due to its regional importance in marine fisheries sector.

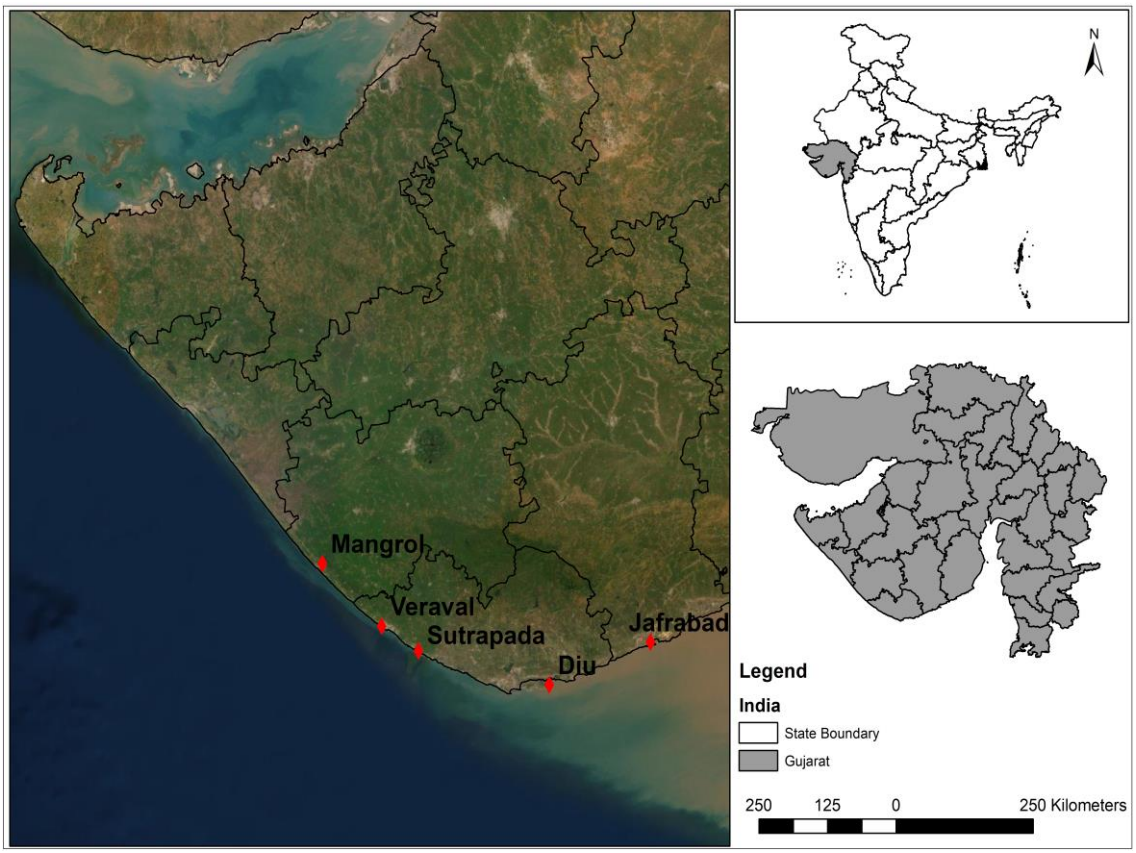

Figure. 1. Locations of Major Fish Landing Centers of South-Saurashtra Coast – Sutrapada, Veraval, Mangrol, Diu and Jafrabad.

In Sutrapada village - bander, about 381 Out Boat Motors (OBM) gillnetters are operating among which most of them are active in fishing. These vessels are made up of Fiber Reinforced Plastics (FRP). The data for the present study was collected from 23 OBM gillnetters operating off the Sutrapada coast.

Fishing season in Gujarat is of 9 months from September to May. In the remaining months fishing activities remains closed from 10 June to 15 August as per the Marine Fishing Regulation Act of Gujarat 2003 and due to monsoon and rough conditions of the sea. Data was collected of whole fishing season from September to May from 2015 to June 2019. The collection of the fishes was performed on monthly basis during winter (November to February) and summer (March to June) seasons. In monsoon (July to October) season fishing activities are closed due to safety reasons thus, no collection was performed during this period. The details of fishing operation were gathered from tandel of the boat and crew member who are directly involved in fishing as per the

Questionnaire. Periodical purposive simple random sampling was done to collect the relevant data.

The following methodology has been employed for the achievement of the desired objectives. The major components have been described below:

The criteria of collection were in the following way:

- Identification and Survey of landing center and fishing ground of an area with the help of Google maps and the Department of Fisheries and fishermen working in that area. Preparation for the field visit with proper resources for on field collection and morphological and morphometric evaluation and for storage and transport to the laboratory. Regular survey for diversity had been carried out for landing center and occasional survey of fishing ground with fishermen during fishing. Visiting the water sources in a proper time where there is a possibility of receiving large amount of fish fauna for assessment.

- Collection of the specimens according to their availability and size ratio. On field photography of the water source, fishermen working and most importantly the specimens to preserve the actual color of the fish digitally. Also, the assemblage of the important details such as GPS location of the water source, habitat of the specimens and the local names of the species found or usually found were considered.

- Interaction with the fishermen regarding the varieties of species found, annual or bi-annual catch, growth rate of fishes, any traditional knowledge of use of any species, problems encountered by them and future outcomes. Post transportation to the laboratory, the specimens were studied with detail for each of the morphological characteristics and morphometric measurements also to find out details like classification, habits and habitats, distribution and description, reproduction, IUCN status, conservational measures and if any available commercial utilization.

- Proper photography of the specimens with required background, w.r.t, to the color and size of the specimen for the purpose of future reference. Preparation of 10% formalin for long time preservation of the specimens in transparent glass jars. Storing

the specimens in properly labelled glass jars in the museum at the Department of Zoology, Faculty of Science, The M. S. University of Baroda, Vadodara.

The collected specimen had been cleaned properly. Informative photographic documentation had been done before preservation. Identification of the species was carried out using morphological features and morphometry. The authentication of the identified fish specimens was done with the help of available keys like "Fishes of India - Francis Day", FAO factsheets, www.fishbase.org. Proper care and maintenance are taken to preserve the specimen and keep it intact. 10% formalin is used for the preservation of the specimen.

To evaluate the fisheries status of the Sutrapada Fish landing center demographic data was collected for the fishermen community. Fishermen demographic archive data were collected from local fisheries office and recent data were procured through questionnaires supplied to present fishermen community. The regular visit to Sutrapada- bunder was made to understand and to collect the information/ data related with fisheries component. The wholesale price of fishes was obtained from fisherman, the information related to offseason activity was recorded. Mostly the offseason activity undertaken at Sutrapada coast is like netmaking, repairing of boats and its engine. Questionnaire was prepared to fulfil the requirements of the present study (Masani, 2012). Due care was taken while formulating the questionnaire to include all the relevant questions necessary to be answered by the respondent to fulfil the laid down objectives of the present study. The questionnaire used for the present study is given in Annexure II.

Following data was collected through the formulated questionnaires. Age-group of the Fishermen, Sex-ratio of the Fishermen, Household facilities of the Fishermen family, Literacy rate in the Fishermen community, Residential status of the Fishermen community, Government assistance received by the Fishermen community, Basic needs of the local Fishermen.

To achieve the aim of the study the objectives were set forth. Two major aspects were continuously taken care off to register accurate Ichthyofaunal diversity and Fishery and Fishermen details.

The rich marine biodiversity consisting Gujarat state is having about 306 Ichthyofaunal species (Joshi et al., 2017). Wherein, Gujarat fishery presently dominated by fishes like

ribbonfishes (*Trchiurus lepturus*), Bombay duck (*Harpodon nehereus*), croakers, carangids, threadfin breams, lizardfishes, tuna (*Euthynnus affinis*, *Thunnus tonggol*, *Katsuwonus pelamis*, *Thunnus albacores* and *Sarda orientalis*), seerfish, pomfrets, catfish, flatfishes (Joshi et al., 2017). Sutrapada being a second largest and developing fish landing center of Gir-Somnath district. It holds the 1/3rd diversity of the total diversity recorded from Gujarat. It requires focus on the diversity of the capture fishes for the conservation and fisheries management point of view. Fish diversity data will emphasize the further studies on the other biological aspects. Fisheries data is also required for the proper management of the fish production and local fishermen.

The marine fishery recourses of Sutrapada consisted exclusively of capture fisheries. The potential Fishing Zones covered and continuously visited by the fishermen of Sutrapada whereby the area covered is based on few important aspects like, available fishing crafts and men power, type of gears they operate, varieties of fishes etc. It was observed that fishing is mostly carried out up to 50 meters bottom depths due to either indigenous crafts or motorized crafts are operated with comparatively less men power. Occasionally the fishermen do visit long distances for a week duration on board trawlers.

Many collected fishes are having economic importance and sold in the local fish market. During this study period, 114 fish species belonging to two classes, 18 orders, 55 families and 93 genera were identified. The most dominant family found was Carangidae (n = 15), followed by Scombridae (n = 9), Sciaenidae (n = 6), Carcharhinidae (n = 4), Synodontidae (n = 4), Ariidae (n = 4), Clupeidae (n = 3), Engraulidae (n = 3), Nemipteridae (n = 3) and rest families constituted of single or double species. Species of family Carangidae is highly valuable commercially and also used as game fish exception with species (*Atropus atropos, Alepes kleinii, Scomberoides tol)* are of less commercial value. In the family Engraulidae, *Coilia mystus* is the subsistence fisheries where as others species are of commercial value, followed by family Nemipteridae (*Parascolopsis eriomma)* which is subsistence fisheries, from family Sciaenidae species like *Otolithoides biauritus* is a commercial whereas *Otolithes ruber* is minor commercial and *Roncador stearnsii* is for game fishing. The exception among them is the species, *Sardinella maderensis* in the family Clupeidae which is highly commercially exploited in Gujarat. As per IUCN records amongst 114 species of fishes captured and reported at Sutrapada, 71 are under Least Concern (LC), 16 Not evaluated (NE), 15 Data Deficient (DD), 04 Vulnerable (VU), 04 Near Threatened (NT) and 02 Endangered (EN) (IUCN, 2021). Solanki *et al.*

(2020) carried out a study on commercially important of marine fin fish and shell fish along Okha (Dwarka district) fish landing center, Gujarat and reported 86 fin fishes belongs to 74 genera. Out of all the recorded species, Clupeids and Carangids were higher in numbers.

Tank et al., (2019) reported the statistical information on the major fish landings at Veraval Coast, Gujarat which very close to Sutrapada. Major resources landed in the trawl net were Ribbon fish (19%), threadfin bream (18%), white fish (7%), shrimp (6%), grouper (5%) and squid (5%). The catch of ribbon fish was declining from February to April which September onwards the catch of ribbon fish was increased. There was declined in the catch during November may be due to cyclone in 2011. A high total catch fluctuations were recorded whereby highest catch was recorded during November 2010 and lowest during February 2010.

The fish market price study revealed that the fish price varies between 20 to 1,500/- per Kg. The highest price fetched fishes in the market were Jew fish (Ghol), Silver pomfret, Chinese pomfret, Indian Scad, Chinese herring, silver conger eel, Sharks, Ribbon fishes etc. The highly valued fishes mostly consumed fresh and remaining catch goes to the processing plants, from where after value addition and freezing those were exported to the other countries.

India is one of the largest fish producing nations in the World (Parmar et al. 2015). India possesses a total of 2492 marine fish species (7.4%) of total world marine fish resources reported by CMFRI (Gopalakrishnan 2017). The highest number of marine species diversity was reported from Andaman and Nicobar Island. A study reported 1,121 species from the east coast and 1,071 species from the west coast of India (Sluka 2013). The present study records 114 species which shares 4.57% of the total diversity found in India. This represents the importance of Sutrapada fish landing center in diversity as well as fisheries point of view.

Success of any fisheries depends on several aspects related to this activity and center. Sutrapada is one of the fast-developing Fisheries center in Gujarat and play a significant role as is very close to most important fisheries center – Veraval. The fisheries center is having various basic and ancillary components.

The regular interactions were carried out with the local fishermen to gather the information regarding the fishing activities, fishing trips, fishing time, post fishing activities. Fisherman from Sutrapada go for intraday as well as multiday fishing for 2 to 10 days covering areas like Mumbai, Dwarka, Porbandar, Diu etc. depending on days. For one day fishing they depart from their base at morning or noon and travels 5-6 hours to reach the fishing ground and common Catamaran type of craft is used with normally 08 fishermen group for one boat. Usually Gillnet is operated at night preferably during dark nights or after the moon has set. The net is released into the water and kept drifted with the current till the operation of net is completed. Usually, the haul made per trip was 4-5. Generally, 5-6 hours were taken for one haul. Nets are usually operated at 20-45 m depth. Fishing operations were confined to the surface and mid-depth zones at the fishing grounds. The fisherman gets back to the coast to unload the catch in the morning as well as afternoon hours.

Gill net is a traditional gear commonly operated along maritime states of India. The gillnets were fabricated by local net fishermen in a shed near the landing center or by woman at home. The fabricated nets were as per the individual requirements of fisherman and local practices. Mainly six different types of gillnets were in practice along Sutrapada coast. The nets are locally known as *chokla, patira, jada jaal, pakha jaal, ghaghra, maoul na jaal, point na jaal etc.* Mesh size, length of net and depth of net may vary according to the type of gillnet. Fisherman decided upon the type of gillnets based on availability of catch and operational seasons. Generally, they carried more than 90 net and made long chain and joining one after the other based on the condition.

The Outboard machine (OBM) gillnetters operated off Sutrapada village were Fiber Reinforced Plastic (FRP) coated. There were about 381 OBM gillnetters in Sutrapada and most of them were active in fishing. These OBM gillnetters were fitted with 2 cylinders, 8 horse power (HP) engine, which operated with kerosene. The vessel and engine specifications for OBM gillnetters operating from Sutrapada fishing village is like, the length of OBM gillnetters varied from 9.6 to 11.4 m and their breadth varied from 1.21 to 1.80 m. The tonnage of these gillnetters ranged from 1.58 to 1.6 t. They used to have one fish hold in the boats. The OBM gillnetters belong to the local fisherman.

During the study period of 2014-2017 along with the diversity study, catch composition and fish catch in kg data were also obtained from local fishermen as well as Department

of Fisheries, Sutrapada. Regular monthly field visits were carried out at the landing center when fishermen returning from the long duration fishing. At the time, fish species were observed from the landings of the particular boat. It was observed that each month, a particular boat catches 25 to 30 species in long duration fishing activity. Their preservation techniques were also studied. In which, large fishes were placed at the bottom especially bony fishes and elasmobranchs were placed at the top. In the fish hold on board, regularly reshuffling of this catch in the hold is done and fresh salt as well as ice is sprinkled. It was observed that in 2014-15, the catch of all the species were higher while in 2015-16 and 2016-17 the catch was equal and gradually decreased compare to previous year except ribbon fishes and mackerels. In 2014-15, black pomfret, sharks, cat-fishes and leather jackets were higher in catch. The gillnets fishery off sutrapada coastr was supported by White pomfret (vichuda), Black pomfret (halva), Hilsa (Palva, Chakshi), Shark (Magra) Ray, Cat fish (Khaga-khaga), Leather Jacket (Sag-Aal), Seer fish (Chhapari, Surmai), Ribbon fish (Patti, Baga), Silver bar (Dal), Perches (Kothi), Small Sciendies (Dhoma), Tuna (Setava, Gedara), Carangies/ Mackrel (Bangdi), Sole fish (Jibh), Other clupids (Palvi, Kati).

The fisheries activity solely depends on either fishermen community working by birth or skilled workers and entrepreneurs. Demographic survey to understand the status and the needs of such fishermen community is very much essential. Here we have collected data through physical survey and meetings with fishermen community of Sutrapada fishing village.

The random samplings of fishermen were carried out to check the sex-ratio and age-group involved in the fishing activities at Sutrapada Coast, Gujarat. The findings of the survey resulted that the sex ratio of local fisherman involved in fishing activity of Males was higher than Females, having 57 males and 29 females. The sex ratio of fisherman is 66.27 % of the total population is whereas 33.72% are female in Sutrapada bunder. Even though, the fishing activity is mostly done by all age groups. The larger age groups individual involved in fishing activity was between 31-40 years, gradually declining till 71-80yrs. In the survey of 86 fisherman the Sutrapada fishing dominance of age group 31 to 40 as around 32% fisherman are involved in fishing followed by 41-50 age group having 31% of fisherman than to 51-60 age group around 23% whereas in age group of 61-70 there is just 6.9% of fisherman as well as in age group of 21-30 there are just 4.6% of fisherman but only 1.2% of fisherman are involved in the age slab of 71-80. The

literacy rate of the local fisherman was higher for below 10^{th} class. The more number individuals prefer to directly get involved in fishing activity than acquiring knowledge about it. Literacy rate should be increased through the proper awareness and management. This will helpful in acquiring the proper knowledge of fishing and conservation of the biodiversity. From the random sampling during the survey of literacy rate, it was observed that the literacy rate 69.76 % of the fisherman is having education up to class 10 or below and around 30.23 % of the population is only class 10 pass whereas there are no fisherman having education above class 12.

Government assistance is the remuneration provided by the government to the local fishermen in case of any causalities, damage to the crafts and gears etc. Almost, all the fishermen received the government assistance after the application. The 72.09% of fisherman are getting the government assistance whereas 27.90% are not receiving any grant from government. The residential status of the fisherman staying in the vicinity was higher. Majorly the fishermen were having their own house and a fewer number of individuals stayed as tenant. There were some fishermen who were migratory and have moved there for some time during the fishing period. The residential status of the fisherman is around 62.79% of fisherman of Sutrapada is having their own house and around 37.20% of fisherman are on rent whereas 1% are only migrant fisherman in the village as per survey report.

The Basic needs included the internet facility which was necessary for the signalling processes for fishing activity being neglected. The other basic needs including water connection and electricity connection was better but the sewage connection was quite poor and requires to be considered by the government for maintenance. The basic facilities available to the fisherman like electricity connection to the house of 100 % of fisherman, water connection to 98.83% whereas sewage connection is just 8.1% to the fisherman and only 2.32% of the fisherman are using Internet rest are not having the facilities of the internet connection. Household facilities include basic electronic gadgets such as television, fan, radio, refrigerator, mobile (android/basic). Fan was the common gadget which was owned by all the fishermen followed by television. Very few fishermen own the refrigerator and mobile. So, economic standard is of average type of these fishermen.

Finally, it is concluded that the study reports that the coast of Sutrapada consists rich diversity of Ichthyofauna. The reported number of species are comparatively more than other major landing centers of the Gujarat (Joshi *et al.* 2018; Solanki *et al.* 2020). During observations, it was found that the catch consists of the juvenile forms of the Ichthyofauna. Commercially and ecologically fishes are very important thus the diversity of fishes needs to be conserved, values and managed properly. The present study will emphasize the proper management of the fishery and conservation of the fishes at Sutrapada coast.