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Fishing Gear and Methods of the Lower Mesopotamian Plain with Reference to Fishing Management

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Abstract

Marine and freshwater fishing gear and methods are described from the lower Mesopotamian plain. In this region, there are four main fishing methods in the marshlands and three in the local marine habitat. The most popular fishing technique in those areas is the use of nets. Both active and passive fishing gear are categorised in the studied area. Locally-designed fishing methods by Marsh Arabs are also described. Although the Marsh Arabs seem to stick to the traditional fishing gear and methods, such gear is not efficient enough to provide a catch that can maintain better income for the fishers. To the contrary, fishers operating in the marine habitat of the lower Mesopotamian plain use fairly up-to-date fishing gear and techniques. The marshland restoration plan through its ecocultural restoration steps will save the tradition and heritage of the Marsh Arabs in particular and the Iraqis in general by enabling the fishers to use their traditional fishing methods and gear whenever these are compatible with good conservation practices.

The effect of each type of fishing gear and methods is discussed from a conservation point of view. In addition, several conservation issues were raised and discussed, i.e. non-target animals and by-catch. Non-target animals were usually associated with the target animals and were usually caught with them and then destroyed. By-catch is usually thrown away into the sea or left on the bank of the marshlands after the net is pulled out. Responsibility for checking mesh size and issuing fishing licences at the present time is loose and not controlled. Fishers in both marshlands and marine habitat are currently working without any regulations.

Fishermen in the lower Mesopotamian plain are well familiar with the boundaries of the fishing grounds and respect these as a part of their tradition. The fishing grounds that are characterised by species of high value are usually owned by the stronger tribe or exploited by companies that use better fishing vessels. Social and religious factors were shown to have marked effects on the fishing activity, which can, in turn, confound fisheries assessment.

Traditional management systems can be implemented in the marshlands. Such systems are still operational in spite of the population growth, changes in legal systems, urbanization, commercialisation and technological change.

The impact of fishing activity on the aquatic habitat was studied in the marshlands and the marine habitat. It is clear that there is a substantial impact on the aquatic habitat by artisanal and modern fishing methods and gear.

Further suggestions for fisheries management and steps for the rehabilitation of the aquatic environment are put forward to help future workers to understand these problems. Such suggestions are discussed in relation to the nature of the environment in both the marshlands and the marine habitat and the way of life of the people living in those areas.

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Introduction

FISHERIES MAY PLAY A VITAL ROLE in providing food, income and employment in many parts of the world (Jennings et al., 2001). Fishing is a profitable and effective way of getting food, since artisanal fishermen only harvest what they need.

Mesopotamia lies in the northwestern part of the west Asian subregion (Sino-Indian Region) (Almaca, 1991). The region of the lower Mesopotamian plain is characterised by its unique geographical situation. It is bounded by the northwest corner of the Arabian Gulf and its northern borders face the greater marsh area of Iraq (30° to 33° N, 45° to 48° E) (Figure 1). There have been two main competing theories of how the characteristic features of the region developed. Lees and Falcon (1952) insisted that there was no evidence that the northern extent of the Gulf had ever varied significantly from its present limits since the early Pliocene. They asserted that the Tigris-Euphrates-Karun Delta had been very stable during the Quaternary period, without appreciable progradation of the delta, due to a delicate balance between subsidence and deposition of sediments (Sanlaville, 2001). Later studies, especially those of Larson (1975) and Sanlaville (1989), criticised their assertions. More recently, Aqrawi (2001) stated that plotting his own radiometric dating results for lower Mesopotamia (Aqrawi, 1993) together with others' results from Bubiyan Island (Al-Zamel, 1983) and from the Fao Peninsula and other world regions (Godwin et al., 1958) confirmed the global Holocene sea-level changes theory rather than the regional tectonic subsidence hypothesis of Lees and Falcon (1952). The largest marsh, Hawr al-Hammar, has a historically recent origin that goes back to about 636 A.D. (Banister, 1980; Berry et al., 1970, Rzóska 1980).

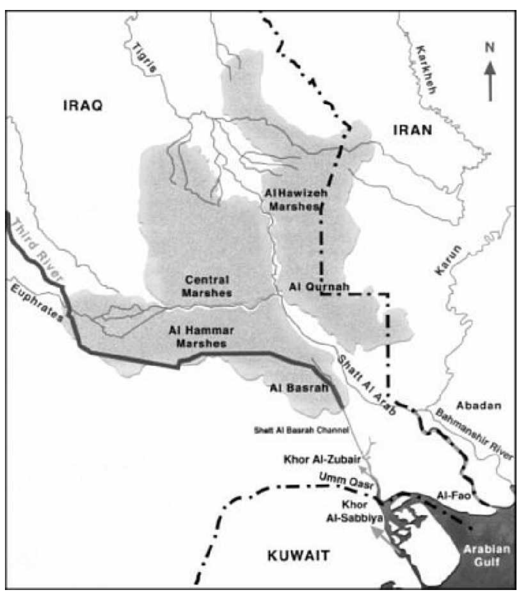


Figure 1. Southern marshes of Iraq (Al-Yamani et al., 2004)

The Mesopotamian marshlands once constituted the largest wetland ecosystem in the Middle East and Western Eurasia (Maltby, 1994; Nicholson and Clark, 2002). The Mesopotamian marshes are important for economic, social, and biodiversity values characterised by frequency of water flows, accumulation of nutrients and organic matter and the production of commercially important vegetation and fish (USAID, 2004). Marshes serve a variety of functions for human and other ecosystems including: acting as huge settling tanks for the silt deposited by the Tigris and Euphrates Rivers (Wilson, 1925); acting as a natural filter for water and other pollutants in the two rivers (Partow, 2001); acting as a natural sponge storing water during high river flow and releasing water during low flow; creating nursery grounds for fish and aquatic birds and refuges for terrestrial animals (USAID, 2004); and being highly productive in vegetation cover (e.g. reeds) harvested commercially for building material, mats, and cattle forage. They are an important stopover along the inter-continental flyway of migratory birds, support endangered species, and sustain freshwater fisheries. In addition, they have been home to indigenous human communities for millennia and are regarded as the site of the legendary "Garden of Eden" (Eden Again Project, 2003).

Besides the water masses of the marshlands and the north west regions of the Arabian Gulf, there are two more main water bodies in the area that contribute to the local freshwater/sea water fish industry: the Shatt al-Arab River running through Basrah City, and the Shatt al-Basrah Canal connecting the marshlands to the Arabian Gulf area (Al-Hassan & Hussain, 1985). The connection between the marshlands and the Arabian Gulf is quite strong. The coastal fisheries at the north of the Gulf depend mainly on the flow of nutrients from the marshlands through the Shatt al-Arab River. On the other hand, the marsh area represents a spawning migration and nursery grounds for the most commercial penaeid shrimp, *Metapenaeus affinis*, and a number of migratory fish species such as *Tenualosa ilisha* and *Nematalosa nasus* (UNEP, 2000, Al-Hassan et al., 1989).

The variety of water masses and habitat diversity is associated with great fish biodiversity in the area. This is evident through the fish catch on offer at the central fish market at Basrah City. On the other hand, the habitat diversity allowed the native people of the lower Mesopotamian plain to use different types of fishing gear. Two strictly different groups of fish were fished in this area, freshwater fishes from the main rivers and the marshlands and marine fish species from the northwest region of the Arabian Gulf. According to Ali et al. (2005), sixty-six fish species inhabit freshwater systems of Iraq while 440 species are marine, and 16 species inhabit estuaries. However, the number of fish species reported by the authors is not yet taxonomically confirmed. Of these marshland species, Table 1 shows the common commercial fish species of the marshlands.

Most traditional fishing methods and management patterns are still applicable at the present time. A clear example of such issues can be drawn from the artisanal fisheries in the Arabian Gulf area (Al-Yamani et al., 2004). However, there are a number of obstacles that might face the encouragement to use them. Among these obstacles are the social and educational levels of the fishers operating in the lower Mesopotamian plain and the managerial level of the fisheries authority that will be responsible for control and implementation.

The aim of the present study is to review the fishing gear methods used by people of the lower Mesopotamian plain and to report on the future issues of fisheries management in this area.

Table 1. List of the commercial fish species occurring in the Iraqi marshlands. Species are arranged according to their importance as food.

Scientific Name	Common Name
Barbus sharpeyi Gunther	Bunni
Barbus xanthopterus (Heckel)	Gattan
Barbus luteus Heckel	Hemri
Aspius vorax Heckel	Shalik
Carassius auratus (Linnaeus)	Samti
Ctenopharyngodon idella (Valenciennes)	None
Cyprinus carpio Linnaeus	Samti
Hypophthalmichthys molitrix (Valenciennes)	None
Tenualosa ilisha (Hamilton)	Saboor
Liza abu (Heckel)	Khishni
Nematalosa nasus (Bloch)	Jafoota
Silurus triostegus Heckel	Gerry
Alburnus mossulensis Berg	Samnan
Mugil dussumieri (Valenciennes & Cuvier)	Biah

Historical perspective

Fish have been the major food item in Mesopotamia over the last 5000 years apart from milk and grain. Fish were considered as one of the sources of early human civilization in the Euphrates and Tigris Rivers with their tributaries and coastal waters of the Arabian Gulf (Sahrhage, 1999). Many kinds of fish are mentioned in administrative documents from the third millennium B. C. up to the period of the first dynasty in Babylon. A Sumerian text from about 2000 B. C. describes the habits and appearance of many species of fish in some detail (Saggs, 1962). The inhabitants of Babylonia were no less interested in the observation of animals, and fish were as accurately and recognizably depicted on the bas-relief as were contemporary mammals.

Ancient people of Mesopotamia had skilful ways of preparing fish for food that included eating it fresh, salted, smoked, and dried in the sun (Maspero, 1896). Fish was not just considered a food for the poor people, but was also included in the menu for the palace of kings of Mesopotamia (Postgate, 1994). Moreover, it was included among the food that was offered to the gods in temples (Saggs, 1987). Fishermen were actually found in large numbers amongst the temple personnel, being divided into “freshwater fishers,” “sea fishers,” and “fishers in salt waters.” The latter group denotes fishermen operating in the tidal lagoons of the delta of the Tigris and Euphrates Rivers. According to the code of Hammurabi, fishermen were given some rights similar to those given to certain classes of society like priestesses and merchants (Postgate, 1994). Fishing techniques such as spearing, harpooning, angling, and the use of baskets and various other types of nets were already well developed during the time of ancient Mesopotamia (Sahrhage, 1999).

Fishing gears and methods of the lower Mesopotamian plain

Iraq has the richest water resources among countries in the Middle East due to the presence of the two great rivers Tigris and Euphrates, smaller rivers such as Shatt al-

Arab and Shatt al-Basrah, the great marshland area, and the northwest sector of the Arabian Gulf. As a consequence, fisheries resources, both freshwater and marine, are an important source of revenue for the country. Fish production is remarkably low throughout the region due to use of old-fashioned fishing gear and methods which are not sufficient to fulfil the continuous demand of this vital commodity (AOAD, 1986).

It is not only important to know the description of the traditional fishing methods used in the marshlands, but it is also important to understand that such methods are among the Marsh Arabs' tradition and culture. They are also considered so for the Iraqi national heritage. At the present time and with the start of the ecocultural marshlands restoration, such tradition and heritage will be restored.

Fishing gear is conveniently divided into two broad categories based on the method of capture: active gear that is propelled or towed in pursuit of the target species, or passive gear, which target species move into or towards (Table 2) (Jennings et al., 2001). There is a multitude of different net designs, each developed to catch particular species or for fishing in a particular environment (Von Brandt, 1984, Sainsbury, 1996). More specifically, Botros (1968) divided fishing gear into three main groups, i.e. entangling, luring and pursuit. Both active and passive primitive gear and methods are used to catch fish in the lower plain of Mesopotamia, where the native people of the marshlands follow their own fishing methods that they invent (Al-Khait, 1978). Differences in the fishing areas within the lower Mesopotamian plain will directly affect the type of fishing gear and methods to be used. Sometimes different gear and methods were used at the same place due to such factors as the behaviour of target fish and the nature of the bottom.

Table 2. Fishing methods, number of fishermen required, period of fishing, and amount of catch in the lower Mesopotamian plain.

Fishing Methods	No. of fishermen required	Period of fishing (hours)	Amount of catch
Surface Gill Net	2-4	3-5	6-11 Kg
Seine Net	15-20	5-7	500-2500 Kg
Cast Net	1	variable	2-3 Kg
Pot trap	1	variable	2-4 fish
Spear	1	1-2	One fish
Hook & Line	1	variable	One fish
Long Line	1-2	6-10	30-40 fish
Drift Net	6-8	2-3	10-15 Kg
Gargoor Trap	2-3	8-10	9-12 Kg
Valve Room Trap	3-4	8-14	9-15 Kg
Milan Trap	3-4	24-36	15-20 Kg
Hadra Trap	3-4	24	10-15 Kg

People in lower Mesopotamia fish in all seasons, but fishing becomes very heavy from March to May when there is internal migration of a member of the carp family (Cyprinidae) toward the marsh area for reproduction (Al-Hamed, 1966). This phenomenon is locally known as "Zara" (Arabic local dialect for schooling).

A. Fishing gear and methods in the marshlands and rivers

I. Nets

1- Surface Gill Net (Figure 2): Surface gill nets derive their name from their main method of capture. Their simplicity of construction and operation makes them one of the most basic and widespread methods for fishing in the inland waters and the preferred method in most lakes. In addition, gill nets are vulnerable to poaching and operators frequently spend the night watching over their gear (Wellcome, 2001). Gill nets are among the most selective fishing gear with respect to the size range of target species captured. They can be highly selective for size classes of the target species provided the net is well serviced and tended regularly. As fish attempt to swim through the mesh of the net, they become snagged by their gill operculum, fins or by their scales. Small undersized fish usually are able to swim through the mesh unharmed, whereas excessively large fish are unable to penetrate the mesh sufficiently to become trapped. Gill nets are basically a series of panels of meshes with a lead footrope and a headline with floats.

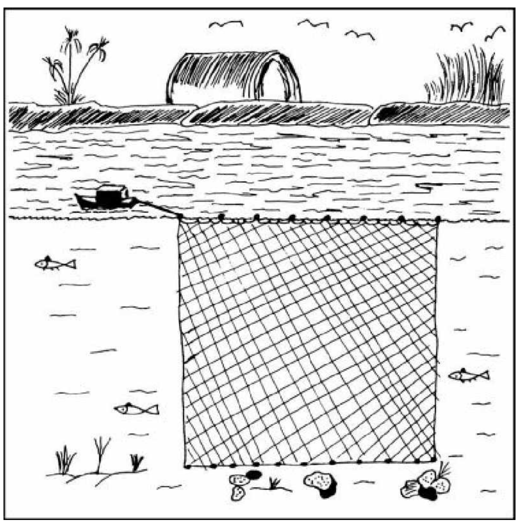
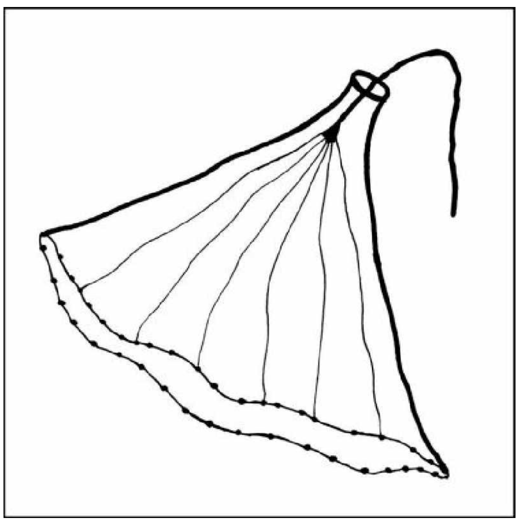


Figure 2 (left). Surface gill net. A small boat is usually used to operate this type of net.
Figure 3 (right). Seine net. Several people need to operate this large and heavy net. (Al-Yamani et al., 2004)

Fishermen in the lower reaches of the Tigris and Euphrates rivers, the Shatt al-Arab River, and the Shatt al-Basrah Canal also use these types of nets. The usual gill net size used in the marshland is 180 x 270 ft. Headline floats are made of pieces of date palm stems, while the footrope is weighted with small stones rather than lead. Different construction methods are used for nets with different mesh sizes. The common legal gill net is called “Suba’e” (Suba’a: Arabic for seven), where there are seven mesh holes to the foot. The illegal gill net is called “Hedash” (Heda’ash: Arabic for eleven) where there are eleven mesh holes to the foot. The latter are considered illegal due to their small mesh-size, which can capture the undersized fish. The locals in the shallow marsh areas characteristically direct fish towards the net by using noise generated by hitting empty tins to lead fish toward the nets.

2- Seine Net (Figure 3): Seine nets are encircling nets of various types. The main two seine nets are the purse seine and the Danish seine net. The former is for encircling schools of fish on or very near the surface, and the latter is for bottom schooling fishing. The usual size of this net used in the marshlands ranges between 400-1000 meters long and 6-7 meters in height. The full efficiency of this net can yield 500-2500 kg of fish (Al-Khait, 1978). There are usually 20-50 pockets connected to the main panel of the net. The local people of the marshlands anchor one end of the net to the shore while the other end is taken away by small boat, paying out the net in a circle, eventually returning to pick up the anchored end before hauling. The fish captured using this technique are usually landed in excellent condition, because they spend little time in the purse, and command a high price at market. The effectiveness of fishing is partly due to the movement of the warps across the bottom, which disturbs and guides the fish within the area being worked. Several species of fish are energetic jumpers and may escape by leaping over the net as it is closed. Sometimes illegal small-meshed nets are used in the area.

There are several types of seine net used in the inland water bodies in southern Mesopotamia, all depending on the size of the mesh.



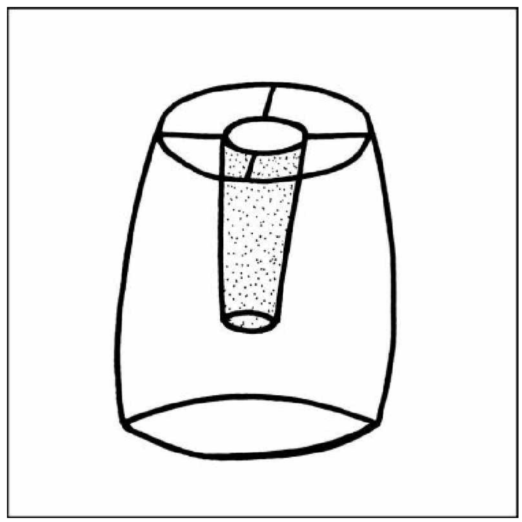


Figure 4 (left). Cast net. One person operates this net.
Figure 5 (right). Pot trap.

3-Cast Net (Figure 4): The cast net is circular, measuring from 5-6 meters in diameter, with bars of lead attached to the edge, and is used by a single fisherman. The cheapness and transportability make cast nets one of the most common gears in inland water fisheries. They are popular with artisanal and subsistence fisheries. There are over 20 brail lines attached to a 9-meter hand line made of sash cord, which causes the net to pouch or bag around the trapped fish with the help of the lead at the edge of the net. One end of the hand line is tied to the wrist to leave both hands free to throw the net. The fisherman either stands in shallow water or in a boat and throws the net forcefully out onto the water, where it lands like a parachute and sinks to the bottom. Cast nets are selective for lower size ranges, and larger, faster-moving fish can escape the falling net but may become entangled in the process (Wellcome, 2001). The catching efficiency may be improved by the addition of pockets at the circumference. The cast net for big fish has a larger mesh and heavier sinkers. The marshlands native people usually retrieve the catch by taking the net up into the boat with the catch inside. There are some illegal versions of this net where a small mesh size is used.

II. Pot Trap (Figure 5)
Pot traps are among the most primitive of fishing implements and have remained little changed. Generally, traps take advantage of the movements of fishes along a tidal gradient or migration route. This type of trap is basically designed to catch crustaceans, but the native people at the marshlands found it good for catching fish. Most pots are similar in design: comprising a ridged frame usually made of palm leaves, with a mesh covering in which there is a single entrance. The entrance is fitted with baffles to prevent animals from escaping. Pot traps are mainly used at the time of breeding migration.

Pots are usually deployed randomly with both ends anchored and marked by a surface float of date palm bark. Most local fishers use "dough" or a piece of unwanted fish as bait. Pots tend to be set for longer than other gear, as it takes time for the bait within the pot to begin to attract the target species. Catch rate increases over several days as the feeding activities of animals consuming the bait increases the dispersion of attractant odours. The most potent attractants released by the bait are amino acids and adenosine triphosphate (ATP) (Zimmer-Faust, 1993). Pots buoys characteristically bear the owner's mark, and individuals from different Marsh Arab tribes generally respect pots of the other tribes and do not poach them. This behaviour arose from their religious and cultural origin.

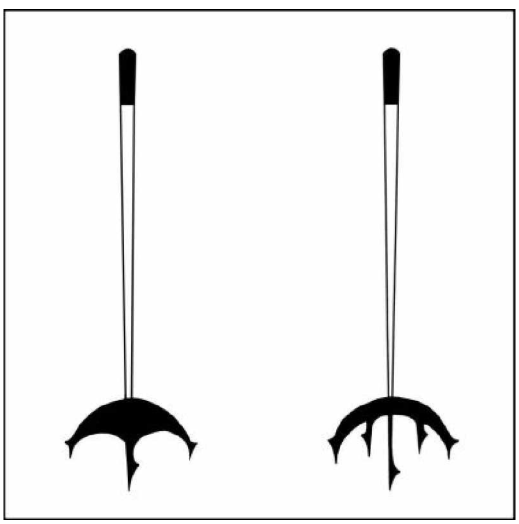
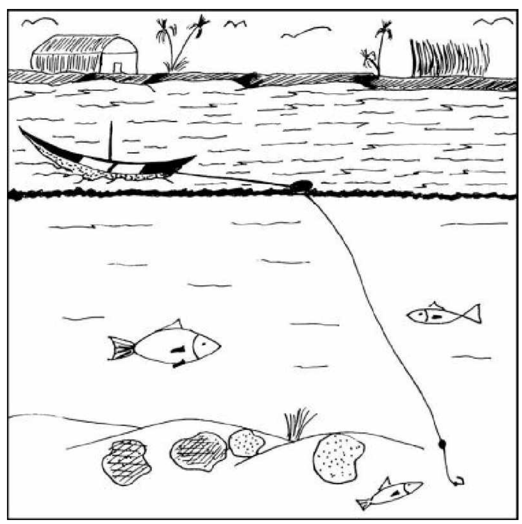



Figure 6 (left). Different types of spears used in fishing by Marsh Arabs.
Figure 7 (right). Hook and Line, a famous personal fishing method in the lower Mesopotamian plain.

III. Spears (Figure 6)
The use of spears to catch fish is among the most ancient forms of hunting and they are still used to the present day. Sumerians and Babylonians used spears of various designs to catch species of barbel in the rivers and marshlands of southern Mesopotamia (Saggs, 1987). Similar spears are in use by modern Ma'dan tribes (Marsh Arabs) (Hadid and Al-Mahdawi, 1977).

The type of spear usually used in the marshlands is generally comprised of a 2-meter handle, usually of hard palm tree wood, tipped with single or multiple pointed heads. The spear is used from a standing position in a small canoe. Most of the time, the fishermen throw some food items in the water to attract fish. This fishing method is used mainly at night where fishermen take with them an oil lantern to attract fish to the surface of the water. Spear fishing is a quick fishing method, but it is dangerous from a hygiene standpoint, as the spear head is seldom clean and may contaminate the catch. This becomes evident when the longer the catch remains before eating or selling at the local market. Marshlands fishermen often sell their spear fishing catch at the nearest city fish markets, which are often overseen by regional health and safety officials.

IV. Hook and line (Figure 7)

The ancient Mesopotamian people used this type of fishing method, different types of hooks having been discovered during the excavations in both Sumeria and Babylonia (Sahrhage, 1999). They are also mentioned in the writings of the ancient Mesopotamians (Contenau, 1954). At the present time, Mad'an tribes living in the marshlands of southern Iraq use similar types of hooks to catch fish. Instead of lures, the local people use various baits such as meat, small fish and dough in their hook and line fishing gear. Movement of the line when fish are eating the bait is indicated by a piece of date palm bark connected to the line and floating on the surface of the water.

In the centre of the marshlands, Marsh Arabs have a few other primitive methods of catching fish (Al-Khait, 1978). These are:

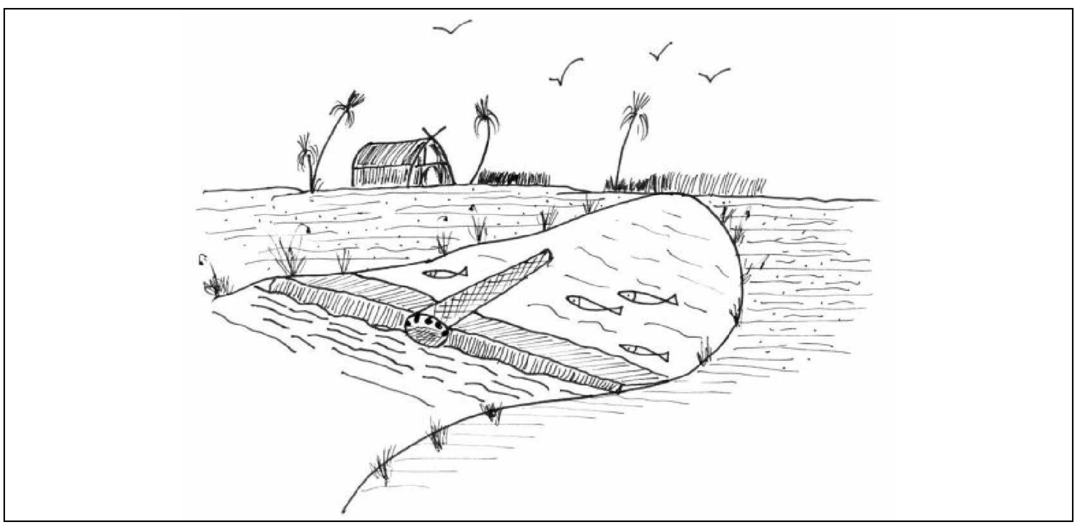


Figure 8. Al-Shiah (Mud Dams) fishing method. A unique fishing method used by Marsh Arabs.

A- Al-Shiah (Mud Dams) (Figure 8): In this very primitive fishing method, the fisherman makes a small mud dam across an enclosed water area and covers its entrance with a net made of cotton threads. The hole in the net is designed to let the fish in only. On the top of the net, near the surface, the fisherman usually fastens some empty tins so that they make noise when the net moves as the fish enter. Then the fisherman jumps in the enclosed area and catches fish by hand or encircles them with a piece of cloth.

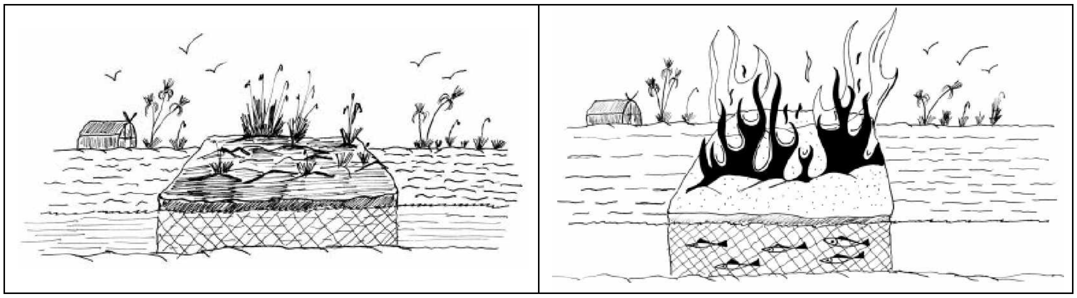


Figure 9. Al-Suwaise (Burning fishing method). a. (left): Selected small reed island with net surrounding its base. b. (right): Island on fire; fish swimming to the edges of the island where they are caught by the net.

B-Al-Suwaise (Burning Method) (Figures 9a, 9b): In this method, the fisherman chooses a small reed island, encircles it with a net, and then sets fire to the reeds. Fish will move away from the shore of the island towards the net.

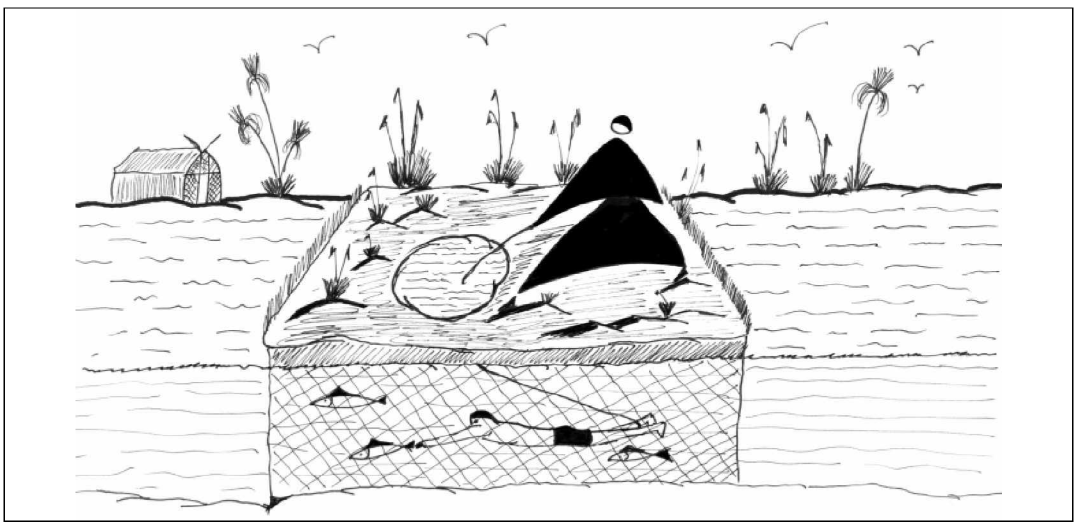


Figure 10. Al-Tawamees fishing method. Man standing on the top of a small reed island holding a rope tied to the ankle of another man diving below trying to catch fish.

C- Al-Tawamees (Fishing by diving) (Figure 10): Small reed floating islands are selected for this type of fishing. More than one fisherman is involved in this operation. A hole is dug in the floor of the reed island by one of the fishermen, whilst the other ties a rope to his ankle. He then enters the water through the hole, leaving the other fisherman to hold the rope. This is used as a guide to the diver to surface. The fish are caught by hand one at a time. The diver paralyses the fish by bending, breaking its backbone.

D-Al-Zahar (Fishing with poison): The marshland Arabs have a very thorough knowledge of the nature of the aquatic plants living in their areas. They knew them by local names given by their ancestors over the long history of the marshlands, the names relating to the physiological action of the individual plant species. They also knew what could be extracted from each plant and for what purpose it could be used. The common name of the plant that they usually used as a poison to kill fish is "Neem" (*Azadirachta indica,* Family: Miliaceae). They usually crush the plants and mix them with dough and spread it on the surface of an enclosed water area. Fish of different sizes and types will be affected by the poison and float to the surface of the water killed or temporarily anaesthetized. Most poisons affect the gills of the fish and the flesh is generally safe to eat, although when pesticides are used residues may accumulate in the fish flesh to toxic levels. The number and size of the fish depend on the concentration of the chemical present in the plant. The catch from this method of fishing usually fetch higher prices because the flesh is undamaged and very difficult for the non-expert people to tell whether the fish had been poisoned or not. Marshland fish caught with chemicals are easily recognised by their reddened eyes and swollen abdomens. Sometimes fishermen agitate the mud at the bottom of the marsh to liberate hydrogen sulphide gas, which suffocates fish and makes it easy to catch them by hand or by encircling them with net or a piece of cloth.

B- Fishing gear and methods in the marine territory of the Lower Mesopotamian Plain

The southern Mesopotamian plain borders a coastal zone of the Arabian Gulf of about 105 km extent. This zone consists mainly of intertidal mudflats backed by bare silt flats, often with an intervening narrow strip of date gardens. The most extensive mudflats occur in a huge tidal basin, Khor al-Zubair, near the border with Kuwait, and along the north shore of Khor Abdullah west of the region of Fao city at the mouth of the Shatt al-Arab River.

The native people of the southern part of the lower Mesopotamian plain follow different types of fishing methods from those living near the inland water bodies. These differences are due to the nature of the habitats and fish species composition of this part of Mesopotamia.

Estuarine and marine fishing environments occur near Fao city, where fishermen have the choice to fish in both habitats. For higher commercial catches, fishermen mainly operate in the deeper marine water around Fao city rather than at the estuary of the Shatt al-Arab River. They use the same fishing gear and methods as other Arabian Gulf States fishermen, which are as follows:

Long lines (Figure 11): The gear consists of a length of line, wire or rope to which baited hooks are attached via shorter lengths of line. Long lines are highly selective as a result of hook size, and unwanted catches of invertebrates are rare. Long lining is one of the oldest fishing methods in the northwest region of the Arabian Gulf, and both professional and amateur fishermen practice it. Professional fishermen usually use a large wooden boat locally known as a "Hadak" (an Arabic word describing the action of sitting waiting for the fish to be caught on the line). Different types of artificial threads and vast numbers of lures were used in this method, depending on the type and size of the target fish species. The maximum number of lines for each boat is usually ten. For the bottom species of fish, fishermen usually used longer line connected with multiple hooks and provided with large sinkers to keep it in place near the bottom. The fishing operations take place in both morning and afternoon, and the fishing trip lasts for 2-4 days depending on the distance to the nearest port and the amount of ice available on board to keep the catch fresh. This method usually targets sharks, cobia (*Rachycentron canadum*), barracuda (*Sphyraena* spp.), croakers (*Otolithes* spp.), and the emperor fish (*Lethrinus* spp.).

1- Drift net: This method is similar to the method of gill net in the mechanism of catching fish. Small wooden boats called “Boam” or “Dhow” (Arabic for owl) reaching 20 meters in length were made especially for this type of fishing. The length of the net reaches 60 meters and width varies between 4 and 6 meters. Date palm barks are usually used as floating material fixed to the upper line while stones are used as sinkers to keep the net spread open in the water. The fishing boat usually spends 2-3 hours in each fishing area. Eight fishermen are involved in lifting the net and the catch from the water: three to pull the upper line, three to pull the lower line, and two to collect the catch entangled by the net and to prepare the net for the next throw.

The species targeted by this method are the Indian shad (*Tenualosa ilisha*), silver pomfret (*Pampus argenteus*), and dorab wolf-herring (*Chirocentrus dorab*).

3-Traps: As in inland water bodies, traps are used in the marine territorial area bordering southern Mesopotamia, and are considered among the most common trap fishing methods in the Arabian Gulf area. Four main types of traps are in use in the area. Trap fishing gears are either movable or fixed. The movable traps include the Gargoor trap, whereas the movable traps include the valve room trap, Milan trap, and Hadra trap.

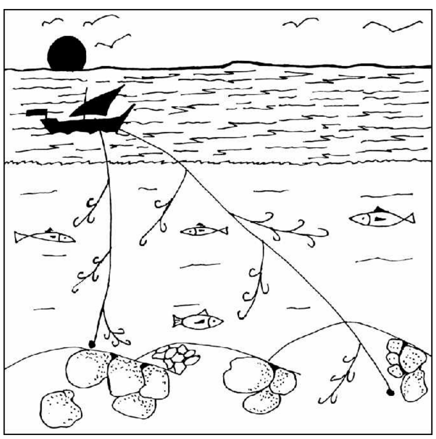
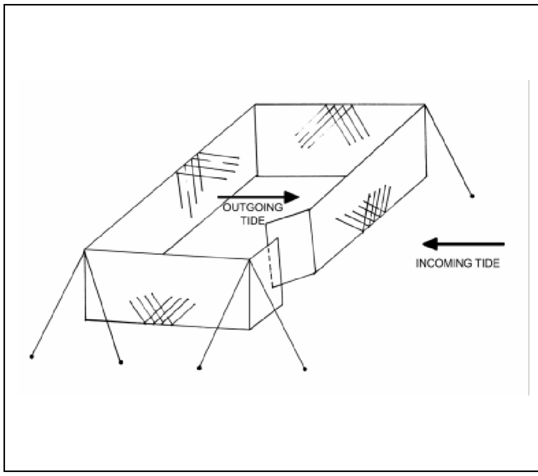


Figure 11 (left). Long lines fishing method.
Figure 12 (right). Gargoor traps (Al-Yamani et al., 2004).

A- Gargoor trap (Figure 12): This is the most commonly used movable trap in the northern part of the Arabian Gulf area. Fishing boats are usually seen carrying several gargoor traps on their deck on their way to the fishing grounds. This artisanal fishing method is commonly used by the native people of southern Mesopotamia. The gargoor trap is usually constructed as a small chamber in the shape of a hemisphere with a one-way inwardly tapering conical entrance.

The floor of the trap is made of pieces of wood and a mesh of wire, while the roof is made of arches of stiff wire supporting an outer wire mesh. A large stone is usually put inside the trap to keep it at the bottom (Al-Kholly and Solofiuof, 1980). The trap is baited inside the dome, usually with fish. The top of the dome is connected to a rope fastened to a float such as a large plastic container. Five to ten traps are put in each fishing area, the number used depending on the size of the fishing boat. Each trap will be located about 50-60 meters apart. Traps were usually marked to indicate their owner and are not poached by other fishermen, in accordance with the teachings of Islam.

This method is used to catch large fish species such as grouper (*Epinephelus* spp.), emperor fish (*Lethrinus* spp.), sparid fish (*Argyropus* spp.), and sweetlip (*Plectorhynchus* spp.).



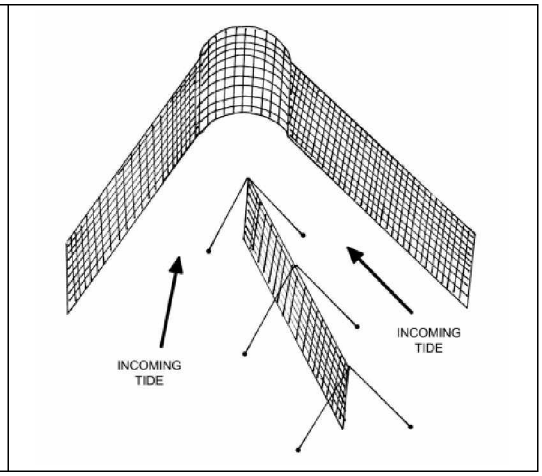


Figure 13 (left). Valve room trap.
Figure 14 (right). Milan trap.

B-Valve room trap (Figure 13): the usual shape of this trap is either circular or square with walls of nets and an entrance fitted with a door-like valve. The door valve opens during high tide and closes during low tide. The size of the trap and the mesh size depend on the targeted species and some physical factors such as winds and the nature of the tide. This type of trap is mainly used in the Shatt al-Arab River estuary at the city of Fao to catch the large-sized fish and sometimes to catch prawns.

C-Milan trap (Figure 14): This old trapping method is mainly used in winter in the Khor Abdullah area. This trap is used to catch several fish species of medium to large size. Khor Abdullah is regarded as a good fishing ground for the king prawn *Penaeus semisulcatus*, and Milan traps are usually used to catch them there.

The Milan trap consists of two wings each 400 meters long, a death or killing room 2-2.5 meters in diameter, and a guiding wall of net sticks 500 meters long. The trap is V-shaped and with a maximum height of 2.5 metres. The sticks of the trap are usually made from the stiff mid-rib of date palm leaves or reed plants. With the help of the guiding wall, fishes are directed toward the killing room where they remain until the fishermen come to collect them at low tide.

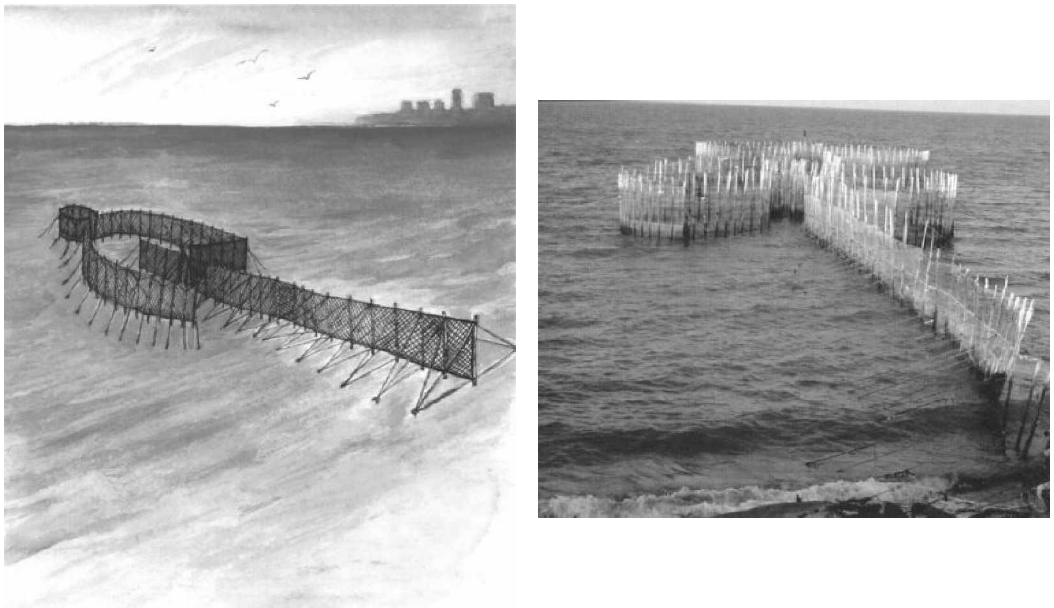


Figure 15. Hadra trap. a. Diagram. b. Actual Hadra trap (Al-Yamani et al., 2004).

D- Hadra trap (Figure 15): The Hadra (Arabic for enclosure) is a traditional, semi-permanent fish trap erected in the intertidal and shallow subtidal zones. Simplicity itself, the Hadra is a highly efficient means of harvesting a wide variety of commercially valuable fish, which swim over tide-covered beaches in search of food.

The traditional construction material is date palm wood, but the modern-day Hadra is made from bamboo poles and galvanized chicken wire that create a rigid structure when strung together. When driven into the shore below the high tide line, it forms a long, straight fence that runs perpendicular to the beach as it heads into the deeper water. The wall curves inward in a spiral to form an enclosure, and then again curves inward, creating a small gap. As the rising tide submerges the trap, the fish swim along the shore and encounter the barrier, and then instinctively they try to swim back along the fence toward deeper water, but are instead guided into the first enclosure. Attempting to escape, they swim into the smaller central gap where they remain. When the tide goes out, the fishermen simply walk across the shore and collect their catch using a hand net. The traps are checked at least once a day, sometimes twice, all year around. Larger fish species are targeted by this method. This trap catches other marine animals such as turtles and dolphins, especially in deeper water toward the south of the Arabian Gulf (Meakin and Al-Mohanna, 2000).

Conservation Methods

Some fishing gears are species specific, while others are less discriminating. Some indications of the potential negative side-effects of using certain gear configurations in terms of number of non-target species caught have already been mentioned in the description of the fishing gear and methods for both freshwater and marine fisheries. Most of the target species living in the freshwater and the marine environment of lower Mesopotamia are associated with non-target animals. When such fishing gear as towed or encircling nets are used to catch near-bottom-living demersal fishes, capture of non-target bottom living species is inevitable. In the marine habitat of southern Mesopotamia and in the mid-water and pelagic fisheries, nets may be towed for many hours. As a result, any dolphins, marine turtles or even birds that are caught incidentally are usually drowned by the time the net is hauled in. This is also true with gill nets and traps used in the inland waters where other aquatic animals may be trapped. Young dolphins are sometimes caught in the gill nets set for Indian shad, *Tenualosa ilisha,* in the Shatt al-Arab River near Basrah, and freshwater leatherback turtles may be caught in gill nets set in the marshlands area. Since different fish species share the same environment in the marshland for example, it is almost impossible to catch barb fish species without other religiously forbidden fish species such as catfish and freshwater eels. Long lines are considered to be amongst the most selective fishing gear in terms of the size and identity of the target fish captured. However, there are numerous examples of marine animals other than fish having been entangled or trapped in static gear (Meakin and Al-Mohanna, 2000). Regrettably such incidental catches undoubtedly give fishermen bad publicity, although most fishermen would gladly avoid these accidental catches if it were possible.

Regardless of the ethical considerations, bycatch often has financial implications for fishing operations. For example, in the marine waters of lower Mesopotamia, sharks are often entangled in the nets and effectively render the net useless. Similarly, in the marshlands, several freshwater catfish species with sharp pectoral spines are commonly entangled in the nets. Thus the pressure to minimize incidental catch and bycatch has come from fishermen, environmentalists and the conservation-motivated public.

Research to reduce bycatch only began about 20 years ago by leading fishing countries (Jennings et al., 2001). Presently, trawlers use a filtering system to remove large bycatch (Robins-Troeger et al., 1995, Brewer et al., 1998), but such devices definitely are not present in the fishing boats operating in the marine zone of lower Mesopotamia. As to the fishermen operating in the marshlands, they do remove the unwanted catch, but only when the net is out of the water. In addition, they leave the bycatch on the bank instead of returning it to the water.

Under the former Ba'athist regime, the State Organisation of Fisheries was responsible for administration of inland and marine fisheries. This organisation had total authority to deal with all concepts of fishing licences for operation in both freshwater and marine habitats. As a Ba'athist organisation, they used to discriminate in issuing such licences. No licences were issued to non-Ba'ath people and no licences were issued to ordinary Marsh Arabs unless they provided a letter of acknowledgement signed by the party member of their region. In addition, control over the most productive fishing areas of the marshlands was supervised directly by Uday Hussein, the eldest son of Saddam Hussein, who would ask fishers to pay him before operating in those areas. Later, after a short period of operation, the State Organisation of Fisheries was abolished and replaced by cooperatives that served marine fisheries in Basrah Province only. As to the inland fisheries operations, they remained under direct control of Uday Hussein and his followers.

Mesh size restrictions have been used as a fish stock conservation tool for many years. The net meshes used in many fisheries are typically diamond-shaped. In case of the trawling nets, once the net is in operation, the drag and weight causes the meshes to close. The meshes then become blocked with debris and bycatch, further reducing the target efficiency of the net.

As far as fisheries legislation was concerned, law No. 48 was issued in 1976 to regulate the exploitation and management of the fisheries sector. According to this law, the State Organisation of Fisheries was fully responsible for checking the mesh size of the nets used by fishers operating in the inland waters and marine habitat. The implication of the law was not correctly followed regarding the mesh size issue as the State Organisation of Fisheries tended to be easy with those fishermen who were members of the Ba'ath Party and strict with those who were not.

Fishermen in the marshlands and the marine waters of lower Mesopotamia violate local fishing laws by using illegal mesh sizes, but fisheries inspectors are unable to detect most illegal fishing incidences due to the inaccessibility of many areas in the marshlands.

Static gear is vulnerable to loss through bad weather conditions or when fishing vessels accidentally snare and tow them away. Regrettably, lost gear can continue to fish independently in some cases. This situation is especially common in the Shatt al-Arab River where fishermen put their set nets across the whole width of the river to catch Indian shad, *Tenualosa ilisha*. Damage to or severing of the net occurs when boats cross the fishing lines, after which the loose part of the net floats with the tide catching many aquatic animals. Several fish specimens were observed on the Shatt al-Arab riverbank entangled in a broken net (personal observations). Some conservation measures need to be implemented to encourage set gear fisheries to tag gear to make it easier to find in the event that the surface marker buoys are lost.

One of the best ways to reduce bycatch is the use of common sense. Many fisheries research organizations now produce "good-practice" guides that are distributed to fishing organizations. These encourage fishermen to avoid using set net gear in close proximity to the bottom of the fishing grounds. Inevitably some of the best fishing grounds also support large bird or cetacean populations. In the case of the marshlands, the standard of education becomes a barrier between the fishermen and the local authorities, with the fishermen paying no attention to fishing regulations and ignoring inspectors' warnings.

Socio-economy of fishermen

Motivation, behaviour and attitude of fishermen are always important when the assessment and the management of fishing are addressed, although social aspects of fishing management are often neglected.

Fisheries motivation

The two main motives for fishing are food and income. Humans, like other animals, are selective feeders and their foraging activity depends on both physiological need and feeding behaviour (MacArthur and Pianka, 1966, Emlen, 1966). Fishermen usually rank the desirability of prey according to energetic or nutritional value, and foraging decisions will be based on a cost-benefit balance in which the currency of the benefits is energetic or nutritional reward.

On the other hand, aquatic organisms became valuable as a means of earning money or as a commodity that could be traded for other goods. Thus, in the marshlands, it is very important for individual fishermen to know the boundaries of their fishing areas, since each tribe has its own traditional area. Although area boundaries are not marked, they are well known to local fishermen. The marine boundary is defined by the exclusive economic zone, which extends 200 nautical miles from the coast, and protects natural fisheries resources (AOAD, 1986).

During the transition from subsistence to a market economy, the behaviour of fishers often changes because they realize greater overall benefits from selling fish than eating them. This case is quite clear in the villages distributed throughout the marshlands. Here all of the fish caught by villagers close to the fish markets of big cities are usually sold, but for villages located far away from major centres and not within easy range of a fish market, only about 10% of the catch is sold. The former villages use the income from fishing to pay for new motors for their boats, for fuel, for village improvement projects and to upgrade their life style, while the latter villages have a much smaller income that pays for little more than some new boats and fuel (Al-Khait, 1978).

The behaviour of fishermen within their own fishing grounds is influenced by the relative importance of the relevant market economy, which also explains differences in behaviour between fishermen on separate fishing grounds. Within each fishing area, there is a tendency to catch species of higher value by those fishermen who plan to sell their catch. In both the marshlands and the marine waters of lower Mesopotamia, areas with high-value species are usually owned by the stronger tribe (in the case of the marshlands) or exploited by companies that use better fishing vessels (Al-Khait, 1978). Moreover, even though there are no major differences in the structure of the fish communities between grounds, fishermen in the proximity of the main city centres tend to target high value species, while rural villagers are still targeting many species that they fish traditionally rather than dramatically changing their fishing behaviour to suit the whims of the fish markets (Jennings and Paulin, 1996).

Fishing behaviour

Social and religious factors have marked effects on the behaviour for food and income, which are thus not the only motivations for fishing. Social activity can modify fishing activity in ways that can confound fisheries assessment. The example of villages located near the big city centres as opposed to those situated further away represents an extreme example of how social conditions can interfere with work input to determine catch rates. In the latter case, fishermen do not choose to use the most efficient fishing techniques available and they only try to maximize catch rates when fish are in short supply, and at most other times they see no need to maximise efficiency. Time rarely restricts the potential for food gathering since villages can easily complete their fishing and other tasks in one day and refrigerated facilities for storing excess catch are rarely available. They catch enough fish for immediate consumption and treat the prolonged periods of fishing as a recreational and social activity that provides an important chance to spend time away from the village. Of course, this information may be completely unknown to the analyst who only sees catch and effort data on a computer screen, and demonstrates why fishermen, assessment scientists and managers should always discuss their work among each other (personal observations).

Throughout history, man worshipped the water. Ancient Mesopotamians considered water as the means of their existence and the eternal source of their food and even worshipped water gods such as Enki, god of the sweet water (Parrot, 1961). Fishing has long been and remains one of the most life-threatening jobs, and coastal communities such as those near Fao City live with the omnipresent risk of losing loved ones at sea or in the mid-marshlands area. Not surprisingly, fishing communities are often closely linked to religion and this in turn affects their fishing behaviour. Sandra and Maynou (1998) gave an example of the influence of religion on the behaviour of shrimp fishers of the Catalan coast. Catalan fishers, according to religious tradition, fish during the weekdays but do not fish on weekends. Religion also influences fishing in both the marshlands and the marine habitat of southern Mesopotamia. Here the majority of fishermen in both the marsh area and marine habitats are Shiite Muslim, a religion that forbids eating of fish without scales. Thus, all species of catfish, *Silurus triostegus, Mystus pelusius, Heteropneustes fossilis,* and the freshwater eel, *Mastacemblus halepensis* found in the marshlands (Al-Hassan et al., 1989) are not included among the targeted species. Any of these species that do get caught are usually thrown back again into the water or left on the riverbank. Large catches of these non-target species will thus lead to huge losses in income. In the marine habitats, even greater numbers of scaleless fish species are usually present in the catch, such as *Muraenesox cinereus, Arius thalassinus,* and *Trichiurus lepturus* (Hussain et al., 1988). Bycatch may also include several cartilaginous fish and crustacean species, which are also forbidden as food items by religion and thus represent an additional income loss.

Islamic beliefs play an important role in the timing of fishing activities in the lower Mesopotamian plain. For example, there must be no fishing on Friday or at the end of the Ramadan celebration (3 days) or during the Big Eid (4 days). In addition, during the month of Ramadan, hours of daily fishing are usually reduced due to the religious fasting tradition. Fishermen in the marshlands do not fish on days of the Arabic month of Muharam that commemorates the death of the Shiite Imam Hussain, grandson of Prophet Mohammad. The implications of such factors will be in favour of the health of the fisheries. Any damage might have occurred to the fish stock will be restored through the period of non-fishing.

Conflicts and conflict resolution

Many fishing areas are viewed as common property and some are entirely open-access. As a result, there is little to be gained by one fisherman trying to conserve fish because someone else will simply catch the fish. In other words, the race to fish occurs because it is better to catch a fish today than to leave it in the water. The consequences of the race to fish have been particularly dramatic in the marshlands where management systems and resources have collapsed. For many poor marsh Arabs, and those living at the edges of the marshlands, the marsh area is the only potential source of food and income. Due to the activities of road building that lead to easy access to the marsh area, increasing numbers of people have entered the fishery of the area, which further contributes to the decline in fish catch. The newcomers have initiated a wholesale destruction of the resource base to maintain their livelihood. This may involve fishing with explosives and poisons that damage the ecosystem, killing most of the non-target species and compromising any possibility of sustaining yields in the future. Such fishing has been termed Malthusian overfishing (Pauly et al., 1989) after the Reverend I. R. Malthus (1766-1834), the “prophet of doom” who described the problems of feeding an exponentially growing human population (Jennings et al., 2001).

During the Ba’athist regime, several leading Ba’ath party members obtained a green light from the higher administration, i.e. Saddam’s eldest son, to undergo illegal fishing operations at the most productive areas of the marshlands. Since this action was illegal, no documents were kept regarding such operations in the Ministry of Agriculture. They were estimated by the locals around hundreds of agencies that employ thousands of fishermen to do the job. As to today’s marshlands, the numbers of newcomers cannot be estimated due to several factors. For example, neither the program of reflooding the marshlands nor the return of the Ma’dan tribes has yet been completed. Thus the number of fishers operating in the area is much smaller than when the marshlands existed in their full extent before the late 1970s.

Competition between fishers using different methods is clearly occurring in certain areas that are permanently closed to certain fishing practices. In such areas, stock may become more abundant than in areas open to the same practice (Schmidt, 1997). Fishermen usually deny access to traditional grounds and are tempted to contravene the rules of closure to obtain a higher catch-rate and short-term monetary rewards. These incursions tend to destabilize the effect of the management measure until a free-for-all situation develops. There is a good example of this situation in the Shatt al-Arab River (Jawad, 2003a), where fishermen set static gill nets right across the width of the river as a wall of nets one beside the other, which are left unattended for ten hours or more. Other fishermen using other fishing gear such as cast net, long line, and line and hook are almost unable to use their gear in this area without damaging the gill nets. The race for using different fishing gear has led to a potential conflict that is not yet settled, and there is close competition between strong tribe-supported fishermen using preferred gear. In the marshlands, fishermen belonging to some strong local tribes usually control a fishing area and do not let fishermen from other tribes operate within it (Al-Khait, 1978). Most of the time, such fishermen consistently use one type of gear that is suitable for catching target species. This selectivity in fishing gear will cause a rise in the stock of other fish species not caught by the same method.

To solve this problem a partition of resources between interested parties needs to be implemented. This can be achieved when the tribes supporting fishermen sit and discuss these problems together (such discussion usually took place in the *Mudhifs*, the large guest houses). The negotiation always ends when the weak tribe conforms to the ways of the strong tribe (Jawad, unpublished data). Such partition has two advantages: firstly to reduce conflict between different gear users, and secondly, to exclude such gear as small towed nets from certain areas in the marine habitat.

The existence of competition between fishermen helps us understand how a group of fishermen may respond to management measures. For example, if the number of fishermen in the fishing area were reduced then the number of competitive interactions would also fall and catch ability would increase. This would have a different effect on actual fishing mortality than attempts to reduce efforts using methods such as closed areas or seasons that may increase competitive interactions. Competitive interactions also affect the social stability of fishing communities and this may lead to movement of some fishermen or groups of fishermen from one area to another. Until further development proceeds in the marshlands, and especially until the restoration program is completed, the efforts to reduce the number of fishermen in a given fishing area cannot be achieved. It can only be properly implemented through fishing cooperatives that organise and monitor fishing activity in the marshlands (AOAD, 1986).

Fish wars

Fish might be behind several undocumented battles between strong tribes in the marshlands, who used whatever weapons were available in order to get control over rich fishing areas. Strong well-supported tribes usually win the conflicts and spread their fishing rules in the area. The distribution of fish played such a role throughout history and is still doing so (Kurlansky, 1997).

Such conflicts are absent in the marine habitats of the lower Mesopotamian plain due to the complete control of the area by government and through the fisheries cooperatives that implement the fisheries laws more strictly in the marine habitat. Some social factors stand behind this success. People living south of Basrah in or near the city of Fao are completely socially different from the Marsh Arabs, and have a minimum education level higher than those of the Marsh Arabs. Moreover, Marsh Arabs often have the habit of flaunting authority (Al-Khait, 1978).

Traditional Management Systems

Ruddle et al. (1992) in their work on marine resources management termed the type of management that occurred in the non-industrialized nations as Traditional Management. This seems to be an effective management scheme in such societies because local customs and behaviour discourage the race to fish that has affected common property resources.

Property rights are the bases for traditional management systems (Hall, 1999). There are two levels of operation of such rights. Level 1 includes the exclusive use of local resources that are enforced by the right of a community to prevent poaching. Level 2 looks at the management in the allocation of the shared resources among the communal users. These systems are usually well enforced, as they tend to be self-policed by fishermen. Therefore, the fate of the resources will be under the control of the local community and not subject to human influences outside their control.

Many fishing grounds in the marshlands are managed using traditional systems. These evolved through the need to conserve resources or through conflicts. At the present time, and in rural marshlands areas, these systems are still operational in spite of the population growth, changes in legal systems, urbanization, commercialisation and technological change (Hadid and Al-Mahdawi, 1977).

Traditional systems management focuses on resolving gear use or allocation problems. Access control is enforced by fishermen and by local moral and political authority. Elements of contemporary strategies applied to fishermen who violate them are the major issues of many traditional systems applied in the marsh area by tribes. Supernatural sanctions are probably the most effective punishment for poachers. As Shiite Muslims, the Marsh Arabs have among them a number of individuals termed “Syeds” (The Masters), who claim descent from the Prophet Mohammad. They usually wear green scarves on their heads, the colour standing for peace for Muslims through the centuries. Therefore, any fishing area put under their names will be guarded by their supernatural power and the poachers will face damage or disappearance of gear, or the threat of sickness or death for them or for their families. Clearly, illegal fishing was unlikely to be rewarding when it was against Islamic teaching.

Jennings et al. (2001) suggested that many traditional management systems broke down in parts of the Pacific following colonial intervention. In the lower Mesopotamian plain, however, the colonial intervention instead gave more power to tribes and more support to the traditional management systems. The colonial intervention achieved two aims: first, they can control the whole area by monitoring the heads of tribes; second, they do not need to involve any personnel from their side that might get killed in an unexpected conflict with the Marsh Arabs. Moreover, the colonial forces introduced what is known as customary freshwater tenure systems where certain families of a tribe control each fishing area. The tribe usually appoints some people to manage a fishing operation and the individual fisherman then works within a group in a certain fishing area that belongs to a known family within the tribe (Jawad, unpublished data).

Ecological consequences of fishing activity on aquatic habitat

Fishermen and/or their gear always interact with the habitat to some degree regardless of the techniques they use. Such interaction is obvious and adverse when lost fishing lines entangle non-target species, when pots and traps land on top of benthic fauna, and when nets drag across the riverbed, marsh bed and seabed. There are two types of disturbances that result from the interaction of fishing gear with the environment: physical disturbance, in which the habitat is directly disturbed, and biological disturbance, in which the habitat is disturbed indirectly by removal of competitors and predators from the system (Hall, 1999).

Fishing gear that is deployed at the surface or in mid-water can itself cause environmental effects in addition to the direct and indirect consequences of removing bycatch and prey species. In contrast, methods of fishing for bottom-dwelling species can affect the riverbed, marsh bed, and seabed habitat and its inhabitants to some degree (Jennings et al., 2001).

There are two different groups of fishing techniques that affect the benthic fauna and habitats. The active methods usually involve towing trawls or dredges of all sizes across the seabed. Such techniques are in use in the marine habitat of lower

Mesopotamia. However, artisanal fishermen operating in the rivers and marshlands also use a range of other active techniques such as drive netting, spearing and fishing with chemicals or explosives. The passive fishing techniques include the use of pots or traps, baited hooks on long-lines, gill nets, and drift nets. All these techniques are in operation in both the fresh and marine waters of lower Mesopotamia. The impact of each of these various types of gear on non-target biota and habitat will also vary between different habitats and according to the manner in which they are used. To solve these problems, Marsh Arabs usually come down in the water prior to the fishing operation and start to cut as much aquatic vegetation as possible in order to facilitate their fishing operation. They do this only when they use seine nets. Such action occurs everywhere in the marshlands where there is thick vegetation. The impact of such action is not severe on the aquatic plant communities because only a few fishermen do so at any one time.

Effects of towing fishing gears

Bottom fishing causes more serious damage to the benthic organisms and the habitat than surface or mid-water fishing. Accordingly, most research has centred on the environmental impacts of the former (Jennings et al., 2001). The fundamental question to be answered is “what happens when benthic fishing gear interacts with the river, marsh and seabed?” The straightforward answer is that bottom fishing gear will wreak havoc on animal and plant communities in its path.

Towed and static fishing gears also interact negatively with the environment, however. Towed fishing gear tends to be more effective and sweep large areas of the river, marsh and seabed. In soft sediments this will lead to the turbulent re-suspension of surface sediments, which may remobilise contaminants and expose the anoxic lower sediment layers. This case is evident in the marshlands, where the movement of the towing nets disturbs the soft bottom of the marsh that contains contaminants and silt. On hard substrata, boulders may be physically moved and biogenic structures may be destroyed (Auster et al., 1996). This situation is clear in the rivers and the marine habitat of lower Mesopotamia. The magnitude of the impact on the habitat bottom is determined by the towing speed, the physical dimensions and weight of the gear and the type of substratum. The resultant changes to the habitat may persist for various periods of time, ranging from several years in muddy sediments found in sheltered areas, to decades in the relatively undisturbed deep sea (Auster et al., 1996). In the case of the marshlands, the situation is different wherever the bottom is covered with soft muddy sediments and water movement is negligible. Thus, changes will persist longer here than in areas with continuous wave action or current flow. As to the marine habitat, changes might persist for shorter times. In some cases habitat degradation may be permanent due to the fragmentation of the bed formation. This could happen when big holes are dug in the bottom of the marsh or bedrock is removed from a riverbed or from the seafloor. Such incidences have been observed where heavy towing gear has been used in the marshland and the huge amount of silt lifted by the net has left a large hole in the bottom. Similarly, large boulders were seen in the small trawling gear of the artisanal fishing boats operating in the marine habitat of lower Mesopotamia. Those boulders appeared to be newly fragmented from the bedrock of the area (personal observations).

Towing fishing gear, no matter how heavy, inevitably reduces the surface roughness of the bottom of the aquatic habitat, and thus also the complexity of both the surface and internal structure of soft sediment habitats (Schwinghamer et al., 1996). The presence of micro-topographic relief of the sediment such as feeding pits, shell fragments and small rocks that protrude from the bottom are important to much sessile biota. As fishing gear is towed across the bottom, surface sediments are re-suspended. The heavier particles sink quickly, while the finer particles are winnowed away by currents (Kaiser and Spencer, 1996, Schwinghamer et al., 1996). Divers in the marine habitat often report a fairly smooth seabed in the towed experimental site where towing fishing used to operate (Personal observation), which indicates clearly the effect of towing fishing gear.

The non-target organisms that get disturbed through the use of towed fishing gear are the infauna and epifauna. Towed gear does not adversely affect deeper burrowing fauna (Posey et al., 1996). Kaiser and Spencer (1996) indicated that effects of fishing are much more noticeable in less disturbed areas than in highly disturbed habitat. Such differences are clear in the lower Mesopotamian plain. Due to the current and wave actions and ship traffic, mainly oil tankers, the marine habitat is more disturbed than the river and marsh beds.

Chironomid larvae, dragonfly larvae and worms dominate the benthic fauna of the marsh area. *Stylaria* and *Tubifex* species (Oligochaeta) occur in moderate quantities, and univalve and bivalve molluscs are also present (George and Savage, 1970; Al-Dabbagh and Daod, 1985). Aquatic insects such as water beetles are well represented in the marshlands (Ali, 1976, 1978a, 1978b). A globally threatened species of libellulid dragonfly (*Brachythemis fuscopalliata*), which is known only from Iraq, Israel and Turkey, has been collected in the marshes of lower Mesopotamia, but no recent information is available on its status there (Groombridge, 1993). Consecutive bottom samples from the marshlands during the period 1971-1989 revealed a decline in both infauna and epifauna of the greater marsh area near Basrah city, the decline in infauna being less than that of epifauna (personal observations).

Fishing in shallow water has impacted aquatic plant communities in the marshland areas of lower Mesopotamia. Throughout the marshlands, the emergent vegetation is dominated by common reed (*Phragmites australis*), reedmace (*Typha angustifolia*), papyrus (*Cyperus papyrus*), and occasionally *Arundo donax* (Thesiger, 1954; Akbar, 1985). The deeper, permanent lakes support rich submerged aquatic vegetation such as hornwort (*Ceratophyllum demersum*), the pondweeds *Potamogeton lucens* and *P. pectinatus*, water milfoil (*Myriophyllum* sp.), stonewort (*Chara* sp.), the naiads *Najas marina* and *N. armata*, and water fern, (*Salvinia* sp.). Water lilies (*Nymphoides peltata*, *N. indica*, *Nymphaea caerulea* and *Nuphar* sp.), water soldier (*Pistia stratiotes*) and duckweed, (*Lemna gibba*) cover the surface of the smaller lakes and quieter back waters. These aquatic plants act as breeding, nursery, and protective means for several aquatic invertebrates (George and Savage, 1970; Al-Dabbagh and Daod, 1985; Ali, 1976) and fishes both freshwater and marine (Al-Hassan and Hussain, 1985; Al-Hassan et al., 1989).

Bottom fishing gear usually tears up individual plants and reduces biomass by shearing off fronds. Towing fishing gear may locally increase water turbidity through sediment resuspension, leading to regression in the aquatic plant cover. The dense nature of the submerged plants encourages sedimentation and accumulation of organic matter. The roots and other plant structures help to stabilize sediment in the same way that the roots of trees bind soil.

Effects of static fishing gear

Static fishing gear has relatively little effect on the life at the bed of the aquatic habitat, although there are problems associated with bycatch. Rocks and organisms may be sheared off if ropes, netting or traps become snagged on them. Nevertheless, these effects are relatively minor in comparison with those associated with active fishing techniques. Potential effects on plankton communities fall under the long-term effects of bottom fishing activity.

Indirect effects on habitats

Transport and subsequent deposition of sediments re-suspended as a result of bottom fishing may affect the settlement and feeding of biota at sites remote from the fishing area. Sediment re-suspension may have a variety of effects such as release of nutrients held in the sediment, exposure of anoxic layers, release of contaminants, increased biological oxygen demand, and smothering of the feeding and respiratory organs of various aquatic animals (Kaiser and Spencer, 1996). This situation is clear in the marshland areas near the large rivers such as Tigris and Shatt al-Arab. The re-suspended sediments from the marshlands carrying all sorts of materials will eventually re-settle in the nearby rivers and disrupt the benthic fauna there.

In the marine habitats of the lower Mesopotamian plain, coral reefs are probably indirectly affected by bottom fishing activities. The process of catching the target species will reduce the abundance of corals by destroying them. With the reduction in the abundance of target species, the abundance of other organisms on which the target species used to feed will automatically increase. Several species of parrotfish such as blue barred parrotfish (*Scarus ghobban*) and gulf parrotfish, (*S. persicus*) that live in the area graze on algae and erode the reef matrix. Other target fish species such as emperor fish, (*Lethrinus* sp.) feed on invertebrates such as sea urchins and starfishes. Heavy bottom fishing activities will clearly determine the rates of bio-erosion.

Suggested future management and conservation options

It is clear from the information provided here that fisheries in the lower Mesopotamian plain need an urgent management plan in conjunction with conservation measures to ensure a regulated fishery in the area. Governments and local authorities usually instigate fisheries management because the biological, social and economic consequences of unregulated fishing are undesirable. In most cases, the aims of the management programme are to ensure the economic and social well being of future generations or to protect habitat and species of conservation concern. For such a management project, there must be clear objectives supported by scientific advice and appropriate management actions (AOAD, 1986).

Action

To express the aims of the management plan as a management strategy is the first stage of the management process. A better understanding of ecosystem function will facilitate quantitative strategies. In this aspect, appropriate assessment techniques by fisheries scientists will be of key importance for implementing the strategy. The following steps of management action could be well implemented in the inland fisheries and in the marine habitat of lower Mesopotamia.

The three main steps in management action are catch controls; effort controls and technical measures (OECD 1997), and all have their advantages and disadvantages. Catch controls, also known as output controls, are intended to control fishing mortality by limiting the weight of catch that fishermen can take. These include total allowable catches (TAC) or quotas (Q), which are limits on the total catch to be taken from a specific stock, as well as individual quotas (IQ). Catch controls are amongst the most widely used management regulations (OECD 1997). Such systems can be easily controlled by well-known members of the tribes in communities that live deep in the marshlands, or by members of fishing cooperatives in communities at or near the big city centres and near the marine habitat.

Effort controls limit the number of boats or fishermen who work in a fishery, the amount, size and type of gear they use, and the time the gear can be left in the water. Among the aims of effort control is reduction of catching power of the fishermen and thus reduced fish mortality. The way that fishermen change their behaviour in response to the regulations has a direct effect on the response of fishing mortality to effort control. This is an important point especially for Marsh Arabs who operate in the interior marshland fishing areas, which are remote from government or local authority inspectors. Accordingly, it is important to deal with local fishermen on a tribal basis to ensure that control systems are working. Failure to involve individual tribes in marshlands fisheries management will lead to failure of licensing, vessel and gear restrictions, and effort controls. If the catch controls and technical measures are not imposed, control effort is unlikely to be effective.

Technical measures restrict several technical fisheries issues, including species-related matters (i.e. size and sex), others related to the gears used, fishing seasons, and areas where fishing is allowed. Controlling the size of the fished species is considered as the most useful conservation measure to protect individuals below the minimum landing size. In the lower Mesopotamian plain, fishermen usually make their own nets and seldom purchase legal fishing gear from governmental agents (Hadid and Al-Mahdawi, 1977). Thus, size control and gear are very difficult to regulate in the marshlands. Temporal and areal limits can protect fished species at specific phases of their life histories. Protection of juvenile nursery areas or adult spawning grounds is usually enacted in the lower reaches of the Tigris and Euphrates Rivers near the big city centres, while in the marshlands, the situation is more difficult to control. Marsh Arabs fish in all seasons even in the breeding season of most commercial fish species, such as members of the carp family Cyprinidae. They usually catch fish and sell the yield at the fishing ground to middlemen who usually market the catch in great secrecy (Jawad, personal observation).

Management of fisheries in the lower Mesopotamian plain could use optimisation measures to determine the combination of management actions that would provide the best means of achieving a strategy (Jawad, unpublished data). The best example of optimisation would be to determine the combinations of mesh size and fishing effort that would maximize the profit from a gill net fishery. An advanced statistical analysis could be involved when more than two management actions have to be optimised, for which 2-D and 3-D contour plots are useful and accessible ways of presenting the results. Such advanced activity should be borne in mind for future fisheries management in the area.

Management feedback is an important step in the fisheries management program, as it is needed to adjust management actions and to ensure that management objectives are met. For example, the management strategy for the marshlands' main fish species (Carp family) is to leave thousands of individuals to spawn each year. This situation is similar to that of Icelandic capelin (Jakobsson and Stefanson, 1998). Management action in this case is to control fishing mortality by periodic assessment to confirm the size of the spawning stock, with feedback from the assessment scientists to the managers. A team of experienced people would be required to perform a continuous cycle of setting management strategies, implementing management actions, assessing the impacts of those actions, and modifying the actions in accordance with strategies. Many fisheries in the marshlands and rivers are heavily over-exploited, and minor tinkering with existing management practices would be insufficient to realize long-term biological, social or economic benefits. Clearly, major structural readjustment is needed, which is likely to include extensive decommissioning of boats to remove excess capacity, bans on new entrants to the fisheries, and allocation of property rights. Change would have some undesirable consequences in the short term, notably reduction in income. Such difficulties will be complicated in the marshlands, especially if the governmental agencies or other authorities try to implement the readjustment measure, which could lead to major conflict, since Marsh Arabs are highly vulnerable to income reduction. On the other hand, and in the long term, capacity reduction would produce more efficient industry and happier and wealthier fishermen, although the Marsh Arabs will take long to convince.

It is possible to implement the capacity reduction in the fisheries grounds at the marine habitat of the lower Mesopotamian plain due to the presence of different sectors of the society and different social life. Fishermen in this area will accept the idea, and most importantly, they are easily controlled by authority. This is due to their social background and level of education. Moreover, the fishing area in which they operate is a national waterway, and no one can claim sovereignty on any part of it and declare it a private fishing area. To the contrary, in the marshlands, the tribal influences are quite clear on the fishing grounds. Such conditions are aided by the remoteness of the marshlands and the dominance of the tribal laws.

Managing fisheries for conservation

Maximization of yield was the overriding objective of fishery management for the last few decades. As a reflection of public and scientific concerns about the broad effects of fishing, species and habitat conservation have become increasingly important objectives to fisheries managers and authorities in several parts of the world. In the lower Mesopotamian plain, fishing activities in one way or another impact various non-target species such as dolphins, sharks, birds, and mammals. In the future, therefore, the issues of species and habitat conservation will become the dominant management objectives in several fisheries grounds of the area. In many of the developed countries, fishing is currently seen as a threat to the environment rather than a source of protein and income (Jennings et al., 2001). In lower Mesopotamia, a number of measures have been taken to conserve fish species (Jawad, 2003a). A report by the Arabian Organization for Agricultural Development (AOAD) in 1975 considers the main conservation schemes in force in the region. The recommendations were also concerned with natural and artificial breeding, aquaculture processes, and feeding and fish pathology.

Among the future primary management objectives is protection of endangered species. Several fish species, mammals, birds and invertebrates have been identified as endangered by fishing activities (Norse, 1993; Hawkins et al., 2000; Musick, 1999). There is a growing approach to listing of endangered species in several countries. Such an approach is yet inapplicable for the fish fauna of Mesopotamia due to the lack of basic taxonomical information. Several commercially important barbel species such as *Barbus esocinus, B. grypus, and B. rajanorum* have vanished from the marshlands and the large rivers due to overfishing and changes in their habitat. Species are known only from their original descriptions based on a few specimens collected from one locality. Many may well prove to be synonyms with more widely distributed and better known species. Owing to the poor field data, several fish species presumed or known to be valid are known only from a single river system or lake. Habitat destruction and pollution act as extinction factors for those fish species that are restricted to a single river system or lake. The severe limitations of taxonomic and distributional data on Mesopotamian fish fauna means that it is currently quite impossible to classify fish population from a conservation standpoint (Jawad, 2003a). Some of the taxonomic problems relating to Mesopotamian fishes were discussed by Jawad (2003b), and several attempts were made by Coad (1991, 1996a, 1996b) to identify the fish species of the Tigris-Euphrates River basin. Until a complete and integrated picture of the fish fauna of Mesopotamia is available, plans to protect endangered species cannot be implemented.

In the present time, the marshlands ecosystem may not contribute to the conservation of the fish biodiversity. Factors such as introduction of some parasitic crustaceans, i.e. *Macrobrachium rudi* (Al-Daraji et al., 2005); fish pathogens, i.e. helminth parasites (Bannai et al., 2005); bacteria (Jarallah et al., 2005), and fungi (Muhsin, 2005) may have a direct effect on the health of individual fish in particular and the fish stock in general. The previous factors were observed recently in the post-reflooding period. On the other hand, competition between the native and introduced carp fish species on food items appeared not to be a significant issue to affect the fish biodiversity in the southern Iraqi marshes (Faddagh and Al-Mukhtar, 2005). The International Technical Advisory Panel (ITAP) expected that exotic species are likely to exist in the system because the system has been so disturbed in the past few decades. The recommendation that ITAP put forward regarding the exotic species is to monitor them to ensure they are not out-competing native species (Eden Again Project, 2003). With the absence of complete control by the new government in the different sectors of life in Iraq, fishermen took the opportunity to use whatever fishing methods were available to them and paid no concern about their side effects on the fish stock and the environment. Prohibited fishing methods such as electroshocking and use of chlordane are among the common fishing methods in use today in the marshlands. In both methods, fishes of different sizes are caught and small fish are usually thrown away. This action will have a direct impact on the future fish stock in the area.

Habitat conservation is another objective of management for conservation. It can be achieved using gear restrictions and protected areas, but is not feasible in the marshlands due to the particular behaviour of the Marsh Arab fishermen, who agree neither on the need for gear restriction nor on the need to maintain protected areas.

Another approach for habitat conservation is through providing the optimum environmental conditions for fish stock to thrive. At the present time, the environment of the marshlands needs a high level of restoration due to the presence of several types of toxicants such as pesticides that were used in illegal fishing operations and carcinogenic agents originating from residues of the chemical weapons used in the marshes during the Iraqi-Iranian war. The latter are characterised by low degradability and may transfer to man through the food chain. Other pollutants may contribute to the degradation of the present marshland environment, among which are dissolved chemicals of military origin and industrial and domestic effluent from locations upstream on the Tigris and Euphrates Rivers (Faddagh, 2005). In addition, Neghamish and Ali (2005) found that the sediments and most of the marsh areas have high rates of salinity and Na^+ content.

Fisheries science must become the main factor in future trends of fisheries management in the lower Mesopotamian plain if there are to be desirable consequences. Fisheries science is changing rapidly, bioeconomic analyses are becoming increasingly important in the assessment and management of fisheries, and there is increasing concern about the impacts of fishing on the aquatic environment. More research on the ways in which fishing affects ecosystem processes such as productivity and stability, and how it alters the role of ecosystems as nutrient stores are needed in the near future. Such studies may eventually provide the basis for setting practical management strategies such as limits to the frequency and intensity of fishing.

Rehabilitation of the aquatic environment

When rehabilitating an aquatic environment, it is not always necessary to restore a body of water to its original, historical state. Restoration projects often take a more functional approach by creating conditions that meet the needs of society. The restoration of water bodies to their original condition may or may not be acceptable or even possible depending on the size of the occupied area of a given nation.

Several factors need to be taken into consideration in order to achieve the objectives of rehabilitation of any water body, among which are:

(1) The requirements of society. Conservation goals could be well included, such as general protection of entire faunas or of a particularly rare species, or use-oriented goals such as the maintenance of particular types of fauna for food fisheries exploitation.

(2) The development of the river or lake basin. All water body rehabilitation projects should consider the rehabilitation of the basin in conjunction with the water mass. All activities that occur upstream from the target water body will eventually affect any efforts at a local level through increasing sediment loads, change discharge rates and impede migrations.
(3) The minimum area necessary for restoration. In the rehabilitation processes, the number and well-being of the target species or community will increase if processes are limited to a particular species or community. However, other factors may interfere to limit the fish population growth, such as increase in size of the protected area. In the marshlands, the carrying capacity of the environment at low water may be such that only a small proportion of fish spawned can survive to the next year. In such case only a small amount of the marshes are to be restored for an adequate fish stock to be maintained (Welcomme, 2001).

In order to provide the proper habitat requirements of fish, it is essential to establish the ecosystem requirements for each fish species, factors including salinity, pH, nutrient levels or conditions of low dissolved oxygen and flow rate. Water volume is important during breeding and for feeding, individual species having specific individual requirements (Hickling, 1961).

Important for habitat rehabilitation is protection of water quality, which will fail unless the water is free from toxic pollutants (Wellcomme, 2001). For this reason water quality has been given high priority in the aquatic environment rehabilitation programmes of several countries, and it will be important to follow suit in the marshlands of southern Mesopotamia.

The control and use of vegetation should be included among the major aspects in the rehabilitation program of the aquatic environment, since vegetation provides support and refuge for a wide range of organisms, including fish. The southern Iraqi marshlands are famous for their dense, species-rich riparian vegetation (Akbar, 1985). Several marine fish species such as the clupeid *Tenualosa ilisha*, the engraulids *Thryssa hamiltoni* and *T. purava,* the sparids *Acanthopagrus berda* and *A. latus*, and the mugillid *Liza macrolepis,* migrate up the Shatt al-Arab River towards the marsh areas for breeding and feeding during the spring season (Al-Hassan et al., 1989). In addition, vegetation cover is considered to be the ideal protection for larvae and other developmental stages of a large number of aquatic insect and other invertebrate species (George and Savage, 1970). In the aquatic ecosystem of the marshlands, a balance is usually maintained between vegetation and the other factors, and changes occur slowly over time through a succession of plant species. When such balance is lost due to the influence of humans or to the introduction of exotic plant species, damage occurs through the uncontrolled proliferation of some native element of the community or by the invader (Welcomme, 2001).

The role of education in the Lower Mesopotamian Plain fisheries management scheme

Education is considered as a key component in the effective management systems of all successful fisheries. Through education, several important issues are involved in addition to basic provision and communication of information, including an enhancement of people's appreciation of nature and of the role of the aquatic environment in their own lives and those of future generations. Education becomes the management tool for conflict resolution and the backbone on which other management strategies hang (Fleming, 1996). No water regulatory body, especially for the marshlands, can hope to enforce its regulations without acceptance from the local people, and it is only through education that the locals can learn the issues so that there can be voluntary acceptance of the procedures and regulations.

Educational Plans

In every successful educational programme, there should be clearly identified goals and a series of suitable management strategies to accomplish them. The most important education programme role is that of the leader, who should ideally be locally recruited, preferably with roots in the community, well respected and with boundless enthusiasm. In the case of the marshlands, this leader should ideally be from a well-known tribe, with a background in science education. Any number of assistants and advisors can be added to the team but the figurehead must be familiar with the local communities both physically and metaphorically. This is an especially important issue in overseas projects where the motives of foreigners are not always clear to the local residents.

Education goals may be broad in content or they may relate to specific aspects of the aquatic habitat. Typical goals that might be taken into consideration for a management plan might include awareness of the environment, information on policies, aims and objectives of the protective plan for the aquatic environment, and encouragement of locals to participate in the process of protection of their environments and to gain an understanding of and compliance with the regulations proposed in the management plans (DES, 1993; NOAA, 1994).

Two broad categories of strategies are needed to achieve the goals outlined above: (1) community education and involvement; (2) preparation of education/information materials.

It will be very difficult for the local community to accept management plans for their aquatic environment unless they know beforehand about the contents of the plans and fully understand the rationale behind their formulation (Kenchington, 1990).

People's views on conservation depend upon their own personal assessment of the value of the environment to them, and subjectivity is one of the main obstacles facing the education programme when the local peoples are environmentally illiterate. It is not so much a question of local people being environmentally illiterate but, as the author notes, putting different values of conservation/rehabilitation versus livelihood. Thus, additional efforts are needed in this case to demonstrate to people that the long-term benefits from such a protection programme will outweigh the extra short-term costs that they will inevitably incur. As suggested by Kenchington (1990), representatives of the target groups should be involved in the design of the programme, and in who should receive educational establishment, from primary to tertiary levels. In the lower Mesopotamian plain, universities and research centres, local resource users such as fishermen, local authorities such as municipalities, and non-governmental organizations should all participate in such programs.

Educational field trips should be organised and supervised by educational staff of schools at different levels. Scientific programmes on the conservation of the aquatic environment should be included in the scientific research plan for the universities and research centres in the area. Ideally, new curricula including the conservation programme for the aquatic environment of the lower Mesopotamian plain should be included in courses at local universities. Unfortunately, it is impossible at the present time to fulfil the two strategic aims of the education plan. This is mainly due to the current instability of the region and to other social factors such as the incomplete and non-organised settlement of the Marsh Arabs. The strategic aims need cooperation from all sides, including the Marsh Arabs and government agencies, in order to attain an acceptable status to deliver information and education. It is important for the governmental agencies to provide the educated and skilful manpower, the media, and material resources. The Marsh Arabs likewise need to re-arrange themselves in cooperative groups to understand and implement the information given to them, unlike what had happened before. As tribes, they need to consider themselves as small communities that can work together to educate their people and develop in them the ability to catch up with the other urban communities in regard to environmental education.

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