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Integrated Sustainable Fisheries Management for Pearl Mullet of Lake Van, Turkey

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1. Introduction

The pearl mullet is the sole endemic fish species that can survive in the salty and alkaline waters of Lake Van. Covering an area of 3712 km², with mean depth of 171 m, maximum depth of 451 m, and 1648 m above sea level, this is Turkey's largest lake. Its waters are extremely alkaline and salty. Due to the nature of these waters, it is characterized as a "soda lake". Researchers have reported a pH level of approximately 9.8, with saltiness at 0.19% (Kempe *et al.*, 1978). The lake's biological diversity is significantly different from both fresh and salt waters. Its phytoplankton resources consist of 103 species belonging to the *Diatome, Bacteriophyta, Cynophyta, Chlorophyta, Flagellate* and *Phaeophyta* groups, and its zooplankton resources include 36 species from the *Rotatoria, Cladocera* and *Copepod* groups (Selcuk 1992). The pearl mullet (*Chalcalburnus tarichi*, Pallas 1811), a species belonging to the *Cyprinidae* family, is the only fish that can survive in Lake Van. The pearl mullet is a migrating species. Although it generally lives in the lake, it immigrates to the surrounding freshwater rivers for reproduction purposes and returns to Lake Van after the reproduction period.

The earliest available information on the fishery practices related to the pearl mullet comes from travelers that visited the Lake Van region. Among them, Evliya Celebi (17th century) provides the most detailed account. Having arrived to Van with a general, Melik Ahmet Pasha, Celebi speaks of the lake as the "Van Sea", stating that a certain species of fish exist in these waters that migrate annually to the Bendi Mahi River creek for a month as a flock. He goes on to explain that the fish are captured on their way back to the lake by the provincial treasurer, salted and then taken to the Iran, Nagorno Karabakh, and Azerbaijan area to be sold. He says 900 loads of silver coins are thus collected for the treasury each year and this income is then distributed among the soldiers serving in the fortress around the lake (E. Celebi, 17th Century). The first detailed study on the biology of the pearl mullet was carried out by Akgul (1980); further research was conducted by Danulat&Selcuk (1992) and Danulat & Kempe (1992) revealing new parameters about some physiological and biological characteristics not articulated in the previous study. Other studies on the pearl mullet include: Arabaci's (1995) research on physiological changes that take place during reproductive migration; Cetinkaya et al's (1995) on some selectivity characteristics of nets used for pearl mullet fishing; Sari's (1997a) research which presents the basics of current fishery management practices and proposes an alternative model based on estimated pearl mullet stock quantities; Sari's study (1997b) on mesh selectivity for pearl mullet fishery; Sari

and Tokac's research (1997) on the technical features of Lake Van fishing boats; Sari & Ipek's study (1997) specifying new fishing areas around Lake Van, drawing on satellite imageries; and Sari & Tokac's research (2000) about the productivity of nets used for fishing the pearl mullet.

As of 1997, technological approaches have prevailed in fishery management at Lake Van. With the establishment of a center at the Yuzuncu Yil University focusing specifically on this field, these studies have acquired an institutional identity (Sari 2000a). Sari (2000b) has declared that new fishing grounds have been successfully determined with the aid of the remote sensing and geographic information system. Using the daily AVHRR satellite images taken from the NOAA HRPT ground station situated at the remote sensing center to determine the surface temperature map (SST), in conjunction with depth and flow data, this study has verified that the pearl mullet's distribution area can be successfully established. The effects of these applications, which will ease the transition from the erroneously administered spawning period fishing practices to professional fishing, have been clarified in detail by Sari (2001).

In the event of a failure to prevent spawning period fishing, the new technology will be an added fishery pressure on the pearl mullet population; in light of this possibility, the need for cooperation among relevant public authorities, and local, national, and international non-governmental organizations is clearly an imperative. This paper is a detailed examination of the transition process to sustainable fishery of the pearl mullet, the role of relevant governmental and non-governmental bodies, security forces and universities within this process.

2. The Biology of the Pearl Mullet (*Chalcalburnus tarichi*)

A member of the Carp family *(Cyprinidae*), the pearl mullet is a fish species that only inhabits the Lake Van Basin. Generally of bright-silver color, its back is grayish green, and the abdominal region is silver (Figure 1). Its body is covered with small scales, and its eyes are large (Kuru 1987, Geldiay & Balik 1988). On the average, it measures around 19.5 cm in length, and has an average weight of approximately 80 g. It feeds on phyto and zooplanktons. Its average life span is around 7 years, and the fish reaches reproductive maturity at 3 years old. The reproduction period, at which time the fish immigrate to freshwater rivers in flocks, starts in early April and lasts through the end of July. As they cannot make the move from salty-alkaline water to freshwater directly during the migration, the fish have a brief waiting period at the river mouths for osmotic adaptation, both on their way to the area where they will lay their eggs and back. As the river water temperature reaches approximately 12 °C, the pearl mullets go into the freshwater and start to lay their eggs. Having laid the eggs in small pebbly, sandy areas where the river tends to sprawl out and the speed of the flow is lessened, the adults return to the lake.

Their youngsters start on the journey towards the lake within a week or two after the eggs are hatched. The young pearl mullets wander and feed in flocks around the nutritiously rich shore areas of the lake throughout the summer. Pearl mullets tend to disperse all over the lake in the summer months, but avoid areas where the water is deeper than 25 m. In the wintertime, the fish move within parts of the lake that have a maximum depth of 60 m (Sari 2001, Sari 2003).

Fig. 1. Pearl Mullet (*Chalcalburnus tarichi*)

Fig. 2. Lake Van, important settlement areas surrounding

3. Historical Development of Pearl Mullet Fishery and its Management

The pearl mullet is captured by two different fishing methods, in two different seasons. The fish migrates to freshwaters in order to breed between the months of April and July. However it is not able to have direct access from the salty-alkaline waters of the lake to the freshwater rivers. Due to its biological constitution, the fish must undergo an osmotic adaptation process whereby it needs to wait for a certain time at the river mouths known as "mansap". During this "waiting" period, large flocks gather within the river mouths. The first fishing method involves the capture of the pearl mullets, by casting beach seined nets along the shore (beach seining), from small fishing boats as they are waiting to continue on their reproductive migration by the river mouth. Simple traps laid along the rivers are also employed to capture the fish during this period. Whereas 90% of the total

pearl mullet fishing was done by this method in 1996, by 2006 around 40% was done during the breeding period. The local population has been employing this traditional method, capturing the fish during its migration period since ancient times (Sari 1997b, Sari 2001).

The second method is "winter or professional fishing", whereby the fish is captured at Lake Van, which is its main habitat, between September and April. During this period, fishermen use 8-16 m boats with trammelnets that mesh sizes of 20-22 mm. They start fishing at depths of around 15-20 m in September, proceed to 50-60 m as the weather gets colder, and go back to 20-30 m depths as spring approaches and temperatures get higher. This fishing technique was started during the 1970s and is becoming increasingly more widespread. Nevertheless, at present only 60% of pearl mullet fishing is being carried out in the winter months (Sari, 2006).

Until the 1960's, pearl mullet fishing was at a minimum due to several reasons such as lack of adequate fishing gear and equipment, and the fact that fresh fish consumption culture had not yet developed among the local populace. In those years, the fish could not find a place to migrate for breeding purposes, and sometimes went as far as the irrigation canals at the surrounding fields. As a result, piles of dead fish would be seen for days on end by the river shores in the springtime (Sari 1997b). Albeit in small amounts, all fishing activity was carried out only during the breeding period. Since it affected a minimal part of stock distribution within the lake, there was no need for fishing regulations. However after the 1950s, as fishing activities that took place during the breeding season took on a commercial characteristic and as "winter or professional fishing" also started to become more prevalent in the 1970s, pressures increased pearl mullet fishery. Following the '70s, it became imperative to take some administrative measures.

The first regulatory measure related to pearl mullet fishery was the "closed season", put into application during the reproductive migration period even if it was for a short duration. The dates through which fishing was prohibited during the reproduction period (closed season), and hence the number of days when the lake was off-limits for pearl mullet fishers, kept changing each year due to political or social conditions. However in the 1980's, the ban became more or less consistent and started to be applied between the dates of May 15 and July 1st. In the years that followed, while there was noticeable negligence in monitoring illegal fishing activities, it was also observed that for some reasons, the dates of the closed season on Lake Van was haphazardly designated in different regions and the fishing ban, devised as precautionary management strategy, was abolished in practice, even if not legally. In the 1980s, along with the above mentioned closed season application, a limit was also set on the mesh size to be used, both for winter and reproduction period fishing.

However, as in the case of the closed season application, since the limitations on trammel net mesh sizes were based on the views and demands of the fishermen rather than scientific data, this resolution too failed to be effective (Sari, 1997b). In addition, fishing during the reproduction season was encouraged in a way, because the National Real Estate Organization rented out the river mouths exactly at this period. Unfortunately, this practice was continued until the lastet few years.

As a result of these management strategies, the 600-ton pearl mullet yield in 1967 showed an increasing trend, which can be seen when production is analyzed in 10-year periods as follows: 4000 tons in 1977 (approximate increase of 700%), 10000 tons in 1987 (250% increase), 21000 tons in 1997 (200% increase) and has reached the highest yield within the inland fish production category, with 15654 tons in 2000. Whereas the ratio

of pearl mullet production to total inland fish production varied between 5-9% in the initial years, recently this figure has gone up to 36%. This increasing trend in pearl mullet yield has shown a decline in the last years due to overfishing. Sari (2001) has pointed out that pearl mullet fishery has taken a course that corresponds to the "the theory of development of uncontrolled fishing", stating that preventive measures must be taken.

4. Transition to Sustainable Fishery

Basically, transition to sustainable fishery of the pearl mullet means that fishing during the reproductive period must be prevented, and should only be practiced at other times. In essence, this is the main factor that threatens the species. This approach is prevalent in the new management model recently developed by Sari (1997b). Effective prevention of fishing during the reproductive period will not only result in increased revenues, but will also require less labor and input, as well as ensure the preservation of the species. Efforts to achieve this goal can be evaluated in three phases.

4.1 Phase 1: Defining the Existing Situation

Despite the fact that the pearl mullet presently constitutes 36% of inland fish production in Turkey, unfortunately it is a species that has not been researched sufficiently. As a result, studies on the general biology, stock quantity and fishery of this fish were practically non-existent. As emphasized above, the existing studies were realized with inadequate number of samples and within limited time restrictions. Therefore, revealing the species' reproductive, growth, recruitment and other characteristics had to be the first priority. Studies conducted between the years 1993-1996 focused on the parameters of reproduction, growth, and recruitment, thereby enabling an assessment of stock sizes and the determination of fisheries management basis (Sari, 1997b). The same researcher also stated that calculations related to fishing practices had revealed a exploitation ratio (E) mean of 0.684, and reported that existing fishing practices led to over-exploitation of the pearl mullet population, resulting in a decrease in average length of the species, and a decline in unit and total catch yield. A series of proposals were set forth, with a core approach that can be summarized by the following suggestions: minimum mesh size must be 20 mm in order to prevent over-exploitation; each boat must hold no more than 5000 m of trammel net; the dates of the fishing ban to be applied during the species' spawning season must be re-adjusted according to the reproductive migration patterns of the fish; a separate unit must be established for centralized fisheries management. At that time the sole restrictions on pearl mullet fishing were the unmonitored "closed season" whereby the dates of the fishing ban were determined according to the fishermen's requests, and a limitation of minimum mesh sizes of "16-18 mm" for the beach seine nets– an apparently random figure for which there is no scientific basis. The "closed season" application for the lake started at two different dates, but ended on the same date. As a result, the fishing ban was applied between May15-July 1st for Van (central province) and the river mouths, rivers or streams within the boundaries of the districts of Gevaş, Edremit and Muradiye, whereas the ban was put into effect between the dates of May 25-July 1st for the district of Erciş and within the boundaries of the province of Bitlis. Yet, the distance between Bendi Mahi River (within the boundaries of the district of Muradiye) and Delicay or

Haydarbey Stream (within the boundaries of the district of Erciş) consisted of 17 km only.

As the first step for the realization of these proposals, local and federal authorities responsible of fisheries management were informed about the situation, and were asked to make the necessary regulatory adjustments. However, coming from a region that had not requested any change for years on end, this appeal for change – which could easily be considered "radical" for that period- did not immediately elicit any response. Following lengthy disputes with local and national fisheries management agencies, a decision was reached to unite the dates for the "closed season" application. As of the year 1996, the fishing ban would be applied throughout the entire lake between the dates of May 10-July 1st, in accordance with the recommendation of the university. Thus, as the ban was put into effect synchronously, it was also pulled forward, even if only by 5 days. On the other hand, the subject was brought to the attention of the media, and the dangers of incorrect fishing were explicated.

This transformation was initially met by the negative reaction of the villagers, who regarded spawning-period fishing as their "irrefutable birthright". The previously established dialogue was not enough to convince them. Unfortunately, NOT A SINGLE OUTCOME could be obtained from the measures taken to prevent fishing during the reproductive phase. Spawning–period fishing continued full blast, and there were no controls whatsoever. The local public agency responsible of monitoring fishery activities recommended that the security forces should solve the problem. The security forces responded by emphasizing that basically, this was not their responsibility.

4.2 Phase 2: Developing New Approaches and Experimenting with These Methods

An evaluation of the results (failure) of the first phase led to the conclusion that a "state-centered" approach to fisheries management was not applicable for Lake Van, at least at that time and under those circumstances. Therefore, non-centralist new methods were required. As of 1996, efforts were focused in this direction. First, the correlation between the amount of fishing and prices was clearly explained, based on observations from the previous period. Emphasis was put on the fact that intense fishing activity during the spawning-season was leading to decreased earnings for the fishermen. Having gained an insight about this relationship, the fishermen were inclined to find some solutions by themselves. These fishers were brought together with the sellers, and were encouraged to agree on a quota system, which they, themselves would monitor. The most important aspect of this strategy based on the quota system, was that it would bring a novel approach to the monitoring process that was somehow never accomplished by the state authorities, by drawing on the supply and demand balance as a brand new leverage element, while at the same time preventing erroneous fishing practices through the active involvement of voluntary inspectors. The fishermen and sellers, under the supervision of lead researcher, reached a consensus on this issue and signed a page-long mutual agreement document. The agreement stipulated that the "closed season" application would start on June 1st, rather than May 10th of each year; the fishermen would not catch more than 3 tons of fish daily, and the sellers would not buy below a price specified in the document. This management strategy would be in practice for 2 years, by the end of which, spawning-period fishers would have saved some capital. At the end of the 2-year period, they would all join forces to support the prevention of spawning-season fishing.

The official authorities would not be involved in any part of this process, except for making the necessary adjustments in the circular (Sari, 1998). However, the local fisheries management authority opposed this proposal on the grounds that it would lead to a "fish massacre" in spite of the fact that they had never taken action to enforce control mechanism. So this novel approach, the result of nearly a year's work and built on hard-earned trust, never came to realization. Nevertheless, many national NGOs became aware of the issue during the preparation of this proposal. The errors of the methods used for the capture of pearl mullets took place in the media time and again. National NGOs declared to the relevant ministries and fishers that they would keep on pursuing this subject. This cooperation, while perceived as a hard-to-beat union by the fishermen, also enabled the pearl mullet to become a national issue rather than a local matter. On the other hand, the General Directorate of Fisheries Circular Number 33/1, put into application in the years 1999-2000 required that the above-mentioned dates stay the same, but also stipulated a limit on mesh size and on the number of nets that can be used for pearl mullet fishing. In effect, the circular enforces a 20 mm mesh size and does not allow more than 5000m netting per boat. Throughout this process, the dialogue that had established with the fishermen developed even further. Those who were convinced that spawning-period fishing is the wrong method were brought together, and training programs that explicated the damage caused by erroneous fishing practices were carried out in villages where spawning-period fishing prevailed. These efforts, encouraging spawning-period fishers to convert to winter-fishing instead, were not viewed positively by those fishers who were already fishing during the winter season. They were uneasy about the possibility of newcomers exploiting the few fishing grounds they had found through years of experience, and further decreasing the already lowered yield. In order to determine new fishing areas, a "Remote Sensing Center" was established within the Yuzuncu Yil University structure. New fishing grounds have started to be located using the satellite imageries obtained daily from this center.

4.2.1 Remote Sensing Applications

Remote sensing is broadly defined as collecting and interpreting information about a target without being in physical contact with object. The term remote sensing is commonly restricted to methods that employ electromagnetic energy (such as light, heat, and radio waves) as the means of detecting and measuring target characteristics (Priede 1983, Sabins 1986).

Satellites of NOAA series are scientifically designed and supply two types of imaging products. One of them is Automatic Picture Transmission (APT) and the other is High-Resolution Picture Transmission (HRPT). *Advanced Very High-Resolution Radiometer* (AVHRR) sensor produces 1.1-km resolution images, which are suitable for terrestrial, aquatic, and climatic studies. NOAA AVHRR images have 5 channels and cover visible and infrared range of the electromagnetic spectrum (Sari et al., 2000). In a study conducted by Sari (2000), 12 identical fishing net was used; during the study 6 locations became the chief focus of the investigation. Three of these locations were old, which fishermen have been using for fishing for a long time. The other three were newly-determined- locations being based on the maps showing water surface temperatures and the currents in the lake. Throughout the course of the study it was determined that the average catch obtained from old fishing locations was found between 4.8 to 22.3 kg, while

the average catch in newly determined locations was between 15.4 and 52.3 kg. This translates to 2 to 5 times more product in new fishing locations than old ones (Sari, 2000). The difference between old and new locations possibly stems from the direct relation between the distribution of pearl mullet and high water of the temperature of the lake in the winter.

Smith & Baker (1978) determined the higher primary productivity areas using remote sensing techniques and then tracked the locations of sardine shoals in the seas. Kemmerer & Benigno (1973) successfully detected the locations of fish herds in the open seas using sea surface temperature maps. On the other hand, Narayana et al., (1995) produced sea surface temperature maps by using remote sensing techniques which are beneficial for determining potential fishing locations

In the light of all these findings it might be inferred that temperature plays a determining role in finding new locations for fishing through the use of NOAA AVHRR images; but it would be misleading. Because temperature can not be considered as the single factor determining these results. Biological characteristic of pearl mullet, the currents and bathymetric properties of the lake are considered as the other factors causing this condition. Simpson (1994) pointed out that the most important event of remote sensing in fishing was the determination of potential fishing areas; and then he reported water temperature, coastal and bathymetric borders, currents and salinity as natural factors, which affect the distribution of fish.

When the maps charted and measured by Sari (2000) related with surface temperatures of Lake Van are overlapped with bathymetric and current maps measured by satellite images. When analyzing maps, temperature changes are observed to take place in locations in which currents were much intense while currents show changes depending on the depts of lake. In Van Bay in which bathymetric values change rapidly and irregularly temperature changes are also observed to be higher. If such a relationship (fish distribution, surface temperature of lake, depth and currents) can be put into expression through a mathematical model, daily-obtained- satellite images of fish distribution could be observed quite effectively and fishermen could be directed to much productive areas for fishing. Sari (2000) pointed out that the algorithm compiled through the limited data showing the relationship between surface temperature, currents, depth and distribution of pearl mullet in Lake Van would be insufficient and that much more comprehensive information of every season of the year should be collected in order to compose much valid algorithm to be used every time. When primary productivity values directly affecting fish distribution are added to this relationship, a perfect algorithm could be formulized and put into expression in observing potential areas of fishing through satellite data.

In this way the technical and economical aspect of fisheries management will come to the fore and survey studies of fish lasting for years in order to determine fish distribution areas will be conducted in a relatively shorter period of time and much effectively. The duration for fish finding directly effecting the cost of fishing will be shortened and the expenditures caused by the fuel floating the boats will also be reduced.

Besides this positive contributions to fisheries, remote sensing could also turn out to be negative when it is misused in every branch of technologies. If the fishermen have not enough professional discipline and moral conduct of their works, and have a lack of supervision and control they will exploit the fish stocks easily determined by

satellites images in a short time. For this reason, it would be of greater importance to fill the gaps and irregularities wrought by lack of education and awareness for this profession before this new type of fishing is introduced to communities in the region.

4.2.2 GIS Applications

Geographic Information Systems (GIS) is a computer-based tool for mapping and analyzing things that exist and events that happen on earth. GIS in fisheries are being effectively used in fisheries management, in tracking of spawning grounds of some pelagic fish, in classification of habitats according to environmental factors, in monitoring and conservation of spawning ground of the anadrom species, in coastal and river basin management (Sari et al., 1998).

Lake Van Fisheries Geographic Information System (LVFGIS) has been designed for managing fisheries in an effective way and determining the technical, economical, social, cultural and demographical aspects related with fisheries in Lake Van as well as for compiling data in ArcView software environment. . With this study which encompassed all the communities dealing with fisheries around the Lake Van, LVFGIS facilitated to effective decision making and interpretations of the impacts of every kind of change in the means and modes of this profession.

In the previous chapter, we stated that pearl mullet was the only species adopting itself to live in Lake Van due to extreme values in the water quality in it. For this reason, in this study of LVFGIS only the fisheries management within in the context of pearl mullet has been investigated and information provided here could only be available for such management. We overlapped on LANDSAT MSS images with the borders of the lake, streams, settlements in which fisheries are carried out. Topological pinpoints pertained to the determined settlements were setup and then two categories were composed by defining two different times of fisheries as winter fishery and reproductive period fishery. Then the attribute table related with the sub-branches of every category was composed and linked with layers.

In the category of winter fishing such topics as the name of settlement dealing with winter fishing according to years, its location, the name of cooperative, if existed, the number of boats, the number of nets, number of fishing days, total catch, unit catch, total population of the settlement, people working in fisheries, demographical structure of the population dealing with fishing, mean family members and educational status of fishermen. In the category of fishing in reproductive period, such topics as the name of the settlement dealing with fishing according to years, their locations, number of beach seine net, the number of fishing days, the demographical structure of fishermen, mean family members and educational status of fishermen were investigated.

All of the data compiled through LVFGIS from 1994 on were brought together within the context of GIS. In case of any queries concerning the access of information, decision making and applications made by the authorities LVFGIS can be easily used. For instance, when we want to view the entire domains of the settlement in which the number of the boats are more than 10 it is possible to access information in seconds on the query screen; on the other hand if we want to see the relationship between the education status of fishermen, demographical condition and catch yield, it is possible to evaluate the results by overlapping to different layers in seconds by this system.

Fisheries management is a complicated and difficult task. Especially in such countries as Turkey in which fishermen have no access to scientific data, the fishermen are quite liable to violate the laws and rules of fishing in a way to persuade the authorities for exploiting the fish stock in an irregular and immoral way of fishing. Such fishermen usually come to the authorities and pledge that fishing is the only way of source of their financial and economical well-being; they also threat the authorities that they would begin strikes and uprisings by migrating to the city center. However the functionality of such system as LVFGIS will never allow the ill intentions and misuse of such fishermen for the fact that the pretexts put forward by them will quite easily be refuted through the scientific data provided by such system since this system will monitor all the information about fisheries, total populations, financial sources, the situation of settlement; and thus a much more sustainable and reliable environment for fishing will be established. Fishermen are also having the other demands such as benefiting from subventions and subsidies as well as support from the government on the pretext that their fish were exploited by the other fishermen of the near-by communities and a decrease in catch yield occurred, as well as replacements which they claim to have taking place in their fish stocks. Such cases show us that the applications of LVFGIS are of vital prominence in filling these gaps and regulating such chaotic environment of fishermen (Sari&Guven, 2004).

4.3 Phase 3: Putting New Approaches into Practice

Even though the first and second phase of this study did not produce tangible outcomes, they did enlighten our path to find the true solution to the problem. Having concluded by the end of the first phase that a "state-centered" approach was not applicable, and by the end of the second phase that relying on a "fisher-centered" strategy also did not lead to a solution, the third phase was designed so that the NGOs would have a pivotal responsibility in solving the issue, with the support of "public administrative bodies" and the "fishers". At the outset, the initiative involved touring the fishing villages at regular intervals explaining the damages incurred through the use of improper fishing methods. The local authorities and security forces were also visited at regular intervals and the ecological, economical, social and cultural significance of the pearl mullet was explicated. Brochures and posters addressing the fishing community, local authorities, security forces and consumers were prepared and distributed. Flow of information was established with the Ministry of Agriculture and Rural Affairs, the Ministry of Environment and Forestry and similar federal organizations responsible of fisheries management, in order to ensure that the subject was accurately perceived. Consequently, the gendarmerie in rural areas, and security forces at provinces increased their monitoring activities. Whereas no action had been taken against a single fisherman for violation of the law since 20 years, as a direct result of improved controls, now there were times when action was taken against more than 20 fishermen per day. Whereas 15 truckloads of fish was being sold right across the street from the Governor's office at the center of Van City during the "closed season", it was now difficult to find pearl mullets even at the smallest vendors at remote neighborhoods. However, the spawning-season fishers felt that they had been pushed into a corner and convinced the General Directorate of State Hydraulic Works authorities to direct all of the water in the Bendi Mahi River into the irrigation canals for agricultural purposes, just at the period when the fish were about to migrate to the streams and rivers

to lay their eggs. Despite all efforts, no water was channeled into the streambed until the end of the spawning season. As a result, approximately 1000 tons of fish died in the Bendi Mahi Streambed due to dehydration and the fishers collected truckloads of fish from the streambeds. As of the year 2001, after the issue was taken to court and a dialogue was established with the farmers' and irrigators' unions, a sufficient amount of water was left within the streambeds. An "irrigation training project" was launched in the Muradiye area, so that the farmers would learn proper irrigation techniques and would stop using the wrong methods. Two posters, and 4 different booklets were published for the training project. In parallel with this venture, another project was started to help steer the spawning-season fishers towards professional-fishing, with the support of the United Nations Development Program Global Environment Funds Small Grants Program (UNDP-GEF/SGP). Within the scope of this project, two separate training sets were designed for fishing villages, and were applied throughout all of the villages in the region. In 2002, all of the parties dealing with pearl mullet fishery management were gathered together for the "Sustainable Fisheries Management Workshop". The workshop was concluded with the signing of a proclamation stating all the subjects on which all of the participants had reached an agreement. Thus, even though there had been some arguments, for the first time all the parties had put their signature under a single text. In fact, this agreement was the turning point for sustainable fishing of the pearl mullet. After this stage, every unit began to own up to their institutional responsibilities regarding fishery management. The Preservation and Control General Directorate of the Ministry of Agriculture and Rural Affairs, which had also participated in the shaping of this agreement, in its circular to be effective in the 2001-2002 periods, accepted the joint proposal made by the university and the NGOs to set the dates of the fishing ban from April 15 to June 30. In support of the on-going scientific efforts, the Preservation and Control General Directorate also declared in its circular that the fishing ban would continue to be in effect for the preservation of the pearl mullet and that the same dates (April 15-June 30) would apply for the periods covering 2002-2004 and 2004-2006. This put an end to the legal inconsistencies that had been creating the greatest obstacle to sustainable fisheries management. With the beginning of the fishing ban on April 15, the long held practice of renting the river mouths for fishing purposes in the spawning-season was effectively ended. At present, none of the river mouths around the lake are being rented for spawning-season fishing activities. In fact, although focused specifically on the fishery of Lake Van pearl mullets, these efforts have turned into a model for Turkey's inland fishery management because the problems confronting our lakes are pretty much the same throughout the country, with minute differences. Lake Van is unique in one aspect: the severe pollution seen around the lakes of the Mediterranean and Agean regions is only at the beginning levels in Lake Van. Contrary to the first and second phases, the third phase of this project has provided positive results. The over-exploitation pressures on the pearl mullet stock have been decreased, fishing yield has increased, and profit levels in the fishing sector have risen. The sustainability of these outcomes depends on the dedication of relevant local institutions and organizations, and their determination to maintain these applications. Inevitably, the need has arisen for a local NGO that can ensure coordination between the local institutions and organizations, own up to the heritage of previous efforts, and develop projects geared towards the

future. The Association of Nature Observers was established in 2003 as a result of this necessity.

5. Results of the Transition to Sustainable Fishery

The achievement of sustainable pearl mullet fishery is a subject that is of great importance for the 14000 people around the lake who depend on it for their livelihood. Therefore, even though the studies that have been carried out bear ecological implications, in reality, their economic justifications are the main priority. The studies conducted between the years 1993-2006 in three phases as summarized above, provided excellent results, especially with the NGO-centered local fishery management strategies adopted in the third phase; and have become a model for inland fishery management in Turkey. 17 different training and cautionary materials were produced within the span of this 13-year study. Clearly, the endurance of the messages resulting from studies that deal with societal issues depends on the adequacy of educational and cautionary documents.

The results and benefits attained through the 3-phase studies conducted with the support of these training-cautionary materials are presented in Table 1. As can be seen in Table 1, the number of seine nets employed for spawning period fishing has decreased by half, whereas the number of professional-fishers has gone up by the same proportion. This indicates that most of those who gave up spawning season fishing have started to engage in winter fishing (Sari, 2004).

Parameters	**Years**	
	1996	**2006**
Number of seine nets used for spawning season fishery	92	32
Number of river mouths rented for spawning season fishery	12	0
Number of villages entirely opposed to the project (total 15 fishing villages)	9	2
Number of professional-fishers	101	165
Unit catch in professional fishing (kg/100 m/day)	2.622	8.50
Mean fork length (cm)	16.74	19.8
Number of fish per 1 kg (unit)	16-18	10-12
Total fishery revenues (USD)	3659000	7143000

Table 1. Output data obtained during transition to sustainable pearl mullet fishery

Whereas there were only 6 villages out of a total of 15, that supported the efforts to prevent spawning-season fishing at the initial stages of the transition to sustainable fishery management, today this number has gone up to 12 villages. Unit yield obtained through winter fishing has increased by three-fold in comparison to 1996 figures, going up to 8.50 kg. Decrease in size of captured fish due to over-fishing had been observed

in over-exploited grounds (Pauly, 1983). Sari (1997b) has stated that this decrease in size of captured pearl mullets is a direct result of over-exploitation and has emphasized that the fish size will increase once over-fishing is successfully prevented. As can be seen in Table 1, the increase in mean size of the pearl mullets is very noticeable. In the meantime, as a result of the decline of spawning season fishery, a supply and demand balance has started to emerge, and the revenues obtained from this fish have increased nearly 100%. .

6. Conclusion and Suggestions for Sustainable Fishery

Although there is a rising trend in pearl mullet fishery towards sustainable fishery practices, it must be clarified that "sustainable fishery management" has not yet been achieved. Considering the fact that tens of species have been lost within our inland waters in the last 50 years, the achievement of this current level of protection for the pearl mullet – the only species that can survive in the extreme ecosystem of Lake Van- definitely cannot be underestimated. On the other hand, neither is it possible to paint a rosy picture, or to claim that every problem has been solved.

Presently, 3 of the 15 fishing villages still insist on fishing during the spawning period. A new project has been launched in these villages, with the support of UNDP-GEF/SGP. This study aims to determine the reason for this difference in attitude by researching the social, cultural, and traditional structure of villages that have abandoned spawning season fishery practices and those that have not, while at the same time trying to change the traditional style of consumption, which encourages fishing in the reproductive period. Also within the context of this project is the assessment of alternative income resources for all the fishing villages, with a special emphasis on those villages that have abandoned spawning period fishing practices. Possible alternative income resources pinpointed during previous studies, such as winter fishing, canned fish and salted fish production workshops, and eco-tourism, are being studied for their adaptability to the local population's socio-cultural and traditional structure. Other alternative income resources generated by the local townspeople will also be appraised.

The first priority for full transition to sustainable fishery management is the acceptance of an NGO-centered local fishery management scheme by the fisheries management authorities. Significant steps have been taken to this effect, demonstrated by the fact that the dates for the fishing ban have been determined as a result of regional meetings, and the efforts that are being made to reach decisions with the highest possible participation in the last few years. However, the same sensitivity has not been observed in the application of the legislature. Presently, the security forces still play a major role in monitoring fishing activities at Lake Van. Yet legally, the security forces are only expected to assist the local branches of the Ministry of Agriculture and Rural Affairs, which are actually responsible of monitoring the lake. As a result, inspections are at times slackened, depending on how the administrators of the security forces interpret their range of responsibility. Institutionalized sustainability can only be attained if the responsible organizations are provided with the personnel and equipment they need, and are enforced to fully take on their monitoring responsibilities. This goal is only achievable through the establishment of a single "local administrative unit" that will be the sole decision-maker with regards to all fisheries management decisions for major inland waters such as Lake Van.

Preservation of the habitat is a basic component of sustainable fishery. Precautionary measures that need to be taken for sustainable fishery management of the pearl mullet and the preservation of its habitat can be listed as below:

- Establishing a local administrative unit that can achieve fishery management single-handedly in special ecosystems like Lake Van;
- Creating alternative employment opportunities that will provide a livelihood for the fishermen who decide to abandon spawning season fishery;
- Instigating amendments in the Fisheries Statute for the confiscation of fishing equipment and transport vehicles in order to prevent poaching, taking the Forest Statute as an example;
- Initiating measures to protect Lake Van, the natural habitat of the pearl mullet, from pollution;
- Preventing the transfer of sand from riverbeds, this damages their spawning areas.
- Mandatory construction of fish passage to ease the migration of the pearl mullets on all kinds of water structures that are to be built on rivers;
- Building boats' shelters at suitable places for effectual management and monitoring of fishery activities;
- Setting up processing and cold storage facilities in order to enhance the value of the fish for marketing purposes;
- Applying ecological water distribution in order to ensure that enough water is left in riverbeds for spawning during the reproduction period;
- Ensuring that the ecological needs of the pearl mullet are recognized as the first priority in all the long term planning related to the lake basin.

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Environmental Technologies

Edited by E. Burcu Ozkaraova Gungor

ISBN 978-3-902613-10-3
Hard cover, 268 pages
Publisher I-Tech Education and Publishing
Published online 01, January, 2008
Published in print edition January, 2008

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How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Mustafa Sari (2008). Integrated Sustainable Fisheries Management for Pearl Mullet of Lake Van, Turkey, Environmental Technologies, E. Burcu Ozkaraova Gungor (Ed.), ISBN: 978-3-902613-10-3, InTech, Available from: http://www.intechopen.com/books/environmental_technologies/integrated_sustainable_fisheries_management_for_pearl_mullet_of_lake_van__turkey

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