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Session 16

ESTUARINE FISHERIES IN INDIA

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ECOLOGY, CLASSIFICATION AND FISH PRODUCTION POTENTIAL OF ESTUARIES IN INDIA

INTRODUCTION

- Majority of the flowing waters on the earth finally reach the sea. Near to the coast even small brooks, channels and streams join the sea after traversing small distances.
- At and near the juncture, where the river joins sea, a unique aquatic environment is created having the characteristics of both the marine and freshwaters virtually an admixture of these two environments.
- This water mass is usually called as a buffer zone or ecotone. Estuaries thus come into existence at an area of the sea coast where the river joins the sea.

- An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with freshwater derived from land drainage (Pritchard, 1967).
- **Estuaries are the transitional zones between the rivers and sea and have specific ecological properties and biological composition.**

Ecology of estuaries

Several **unique features** are seen in most estuaries with regards to the physics, chemistry, geology and biological features.

- The fast flowing rivers of upland regions lose their velocity and turbulence and become nearly still except for the changes brought about by tides.
- The depth and width generally increases.
- Waters tend to become clear due to settling of suspended matter caused by great reduction in velocity.
- The bottom of the estuary gets built up due to deposition of materials brought by the flood waters.

- Physical environmental characteristics like penetration of light and temperature change compared to shallow upland river stretches.
- Salinity, dissolved gasses and chemical nutrients again show variations from that in the upper stretches.
- The estuary shows distinct seasonal variations in several of the physic-chemical and biological characters, particularly those waters, which come under monsoonal regime. The estuary can show marine, freshwater and intermediary characters nearly freshwater during monsoon season and flooding periods, marine characteristics in pre-monsoon or summer and between monsoons an admixture feature of seawater and freshwaters.

- **Tidal regimes also influence the estuarine characters** with high tide bringing more seawater into the region and on withdrawal of same during low tide with more freshwater entering the area.
- Biologically an estuary is more unique in allowing the development of a set plants and animals that only can thrive in a buffer media of estuary. **Euryhaline organisms** capable of tolerating some degree of variation in salinity of the waters develop and thrive here.

- Estuaries thus support **freshwater life forms, marine forms and finally the brackish water forms**, capable of inhabiting waters with changing salinity features. Also, this environment will support pure freshwater forms in the upper reaches, euryhaline forms in the middle regions and stenohaline forms in areas near to the mouth. During flooding and monsoon conditions, only freshwater forms are present and during dry period or summer with no or less freshwater inflow more marine forms inhabit the region and the euryhaline brackish water forms exist during rest of the period.
- The estuaries are considered as the **highly productive aquatic ecosystems** for all forms of aquatic life including benthic forms.

- They are ideal and favourable nursery areas for a wide variety of commercially important marine finfishes and shellfishes, as the waters are more sheltered with favourable conditions for breeding and feeding. An assortment of food components, i.e. phytoplankton and zooplankton, thrive here to help for the growth and development of different fishes and shellfishes.
- Many estuaries support a thriving **commercial fishery** of brackish water finfishes and shellfishes.
- Owing to their sheltered nature, estuaries offer safe navigation and anchoring of boats and ships

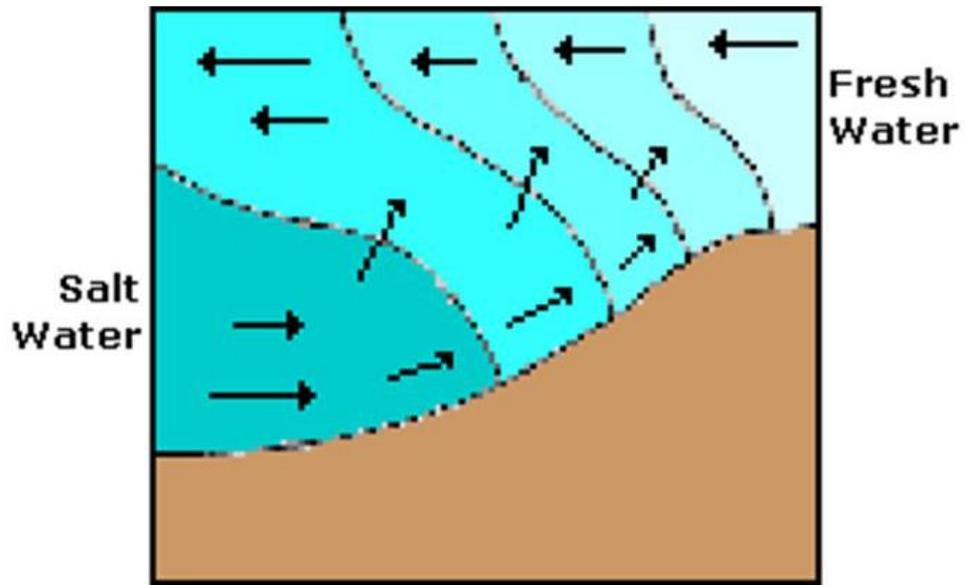
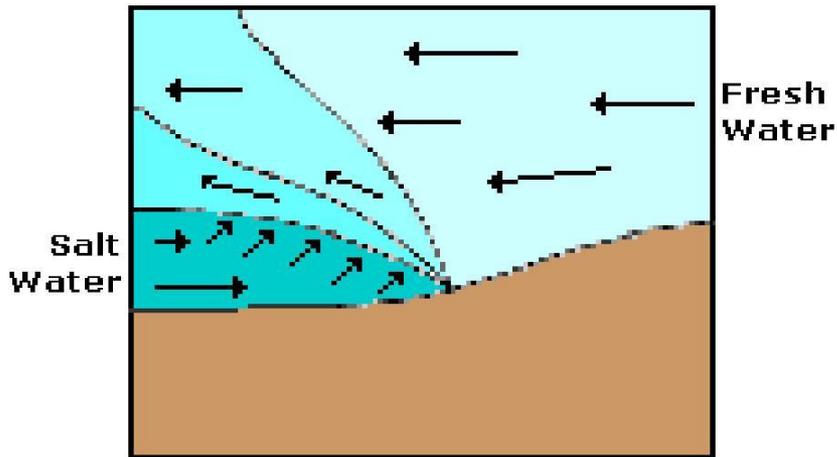
Geo-morphological classification of estuaries

Estuaries are divided into five types as below:

- 1. Saltwedge estuary**
- 2. Partially mixed estuary**
- 3. Well mixed estuary**
- 4. Fjord**
- 5. Bar-built estuary**

- 1. Saltwedge estuary:** It is formed when a river flows into a tideless sea. As the freshwater is less dense than salt water, it tends to flow over the surface of the salt water. The seawater rests on the bottom as motionless saltwedge. Hence, this is called saltwedge estuary.
- 2. Partially mixed estuary:** It is formed when a river flows into the sea with appreciable tidal movements. The turbulence caused at the meeting place, not only mixes the saltwater upwards into the freshwater, but also mixes the freshwater downwards. This dilutes the salt water near the bed and produces a salinity gradient towards the head of the estuary.

Salt Wedge

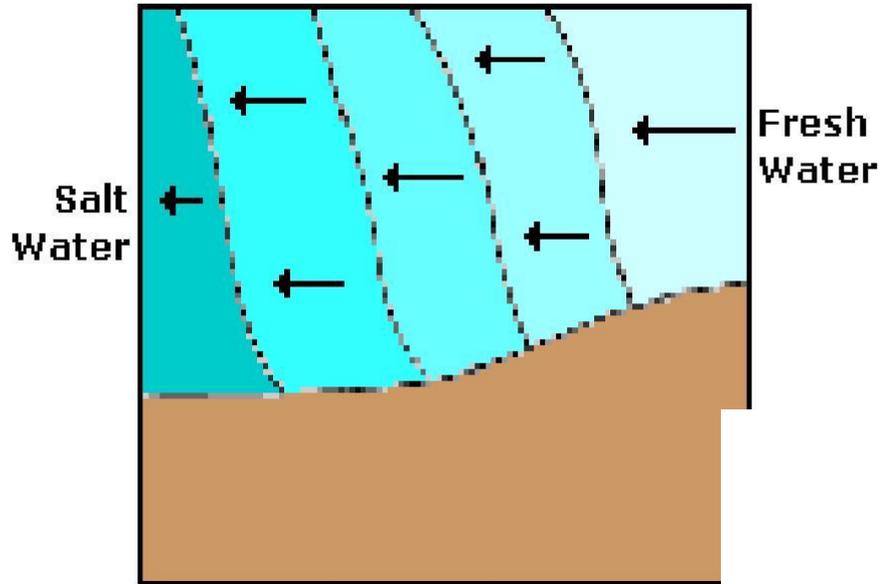


Partially Mixed Estuary

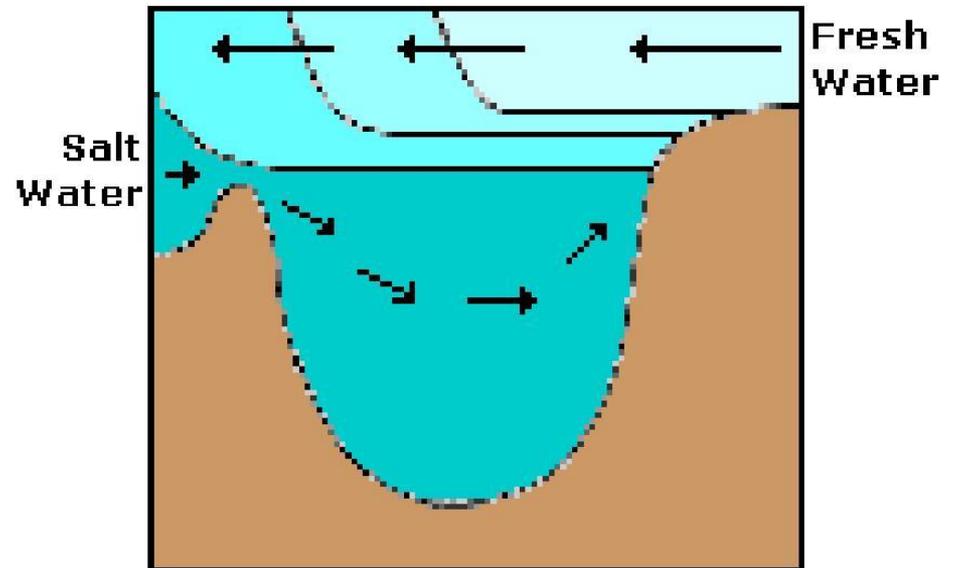
- 3. Well mixed estuary:** It is shallow with a high tidal range, and probably with intertidal mudflats or banks. The mixing is more intense. As it is shallow, there is no vertical circulation. There is a lateral variation in salinity. The freshwater tends to flow down on one side of the estuary and the saltier water enters the other side. Consequently, a horizontal residual circulation is established.

- 4. Fjord:** It is the **deepest estuary**. It can be considered as saltwedge estuary with an infinite layer. The salinity of the bottom layer does not vary significantly. The effect of tidal flow in the mixing is negligible. They often have a shallow bar of rock or silt near their mouths. The tidal flow over this can cause turbulent mixing within a limited area. There is no fjord in India.

Well Mixed



Fjord-Type Estuary



5. Bar-built estuary: It is found when offshore barrier, sand islands and sand spits are deposited about sea level. Such islands or spits extend between headlands in a chain broken by one or more inlets. The area enclosed by the barrier beach is generally elongate and parallel to the coastline. Although these estuaries have a small drainage area, they generally receive more than one river. They are shallow and wind provides the important mixing mechanism. These estuaries remain open during monsoon seasons. They remain land locked when there is no water flow in the river. Hence, they are also called **temporary estuaries.**



Bar-built estuary

Categories of estuaries

- 1. Open estuary:** It is always connected with the sea. It is located at the mouth of the river or lake. It may be perennial, filled with the water of the river throughout the year or seasonal in which the river dries up during summer, isolating the estuary from the sea. **Chilka lake** is an open estuary.
- 2. Embanked estuary:** It is a confined area of brackish water, exposed to sea only during low tides or else it may remain surrounded by continuous chain of barrier islands.
Examples: **Adyar estuary** and **Cauvery estuary** in Tamil Nadu. They are also situated in West Bengal, where it is called 'Bhasabadha' fisheries or 'Bheris'.

Based on mixing and patterns of salinity distribution caused by various factors

There are two types of estuaries:

1. Positive estuary
2. Negative estuary

1. Positive estuary: It is the one in which the influx of fresh water is sufficient to undergo mixing and there occurs a pattern of increasing salinity usually towards the mouth of the estuary. This type of estuary has low oxygen concentration in the deeper waters and considerable organic material in the bottom sediments. Vertical distribution of salinity may range from top to bottom uniformly.

2. Negative estuary: In arid regions, where the rate of evaporation in estuaries exceeds the inflow of fresh water, salinity increases in the upper part of the basin, especially if the mouth of the estuary is restricted by shoreline features that check the tidal flow. The salinity distribution in this type of estuary is the reverse of the positive estuary. Negative estuaries and lagoons are **hyper-saline** but possess a moderate oxygen concentration at depths. Bottom mud is generally poor in organic content.

Classification of estuarine animals

Estuarine animals are classified into five main groups as below:

- 1. Oligohaline organisms**
- 2. True estuarine organisms**
- 3. Euryhaline marine organisms**
- 4. Stenohaline marine organisms**
- 5. Migrants**

- 1. Oligohaline organisms:** This group includes most of the freshwater forms inhabiting rivers which cannot tolerate variations in salinity of more than 1 ‰ and which are not found at the head of the estuary.
- 2. True estuarine organisms:** True estuarine organisms are such that they are geographically restricted to estuaries only and are best represented in their upper and middle reaches in low salinities. Although these organisms have marine affinities, they have adapted themselves to tolerate a wide range of salinity.
- 3. Euryhaline marine organisms:** These organisms extend in their distribution from the sea to the upper reaches of the estuary and can tolerate salinity as low as 15 ‰. A few, however, can tolerate salinities of even 5‰. These organisms form the majority of total estuarine biota.

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4. **Stenohaline marine organisms:** These organisms live on open seashore and at mouths of estuaries. They do not enter estuaries below salinities of 25 ‰ in the lower reaches.

 5. **Migrants:** Certain euryhaline marine migrants spend only a part of their lives in estuaries. Many are predators subsisting on resident estuarine benthic organisms.

Fisheries production potential of estuaries of India

- Various estuarine systems spreading over 14.22 lakh hectare form an important component of the fisheries resources of the country.
- The fisheries of estuaries are above subsistence level and contribute significantly to the production. The average fish yield varies from 45 to 75 kg per ha.
- Estuarine fishery is the mainstay during the monsoon season when fishing in the sea, because of turbulent conditions and stormy weather, gets suspended.

- Food chains in the estuaries differ from the open sea in several aspects. A greater part of the organic production in estuaries is controlled by larger plants (macroalgae, mangroves, etc.) rather than phytoplankton.
- As consumers of the organic matter, zooplankton become less important than the suspension and deposit feeders. Organic detritus forms a major source of food for the estuarine communities. Nearly 49% of Indian marine fish catch originate from estuaries which provide indication of the dependence of marine species on estuaries in early life history.

- The National Commission on Agriculture stated that “under the term estuarine fisheries is included the fishery output from the mouth of rivers, the large brackish water lakes, the innumerable tidal creeks and backwaters along the coast and the coastal canal system.
- Fishes of brackish water are usually marine which can tolerate wide salinity changes and are called euryhaline. These are clupeids, mullets, catfishes, perches and prawns. *Mugil cephalus* forms a large part of the estuarine fishery. In addition, species that are not of commercial value also contribute to the fishery of brackish water.

- They include gar fishes, halfbeaks, eels, flatfishes, sharks, rays and oysters. **Some migratory fishes that migrate to freshwater from sea or vice versa** are also included. They include *Tenualosa (Hilsa) ilisha*, *Polynemus* spp, *Pama pama*, *Tachysurus* spp, *Pangasius* spp and prawn, *Macrobrachium* spp.



SHELLFISH FISHERIES OF BRACKISH WATERS / ESTUARIES AND POND FISHERIES

INTRODUCTION

- Some species of gastropods and bivalves are found distributed in the brackish waters, estuaries, bays, lagoons etc.
- They are the collected by the poor fishermen and fisherwomen along both the east and west coasts.

GASTROPODS

- Gastropods are mostly distributed in the shallow waters, lagoons and reef areas of the coastal sea. They are mainly reported from Gulf of Mannar, and Coramandal coast along the east coast, Lakshadweep and Andaman Islands.
- In the past, these shells were thrown out into the sea as discards. Nowadays, though they have less edible value, they find a prominent place in the commercial shell-craft industry. Many of these gastropods are exploited for food as well as for ornamental purposes.
- The shells are used in making ornaments and curios. They are used whole or cut into pieces of desirable shapes during processing. A few gastropod species are utilized as food by man.

- Demand for consumption of gastropods is not high in India, the same being limited for occasional use by poor class people including fishermen of coastal areas.
- The important species of edible gastropods of Indian coasts are *Cellana radiata*, *Trochus niloticus*, *T. radiatus*, *Umbonium vestiarium*, *Turbo marmoratus*, *T. intercostalis*, *Strombus canarium*, *Lambis lambis*, *Thais rudolphi*, *T. bufo*, *Oliva gibbosa*.
- Most prevalent practice is that the fishermen scoop out the soft body with a hooked iron rod, boil the soft body in a little brine, slice it and sun dry for future use as a fried curry. The gastropod shells with attractive shapes and colours are used as ornamental items.

BIVALVES

- Bivalves that include clams, mussels, edible oysters and window pane oyster are the shellfishes collected from the brackish waters and estuaries in India.
- The clams and mussels are not only limited to the sea coast; they often extend into muddy bottom of bays, estuaries and brackish water zones including the marshy lagoons along both the east and west coasts of India.
- Edible oysters are found in aggregated form on hard rocky or even on semi-hard sandy substrate in the bays and creeks near coastal waters. They are also available in the estuaries and other brackish water areas.

- Mostly, bivalves are collected for their meat and shell. Edible bivalves and ornamental shells gained popularity and their fishery improved after banning pearl fishing in 1961.
- During 1995-99, the average quantity of edible bivalve products exported per annum have been estimated as 580 tonnes, worth Rs.26 million and 567 t of oyster shell powder valued at Rs.1.5 million.
- The bivalve resources are mostly **under-exploited along the northwest and northeast coasts** whereas **over-exploited along the southeast and southwest coasts**

Production trends of bivalves

- The average annual production of edible bivalves during 1996 to 2000 was estimated as 1.52 lakh tonnes, about 2.5 times more than the average landings during the period prior to 1996.
- A variety of clams, oysters, mussels and windowpane oysters are distributed along the Indian coastline. They are mostly collected by the local people. Clams and cockles form 73.8%, followed by oysters (12.5%), mussels (7.5%) and windowpane oysters (6.2%). The west coast accounts for 52.3% of the landing where the catch is utilized for both the meat and the shell.
- Among the maritime states, **Andhra Pradesh is the top producer** (70,705 t) followed by Kerala (58,763 t). The production levels in other states are negligible.

Commercially important bivalves in the brackish waters and estuaries of India

Bivalves resources	Common name
Clams and Cockles	
<i>Villorita cyprinoides</i>	Black clam
<i>Paphia malabarica, Paphia spp.</i>	Short neck clam, Textile clam
<i>Meretrix casta, M. meretrix</i>	Yellow clam
<i>Marcia opima</i>	Baby clam
<i>Mesodesma glabaratum</i>	
<i>Sunetta scripta</i>	Marine clam
<i>Donax spp.</i>	Wedge clam
<i>Geloina bengalensis</i>	Big black clam
<i>Anadora granosa</i>	Cockle
<i>Placenta placenta</i>	Windowpane oyster
<i>Tridacna maxima, T. squamosa</i> and <i>T. crocea, Hippopus hippopus</i>	Giant clam

Mussels	
<i>Perna viridis</i>	Green mussel
<i>Perna indica</i>	Brown mussel
Edible oysters	
<i>Crassostrea madrasensis</i>	Indian backwater oyster
<i>Saccostrea cuculata</i>	Rock oyster

Mode of exploitation

□ Bivalve fishing

Both fishermen and fisherwomen are engaged in the bivalve collection in the estuaries, bays and brackish water lakes. Fishing methods for bivalves are simple, using non-mechanized gear ranging from manual picking to hand operated dredges.

Clams are handpicked by men and women usually during low tide. In the shallow estuaries and sandy beaches, fishers usually remove the sand by their feet or by wooden or metal plates and pick out the buried clams.

- About 50 kg of clams are fished within 3 to 4 hours daily. A scoop net made of semicircular iron frame and nylon net of 30 mm mesh size is used for fishing clams. In deeper areas, fishermen go out in pairs, dive in turns and collect clams.
- In Kakinada Bay, Shoe Dhoni is used for clam collection with a fishing trip extending from 3 to 4 consecutive days. Oysters are gathered by separating them from the rocky substratum with knife. Mussels are also collected in the similar way. For the purpose of harvesting mussels, the fishermen walk through the shallow waters and reach the beds. They also dive in the deep waters and locate the encrusted mussels. Generally knives or iron chisels, fixed to wooden handles, are used to detach them from the encrustations. They are collected into baskets or net bags, tied to their waist.



□ **Fishing season**

The fishing season is usually during the post and pre-monsoon period.

In certain estuaries of Goa, the clam fishery is mainly during the monsoon period when there is no marine fishing activity.

West coast

- The estimated landing of bivalves along the west coast is 52,537 tonnes. Kerala state accounts for 47% of the total landing of clams and cockles. Organized clam fishery takes place in Vembanad and Ashtamudi lakes in Kerala.
- Vembanad is known for the black clam, *Villorita cyprinoides* while Asthamudi is known for the shortneck clam *Paphia malabarica*. Their fishery depends on the export demand. Mussels are the second dominant group, which are gathered all along the coast.
- Of the several species of clams, *Meretrix meretrix*, known as bay clam or great clam is the most popular. They are abundant along the coast of Karnataka, Goa and Maharashtra.

- Another clam, *Meretrix casta*, is very abundant in all the estuaries and the backwaters along both the coasts.
- Oyster fishery is limited to certain estuaries like Dharmadam, Vembanad Lake, Kayamkulam and Ashtamudi Lake. Clams and oysters are very popular in Karnataka where the fishery is conducted in the major estuaries like Udayavara, Mulky and Gurupur.
- Recently, the demand for green mussel has increased and about 2,000 tonnes of *Perna viridis* were landed during 2000. Information on the bivalve fishery and exploitation along the northwestern states is scanty. Nauxim Bay is famous for the fishery of windowpane oyster where about 8,000 to 10,000 oysters are gathered every day.

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- In Maharashtra, bivalves are collected only in certain regions like Ratnagiri coast. Windowpane oysters and edible oysters are the main bivalve resource of Gujarat. However, there is no well organized bivalve fishery in these regions.

East coast

- Tamil Nadu, Pondicherry and Andhra Pradesh are rich in bivalve resources. However, their utilization for human consumption is very negligible.
- Information on bivalve fishery in the northeastern states like Orissa and West Bengal are not available.
- Very extensive beds of clams are found in various sites of Tamil Nadu coast including Adayar and Athankarai estuaries, Andhra Pradesh coast. The clam, *Meretrix casta* is common along the east coast also. Some other species such as *Katelysia opima*, *Paphia* and *Gafrarium* are also found in good numbers in coastal areas.

- The Andaman and Nicobar Islands have several bivalve resources among which the black lip pearl oyster, *Pinctada margaritifera*, the giant clams *Tridacna maxima*, *T. squamosa*, *T. crocea* and *Hippopus hippopus* are gathered for the tourism based ornamental shell industry.
- *Perna viridis* and economically important clams like *Paphia* spp. are used occasionally. In the Lakshadweep Islands, local people collect the giant clams

Utilization

- The bivalves are utilized in various forms such as frozen, dried, pickled and canned clam and mussel meat, oyster shell powder and other ornamental shells.
- Bivalve meat is consumed along the west coast. Smoked and canned oysters are found in big cities.
- In Kerala and Andhra Pradesh, clams are also used for preparation of artificial shrimp feed or directly as shrimp feed.

- Shells of bivalves are used for the production of cement, calcium carbide, sand-lime bricks and lime.
- The lime shell is used as manure, as mortar in building construction, as a pesticide by mixing with copper sulphate, in the effluent treatment and in glass, rayon, polyfibre, paper and sugar industries.
- Attractive bivalve shells are used and traded for ornamental purpose.

Conservation and management

- Bivalves are one of the least managed fishery resources along the Indian coast.
- There is no proper regulation for effective utilization and conservation of bivalve resources.
- Sexually mature bivalves with high reproductive potential constitute bivalve fishery. Indiscriminate exploitation of young clams and mussels take place in some states, especially in Kerala and Andhra Pradesh. Efforts for fishing bivalves can be enhanced in majority of the states