Socio-economic analysis and marketing patterns of the fish farming industry in Trabzon, Turkey

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Abstract The coast of Turkey extends for 8333 km and is surrounded by three ecologically different seas, 33 rivers of 178,000 km, over 200 natural lakes, 168 dams and over 750 ponds, all of which should increase the potential for the fish production of Turkey. In 2007, fish yield in Turkey was 544 773 t (TUİK data), 426 996 t from the sea and inland waters and 118 227 t from fish farming. Declines in natural stocks lead to an increasing demand for fish produce that could only be met by aquaculture. The socio-economic status of the fishing industry in Trabzon city was investigated, including the fishing family composition, level of education, fish processing and marketing. The survey was conducted on 20 farms, from a total of 62 that have product catching certificates.

Introduction

Increasing demand for fish products has resulted in the gowth of fish farms worldwide to meet a substantial part of the world's food requirement, of which China contributes a major portion. Total production from fish farming reached (inland and marine) 7.4 million t in 1980, 16.8 million t in 1990, 35.5 million t in 2000 and 47.8 million t in 2005 (FAO 2007). Fish farmng provides important services including supporting nutritional well-being, providing feedstock for the industrial sector, making contributions to rural development, increasing export opportunities, more effective administration of natural resources and conservation of biological diversity.

Farming is a multi-disciplinary science, not only bio-technical and environmental factors, but also socio-economic issues. Economic research assists both farmers and policy makers (Shang 1994). Sector-oriented economic studies and analyses in aquaculture are important to determine the profitability of aquaculture resources and the efficiency of resource usage, but also to improve operational management, evaluate new production techniques in terms of economics, to display market potential and to find new research areas (Neiland 1994).

In Turkey, aquaculture began with rainbow trout in the private sector in Sakarya-Akyazı in 1986. Public institutions were founded by the Konuklar Government Production Farm in Konya and Eskişehir Çifteler. The first serious marine aquaculture institution was founded for the production and farming of young bream, *Abramis brama* (L.) and perch, *Perca fluviatilis* L., under the leadership of Yasar Holding in İzmir-Cesme, 1985 (Çelikkale & Ark 1999). Aquaculture is growing rapidly in Turkey, over the last 10 years production has reached 118 277 t, increasing approximately 250%, with the total aquaculture production increasing by 22% (URL 1).

There has been an increasing demand for juvenile fish by institutions, these demands have been met and juveniles are now being exported to other European countries. Turkey contributes 25% to the European bream and perch markets and it is estimated to exceed 80 million t by 2030. Turkey also plays an active role in regional policies for aquaculture (URL 2); it is these developments that make Turkey stand out amongst European countries.

Site description and general information

Trabzon is located at 38° 30' - 40° 30' east meridian and 40° 30' - 41° 30' north parallels in an area of 664 km^2. Its northern neighbour is The Black Sea. The rivers in Trabzon are Karadere, Solaklı, Değirmendere, Foldere, Karadere, Kalenia, Yanbolu, Küçükdere and Manahos. Lakes in the Trabzon are, Uzungöl, Balıklıgöl, Aygır Lake, Black Lake and Sera Lake (URL 3). Fish farms in Trabzon city are founded on these riverbeds. Sea cages are a big part of Trabzon production and are placed at Yomra. Aquaculture in Trabzon began in 1976 by Albako and sea cages were introduced in 2004. Trabzon production reached 2043 t in 2005 and 2463 t in 2006, contributing to the total aquaculture production of Turkey (TUIK 2007). Considering all fish species in Trabzon, rainbow trout, *Oncorhynchus mykiss* (Walbaum) farming is prevailing in freshwater and sea production. Beside this, perch farming began in these companies in 2007.

There is a wide distribution of the 62 aquaculture companies between districts; the majority are in Macka and most companies that have <10 t capacity are small family enterprises, but there appears to be a rapid expansion in Yomra and Akcaabat, especially for marine production, to meet demand (Table 1; Tarım Il; Mudurlugu 2007).

Table 1. The place and capacity (t yr^{-1}) of the companies in Trabzon.

	Total	Fresh water	Marine	Capacity			
				≤10	10-30	30≥	juvenile
Merkez	3	3	-	3	-	-	-
Akçaabat	4	4	-	3	1	-	-
Araklı	2	2	-	1	1	-	-
Arsin	2	2	-	1	-	1	-
Çaykara	7	7	-	4	1	2	-
Düzköy	2	2	-	2	-	-	-
Hayrat	1	1	-	1	-	-	-
Maçka	20	20	-	11	5	2	2
Sürmene	4	4	-	4	-	-	-
Şalpazarı	3	3	-	2	1	-	-
Tonya	4	4	-	1	3	-	-
Vakfıkebir	3	3	-	2	1	-	-
Yomra	7	5	3	3	1	3	-
%	100	95	5	62	22	12	3
Total	62	59	3	38	14	8	2

Forty six companies produced 1 569 186 kg of juveniles and received €509 985 of subsidies from the General Directorate of Agriculture Production to produce juveniles. Of these subsidized farms 74% are in the Trabzon Agriculture Provincial Directorate. As a result of this support, the costs of inputs have declined and companies have tried to increase the production to get more support (Tarım Il. Mudurlugu 2008). This study examines the socio-economic status of the most important companies involved in aquaculture in Trabzon.

Materials and methods

Data were obtained using a questionnaire presented to the aquaculture companies. Records from the Agriculture Provincial Directorate and the research results of this study were used, together with publications and statistical data from the Turkish Statistical Institute and Word Health Organization.

The 62 companies that have industrial licenses were categorized into three groups with production ≤10 t, 10-30 t and ≥30 t. Seven questionnaires were distributed to the first and second groups and six to the third group. Twenty companies were randomly selected and interviewed face to face using a questionnaire with 39 questions. The questionnaire involved general information such as the age of the participant, education background, experience and general matters about management structure, sources of finances, income and expenditure account and general problems in production and marketing. Variable costs, gross production value per capita farm and gross margin were calculated for each farm. Variables appear to be dependent on production and deviate according to production level (Rehber & Çetin 1998).

In the variable costs of aquaculture, seed, medicine, chemicals, warming and lighting, fuel pooling, fish larvae, seasonal workers and transportation fees were considered. To calculate gross production value of aquaculture, the amount of production and the average fish prices were multiplied. In the gross margin analysis, each production field was considered individually. The gross margin of aquaculture was calculated by subtracting the variable expenses from the gross production revenue (Erkuş 1995; İnan 1998). The gross profit margin was compared with market prices at each marketing stage to determine the most profitable markets (Aboott 1966).

Results and discussion

The youngest person to participate in the questionnaire was 29 years of age and the oldest 72 years; the majority of participants were over 50. According to the questionnaire, 61% of the producers were primary school graduates, 21% were secondary school graduates and 17% were high-school graduates. The education level of the producers in Trabzon was low (Fig. 1).

About 61% of companies had a Bağ-Kur state insurance, 33% were retired from the state scheme and 6% had insurance in private pension. The size of families involved in fish farm production varied with 61% having between 3 and 5 family members, 28% with 6-8 family members and 6% with 9-11 family members, the remainder had 0-2 family members.

Ninety percent of companies were single proprietorship and 10% were incorporated companies. Incorporated companies were generally producers from Trabzon and Rize. Five percent of companies were established on land owned by private individuals, 20% on land belonging to public institutions and 75% to the owner of the company; 70% of the land on which the trout companies were founded was on private property (Rad 1999). This proportion was similar for companies in Trabzon.

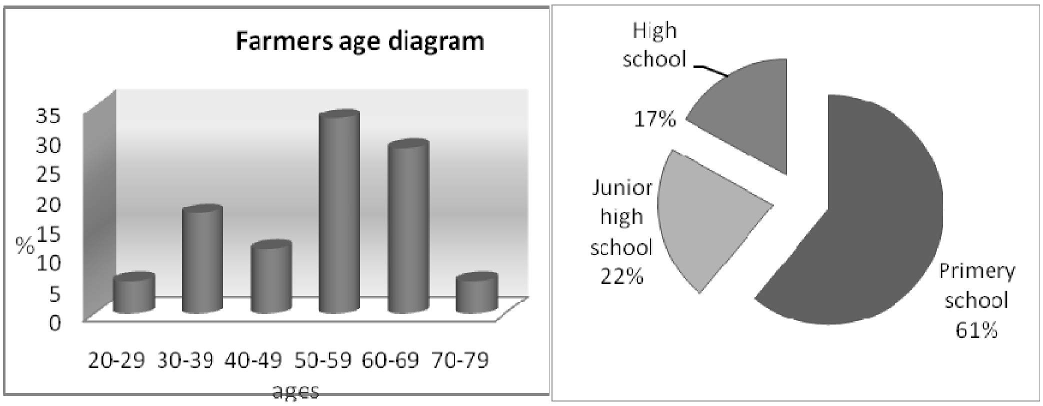

Figure 1. Age and level of education of the producers.

About 33% of companies viewed aquaculture as a hobby, 33% were recommended to start production and 22% because of the potential high profit. Sixty percent of producers considered their capacity to increase production but only 70% of participants had the scope to increase their capacity, with the remaining 30% having no possibilities. Potential to increase production varied between 20 and 500%. Thus it appears that institutional support and profitability affect outcomes. Revenue was used by 15% of the participants to expand the company, 25% of them to fund new companies and 5% of them to make investment in another sector. Producers occasionally funded new companies at sea or in reservoirs in other provinces.

Only 10% of fish farms have not faced any difficulty. Major difficulties faced were turbidity for Group I farms (57%) and household waste, including faecal matter (71%) for Group II farms. The Ministry of Environment and forestry fertilization studies found that some farmers were affected by chemicals used in agriculture. Farms that are far from sources or water and cages in the sea have been affected water temperature changes, especially marine aquaculture farms that have to harvest in July (Figure 2).

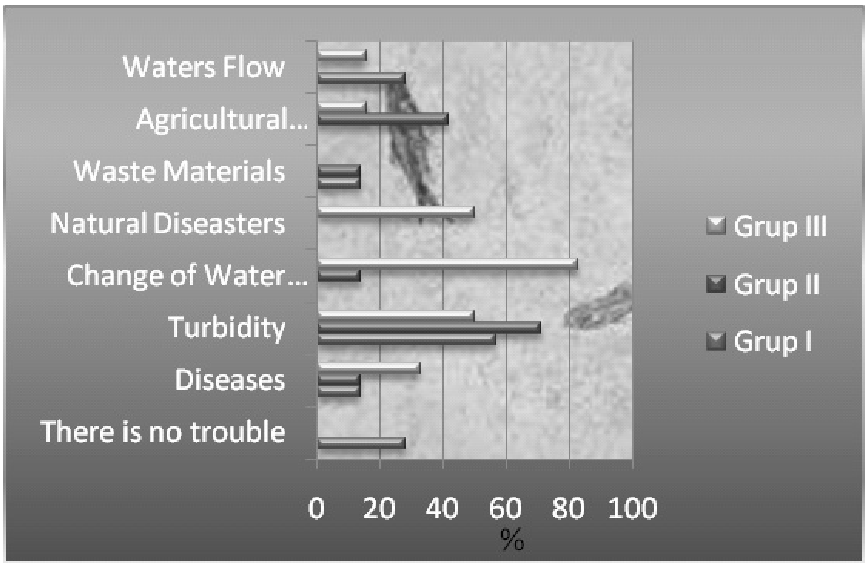

Figure 2. Problems faced in aquaculture production.

Gross margin was calculated from the average production of aquaculture was €11 100 for Group I, €26.193 for Group II and €389 390 for Group III. Excluding Group I, gross margin is higher than 50% (Table 2 and 3).

Table 2. The gross production value, variable costs and gross margin (€)

	Group 1	Group 2	Group 3
Gross Production Value	24.230,00	55.730,00	627.019,00
Variable costs	13.130,00	29.537,00	237.629,00
Gross Margin	11.100,00	26.193,00	389.390,00

Table 3. The percentage distribution of variable costs of aquaculture production unit (€)

Cost Items	Group I	Group II	Group III
Feed	26.45	60.858	357
Packing	630	2898	32.605
Transportation	1260	2898	48.907
Electric	1260	2898	16.302
Drugs and chemistry	630	2898	16.302
Temporary worker	0	0	0
Fuel-oil expenses	630	2898	48.907
Marketing expenses	1260	2898	48.907
Unexpected expenses	1890	2898	48.907

Marketing

Producers usually have several partners; these are farm-owned markets, restaurants or manufactures in Trabzon, Samsun, Ankara and Istanbul, and wholesale fish markets. This side of aquaculture is thriving. Small farms and farms located around tourist places sell their products easily, especially in the summer season. Indeed farms in tourist areas have difficulties in supplying enough products, for example farms which can produce over 100 t will have sold most of their products (Table 4).

Table 4. Aquaculture marketing ways (%)

	Group I	Group II	Group III
Markets	94.9	35	12
Retail sale	3.7	0	6
Auctions	0	0	54
Other farming sale	0	38	13
Restaurants and Hotels	1.2	27	6
Processing manufacture	0	0	9

Price definition

Producers define the prices depending on supply and demand; they collectively set the price around 200-250g fish/1€, but do not always obey this price. In winter, prices decrease because of competition from wild marine catches. Producers which sell via auctions do not set their own prices. Fish dealers make about 11% marketing margin, retail sellers about 24% ad markets about 35%**.**

Marketing services

Marketing services depend on 4 factors. First is the company's access to the market for which the companies have no problems. Second is the distance to the market which are located around city and district centres; again companies did not experience problems, even small companies far from the city and district centre, because they can sell their product locally. Third is the demand per company and the fourth is the availability and type of vehicles, used in transportation. In short, distribution services are effective. Both the agents and producers transport the fish to the external and internal consumption centres, using high quality packaging that maintains the quality of the product. The product is checked twice during distribution, firstly during transportation from the production site to wholesale market, and secondly from the wholesale market to the final consumer buying areas. Carriage from the wholesale markets to the domestic markets in the other cities is mainly (80%) through the use of hired vehicles.

Having a strong market position depends on the effectiveness of the market infrastructure. There are five marketing channel but the biggest problem appears to be competition from abundant wild resources. For example, too many anchovy on the market can cause the price of other fishes to fall.

Although most owners of enterprises are not experienced in marketing, their gross margin would seem to be at a high level, especially those enterprises with a capacity of >10 t yr^{-1} that have an advantage of selling their products, unless they do not use an agent.

As a result of the consistent growth of the sector and increase outputs, it is expected that there will be some difficulties in marketing, resulting in a decrease in profits, and the enterprises should take the necessary precautions to prevent this scenario. Subsidies for 'Supporting of stockbreeding' have depressed the costs of production and enterprises have had a tendency to increase production. Enterprises should take into account the marketing risks for the future, when increasing their production capacity, although it is thought that growth in production in the sector will continue, especially using cage-culture for marine species. It is appears that the enterprises do not intend to employ experienced technical staff, especially enterprises with a capacity of >10 t yr^{-1}, and this may constrain sector growth.

In addition to cold storage, suitable processing techniques are needed to make further progress, such as filleting and smoking techniques. An association of fish farmers that teamed up with producers had difficulty putting this development into practice because of decisions regarding the selling price of the fish, thus the fish farmer association would benefit from collaborations with the market. This would benefit the development of new species such as sea bass, black sea trout, *Salmo trutta labrax* and turbot, *Psetta maxima,* as markets would be developed in harmony.

Chemicals used for agricultural purposes should be applied with caution in river basins where culture activity takes place. The release of domestic discharge to water sources in the centre of some populations can have negative effects on production and so precautions should be taken to reduce this risk. Enterprises that suffer from temperature variability and water quantity problems would benefit by introducing a re-circulation system.

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Interactions between conservation, economic and social objectives of sturgeon culture in Russia: problems and possibilities of optimization

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Abstract After the implementation of flow regulation in the larger rivers in the former Soviet Union between 1950 and 1970, the stability of sturgeon populations in natural water bodies has been maintained by a large-scale system of state sturgeon hatcheries. Approximately 100 million juveniles have now been released into the rivers and seas of Russia. Since 2000, a sharp decline in sturgeon abundance has been observed, possibly due to economical and social problems. These problems have resulted in the poaching of a high number of immature sturgeons and a lack of modern technology at sturgeon hatcheries that would increase the number of juveniles and female individuals. Sturgeon hatcheries did not catch even 10% of the targeted number of mature female individuals. More than 50 % of sturgeon juveniles, released in 2004-2007, were reared from the farmed breeders from the living gene bank of South Branch Federal Centre of Selection and Genetics for Aquaculture (Krasnodar, Russian Federation), including critically endangered *H. huso, A. nudiventris and A. stellatus*. In this paper, the outlook of sturgeon meat and caviar production in Russia, which had an output of 3000 t in 2007, is discussed and new structure of sturgeon development optimisation is discussed. The innovative express method of early diagnostics of sex in sturgeons has proven to be very useful in the course of males that are used for meat production from 2 years of age. The saved immature females can then be successfully used for broodstock formation.

Introduction

The sharp decrease in sturgeon catches in the Azov and Caspian basins proves the necessity of sturgeon culture strategy development under the current geopolitical, economical and ecological conditions. Obviously it should be based on an integrated system analysis of commercial return for hatchery-bred sturgeon fingerlings, with acknowledgement of shortfalls caused by poaching and irrelevant biotechnology as well as poor technological backgrounds of state sturgeon hatcheries compared to world aquaculture achievements. The existing forms of commercial sturgeon culture need to be reviewed and possibly increased, in order for them to operate to the highest potential. In 2007, the total capacity of sturgeon aquaculture was 3000 t in Russia, considerably exceeding the amount caught in the natural water bodies. Worldwide developments have proven greater possibilities for the conservation of many fish species under the controlled conditions of aquaculture.

Release of sturgeon juveniles and catch dynamics in the Sea of Azov and Caspian Sea

By the mid 20th Century when dam construction was initiated on the main rivers, Volga, Kura, Don, Kuban and Dnepr, basic technologies were available for artificial reproduction such as induced spawning, artificial insemination, incubation, adhesive eggs, larval rearing. These have been in use in the hatcheries on rivers that were subjected to impoundments. The hatcheries and nurseries have since reached large scale productions of juveniles for stocking with standard technology. The process involves the capture of wild spawners in rivers, induced ovulation, artificial insemination of eggs, incubation and larvae rearing on live food, in indoor or outdoor ponds of around 2 ha. The juveniles remain in the ponds for approximately one month until the fingerlings reach between 1-4 g.

The release of juveniles in Russia is mostly concentrated in the Ponto-Caspian area and in the Siberian Rivers. In the North of the Caspian Sea the release of all species was around 75 million between 1970 and 1980, this number decreased to 60 million by the end of 1990 and the first years of the 21st Century (Fig. 1).

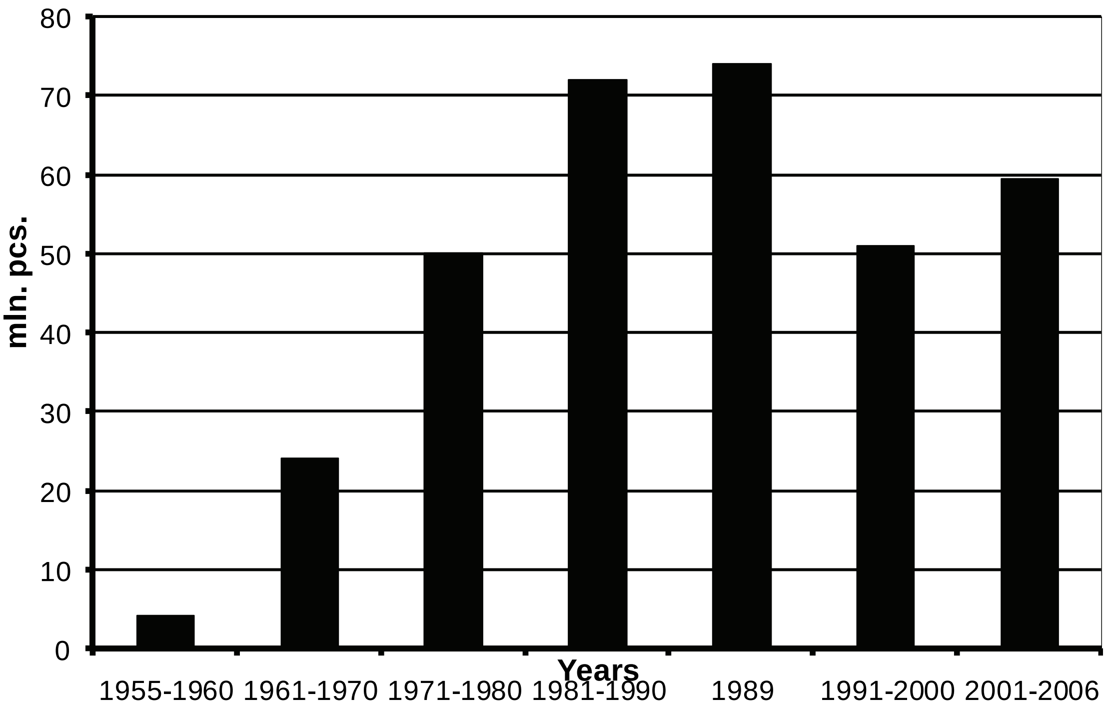

Figure 1. Release of sturgeon juveniles in the Caspian basin by Russian hatcheries.

In the Azov Sea area the release of fingerlings has been maintained at relatively similar level since 1970, with 14-15 million of *A. gueldenstaedtii* and 15-17 million of *A. stellatus*, both weighing 2-3 gr. In addition 500 000 *Huso huso* of 50 g and 200 000 *A. ruthenus* were released by South Branch Federal Center of Selection and Genetics for Aquaculture (Table 1).

Table 1. Release of sturgeon juveniles in the Azov-Kuban region during 1974-2006.

Stage	Year	*A. gueldenstaedtii*		*A. stellatus*		Total (million)
		million	%	million	%	
I	1974-1984	7.3	30.5	17.3	69.5	24.6
II	1985-1990	8.7	37.1	19.2	62.9	27.9
III	1991-1996	11.2	47.5	13.5	52.5	24.7
IV	1997-1999	13.3	46.8	15.1	53.2	28.4
V	2000-2006	7.3	72.3	2.8	27.7	10.1

The index of commercial return for released fingerlings is dependent on weight and was calculated to be between 1-3%. The commercial catch of sturgeon amounted to 28 000 per year and caviar production reached more than 2000 t.

After the dissolution of the Soviet Union and in connection with the lack of a unitary control system, fisheries suffered due to large scale poaching, a decline in natural propagation a decrease in artificial reproduction capacity. The total amount and commercial catches have suffered a sharp decline. Up until 2000, the official catches of sturgeon in the Caspian and Azov Seas was 500 t, caviar production was about 13 t (Table. 2).

Table 2. Sturgeon caviar production and export data.

	1996	1997	1998	1999	2000	2001
Production (t)	82.0	103.0	41.0	16.43	12.84	14.71
Export (t)	17.1	22.9	8.0	9.1	7.71	7.78
Export (US$ x 1000)	4344.1	6970.2	2247.9	2528.5	3377.2	3538.6

Fishing for sturgeon in the Sea of Azov has been prohibited since 2000, with the exception of catching the species for research and enhancement purposes. The decline in sturgeon catches led to the bankruptcy of a major part of rural cooperative enterprises that were involved in fisheries. 50% of fishermen were dismissed, leading to a lower efficiency of commercial fisheries and other negative social consequences such as poaching.

Sturgeon hatchery stock enhancement

The efficiency of fish stocking is not precisely known, in the Caspian Sea 16 million 30 to 50 day old juveniles of beluga were released annually from 1970, but records show that only 0.1% of these were harvested as adults (Khodorevskaya *et al*. 1999; Williot *et al*. 2002). For the Russian sturgeon 20-40 million juveniles (2-3g) were released between 1980 and 1983, this number was not sufficient to stabilize the population and 40-60 million more were released between 1986 and 1990. After this, the hatchery produced fish represented 25-30% of the catch. The number of spawners for all sturgeon species in north of the Caspian Sea was over 3.5 million in 1991 and then 500 000 in

1997 (Khodorevskaya *et al.* 1997). In the case of *Huso huso* the total fecundity of the populations was 10 billion eggs in 1976-1980 and less than 2 in 1990-1995 (Khodorevskaya 1999).

In the Azov Sea basin, all rivers are dammed and there is no natural recruitment, the present stocks have been supported for the last 25 years entirely by stocking. There are 9 sturgeon hatcheries in the Azov Sea basin. The simplified stocking strategy was aimed solely at the release of large number of hatchery-reared juveniles (Chebanov *et al*, 2002).

During last 20 years, before the ban on fishing for sturgeon, the average coefficient of commercial return amounted to 0.46%. One problem towards the farming of sturgeon is the short period of time that the migration run of mature females takes. These are used for artificial reproduction and due to the fact that dams are constructed close to the sea, the female availability is restricted in time and within 12-15 days. In this time the hatcheries have to insure the production of 30 million juveniles.

The large-scale hatchery productions were maintained despite a decrease in available brood stocks during last five years. The number of Russian sturgeon females used for spawning in the Kuban's hatcheries during the 1996-2000 period decreased from 368 to 151 and that of stellate sturgeon from 761 to 230. The decline in females has been observed in this century, only 21 females of Russian and 2 of stellate sturgeon were used for hatchery enhancement in 2007. The restoration of the sturgeon population structure in the Sea of Azov is not possible without developing a sturgeon living gene bank and domestic brood stocks.

Sturgeon Living Gene Bank

All of the Russian sturgeon Living Gene Bank (Krasnodar), at total of 12,000 individuals, includes 24 intraspecific groups of the 6 endangered sturgeon species (Table 2), including *A. gueldenstaedtii*, *A. nudiventris*, *A. ruthenus*, *A. stellatus*, *H. huso*. The sturgeons of the Living Bank have been reared at 3 different experimental farms, including a hatchery with a natural temperature regime and warm water farms (Chebanov 1998).

Table 3. Endangered species in the Russian sturgeon Living Gene Bank (VU - vulnerable; CR - critically endangered; EN - endangered.

Species	Number of year-classes	Number of intraspecific biological groups or populations	National status	International status (IUCN 1996)
A. gueldenstaedtii	9	3	VU	EN
A. stellatus	14	3	VU, H	EN
A. ruthenus	18	7	CR	CR
A. nudiventris	1	2	H	EN
A. persicus	2	2	CR	EN
H. huso	10	4	EN	CR

The electronic system of morphometric data measurement from digital images enables the fast collection of preliminary information during the process of brood stock assessment and further morphometric analysis in the laboratory. The experimental data of general morphometric, genetic, hatchery-biological and other characters of all fish groups presented in the bank, have been collected in the database after the systematisation and processing.

The viable progeny, for the first time in sturgeon culture, was obtained from the farmed spawners of giant, Russian, Persian, stellate and ship sturgeons. For the past few years, approximately 20 million fingerlings, over 50% of released juveniles obtained from farmed spawners, were released into the Sea of Azov. In the future, due to a small number of wild breeders in the Sea of Azov (Chebanov & Billard 2001), individuals for stock enhancement will be provided by progeny obtained from farmed brood stock. It is necessary to provide monitoring of reproductive and other biological characteristics of these brood stocks and its progeny.

Analysis of size, weight and reproduction indices of farmed breeders compared with wild spawners, showed that under optimal conditions, the farmed individuals reached their maturity 1.5 to 2 times earlier and that their reproductive cycles were 2 times shorter (Chebanov & Billard 2001). Monitoring and comparative analyses of the differences between wild and farmed fish of different species and intraspecific groups of sturgeons should include; growth, age at maturity, relative fecundity, morphological and physiological indices. The morphological analysis of cultured sturgeon allows a minimisation of the consequences resulting from a casual selection of individuals for artificial breeding.

Early sexing and staging of farmed sturgeon by using ultrasound technique

The lack of external sex dimorphism in sturgeon does not enable early separation of females from males by visual methods before they become sexually maturity at 5 to 10 years of age. Traumatic methods as biopsy have previously been used to sex sturgeon, if conducted later in their rearing, males reach commercial size. It would be more profitable to only rear females for caviar production.

A non-invasive ultrasound technique is efficient for sexing individuals and can determine maturity stages in fish from the Federal Gene Bank. Females at maturity stages I-II, III and IV, as well as males at stages II and III-IV are very distinctive. This technique can also facilitate the process of valuation for heterogeneous domestic brood stock, enabling the accurate prognosis of fish maturation in the successive spawning season (Chebanov *et al*. 2004). Therefore, the ultrasound method, which takes less than 10 seconds per fish, can successfully examine gonad development offering new possibilities for the selection of individuals, enabling farms to hold on to immature females until they produce eggs.

The application of innovative aquaculture biotechnology and rearing control, such as the ultrasound technique, along with genetics and physiological monitoring of sturgeon brood stocks, could contribute a considerable income towards the genofond conservation and the development of an economically substantial sturgeon culture.

Current commercial sturgeon culture in Russia and possibilities of its optimisation

The broad development of commercial sturgeon culture should be considered as a measure to satisfy the demand for sturgeon meat. This could reduce poaching and the selling of sturgeon meat and caviar on the black market. The development of sturgeon culture should contribute to the recovery of natural populations in the Sea of Azov, Caspian Sea and Siberian rivers.

The initiation of federal and regional programmes for sturgeon population enhancement were a specific feature in the Russian Federation over the last few years, for example the Krasnodar Territory principal program, that was devoted to the sturgeon genofond conservation and offered financial support for the commercial sturgeon culture in the littoral regions. The cost of feed for 50% of sturgeon farms have been covered by the Krasnodar Territory regional budget, as well as 30% of pedigree stocking materials expenses.

From 1994 to 2007, the number of sturgeon farms increased from 19 to 260 in Russia and the gross annual production increased from 200 to 3000 t, while the total production of other farmed freshwater fish species has decreased nearly 3 times (Figure 2).

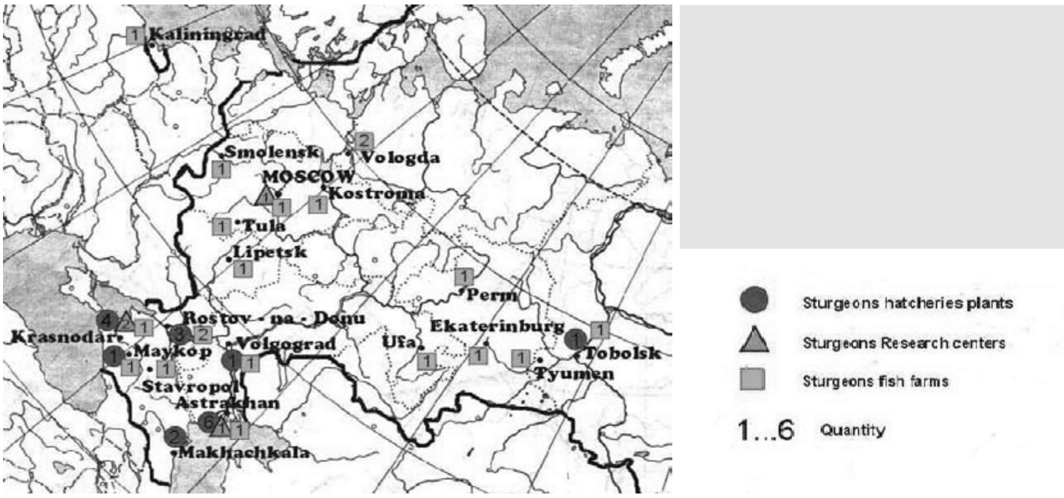

Figure 2. Locations of different sturgeon enterprises in the Russian Federation.

Sturgeon production system

Sturgeon species, mostly bester, are produced in monoculture, either in small ponds measuring a few hectares with in intensive feeding systems so that they reach market size within 24 months or in larger ponds of 100 ha, in a ranching system where they reach market size in 30-36 months. They can also be farmed in polyculture, ponds with substitution by paddlefish and silver carp.

Several production systems for sturgeon aquaculture could be used, such as; industrial waste-heat effluent, traditional ponds for carp culture, raceways or cages in freshwater or brackish waters in the Volga delta and Kuban rivers. More than 75 % of sturgeons produced in warm water farms at power station have been used for meat.

Sturgeon ranching in deltaic lakes and brackish lagoons of up to 1 000 ha, provide promising opportunities and require limited investments and not much artificial feed. Using 3-5-g juveniles, a commercial weight of 1.5-2 kg can be reached within 24-26 months, with a survival rate of 34-38 %. Experimental works have shown an efficiency of ranching in deltaic lakes and brackish lagoons that produced up to 1600 t of sturgeons. Production and economic data of Russian commercial sturgeon culture for 2004-2007 are presented in the Table 3.

Sturgeon caviar and meat production forecast

Approximate forecast data obtained while extrapolating the modern trend of sturgeon production development in Russia have shown that sturgeon meat production capacity could reach 3700 t in the year 2008 and 4500 t in the year 2009. According to expert evaluation, market demand in Russia of sturgeon meat would be 15,000 t at a stable meat price of 12-13 Euro, and up to 20,000 t if the price dropped to 8 Euro.

Table 4. Characteristics of commercial sturgeon culture in Russia.

	2004	2005	2006	2007
Meat (t x 1000)	2.5	2.8	2.4	2.8
Caviar produced from ovulated eggs (t)	1.0	2.0	3.5	5.0
Wholesale price per 1 kg of meat, (Euro)	8.5	9.0	11.5	13
Wholesale price per 1 kg of caviar (at farm gate) (Euro)	450	600	800	850
Number of sturgeon feeding plants/number of plants involved in caviar production	120/4	150/6	250/9	260/10
FCR	3.0	2.8	2.3	2.2
Duration of production cycle time necessary for commercial sizes, (age in years)	3/6	3/5	3/5	2.5/5.5
Production costs per 1 kg of meat, (Euro)	6.5	6.0	5.5	5.5

The demand for caviar if the market price remains at the present level, would be approximately 40-50 t. The estimate for 2009 is that the production could increase to 12-14 t, obtaining eggs from live fish. The production facilities of existing projects would enable the rearing of 11500 t of sturgeons and more than 100 t of caviar.

Possibilities of sturgeon culture optimisation

An advanced scheme of sturgeon brood stock management has been offered in order to increase the efficiency of sturgeon culture and caviar production in Russia and to reach the target for economical, social and ecological objectives. These are based on the non-invasive ultrasound technique to determine the maturity of females at an early stage. The brief description of the scheme is given below. Sturgeon culture optimisation activities also require joint efforts between state sturgeon hatcheries, sturgeon farms and Federal Center of Selection and Genetics in Aquaculture (Fig. 3).

In 2007, Russia produced about 3000 t. of commercial sturgeons with a mean weight of 1.8 kg, females typically contributed 60% to this total volume. As a result, approximately 1800 t, or 1mln immature females were sold at market. Taking into account the growth rate and weight gain of females from hatching to maturation it could take until 2011-2012 to produce 7000 t of mature (with caviar) females with caviar or 800 t of caviar. At the same time, the total weight of females saved for caviar production has not been greater than 1500 t.

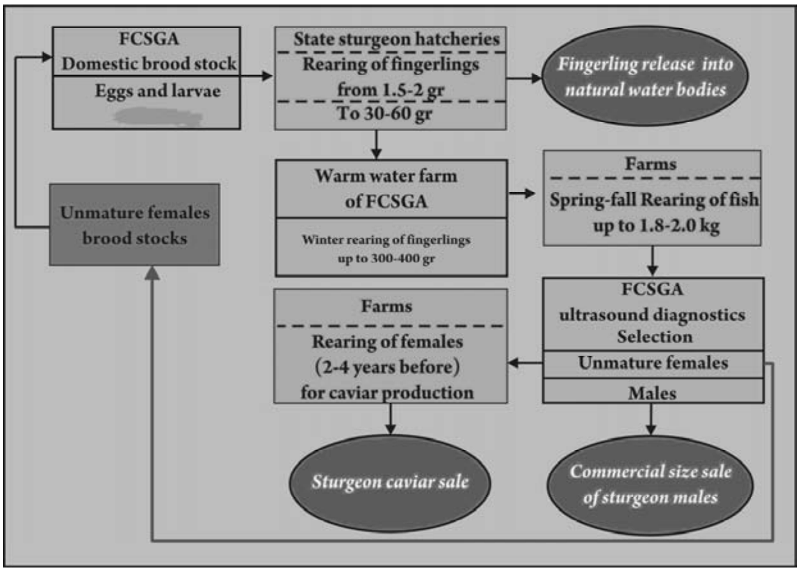

Figure 3. Optimal scheme of interactions between different elements of a new sturgeon aquaculture structure.

Conclusion

In order to reach economical, social and ecological objectives of sturgeon culture optimisation in Russia, it is important to take the following steps;

1) To improve sturgeon hatchery technology.

2) To develop different types of sturgeon culture that will help overcome existing problems such as poaching and selling on the black market. They should also emphasize the regional level of financial support, solving social problems in the littoral regions.

3) To apply new schemes for the optimal structure of sturgeon culture, with joint and coordinated efforts of state sturgeon hatcheries, sturgeon farms and Federal Center of Selection and Genetics in Aquaculture. This should enable the acceleration of brood stock formation and the efficiency of increased caviar production, due to application of early sexing and the ultrasound method for determining the stage of maturity.

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Consumers' willingness to pay for organic trout

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Abstract Although the demand for organic products is increasing across Italian consumers, there is currently a restriction or no real supply of certificated organic fish. Various pilot projects have been carried out over recent years to define the main standards for organic fish farming and particular attention was devoted to organic trout farming. This paper estimates the potential demand for organic trout in Italy and the Willingness to Pay (WTP) for this "new" product. The paper exposes the results of a survey on consumers based on the Italian region of Veneto carried out by using a face-to-face questionnaire. This survey investigated the main consumption habits and analyze the socio-economic factors eventually affecting consumers' WTP, and determine the consumers' WTP a premium price. The results indicated that consumers demonstrate a willingness to pay a premium price to purchase better quality products.

Introduction

It is a relatively common and shared opinion that aquaculture will have an important role in satisfying a steadily increasing demand for fish, since quantities potentially caught in the wild have nearly reached their absolute limit[4]. Aquaculture seems therefore to promise abundant resources for the production of food and may also play a key role in reducing the current pressure on overburdened wild fisheries. Desspite these considerations, many studies have warned that aquaculture could negatively affect the environment, for example, by generating processes of both genetic and ecological contamination, by spreading pathogens and diseases, chemical pollution as well as pollution derived from feed waste. For reasons of food quality and environmental protection, consumers have traditionally stimulated the demand for healthy food. Generally, consumers are increasingly sceptical of the safety of conventional foods and therefore, the crisis generated by the discovery of dioxin-contaminated food and a series of livestock diseases (such as *Bovine Spongiform Encephalopathy*) has increased the demand for organic food. Within that context, the production of food through organic aquaculture appears to be a very good way to supply a market sector with safe and certified products as the main purposes of organic practices are namely the improvement of food quality and of its safety, by implementing environmental friendly processes. While organic farming already enjoys a certain importance for both the production and consumption of some food products, organic aquaculture still stands at an early stage. Although no official statistical data are available concerning the global production of certified organic aquaculture products, it is estimated that the total

[4] Aquaculture production is globally growing at an average rate of 9% per year since 1970, compared with a 2.9% rate for terrestrial farmed meat production and 1.3% for capture fisheries over the same period (FAO, 2002).

production in 2000 stood at round 5000 t and was mainly concentrated in some European countries. This quantity represents about 0.01 percent of the total global aquaculture production and about 0.25 percent at a European level (FAO 2002). The fishes that are most commonly produced through organic practices are namely salmon, trout[5] and crayfish.

The main reason for the relatively slow initial growth of organic aquaculture is the absence of internationally recognized and universally accepted regulations and standards for producing and handling organic aquaculture products[6]. However, in many countries there are now several organic labelling bodies which provide the market with the main standards for the production of organic fish as well as with a series of criteria for the labelling process (EU Commission 2005; De Francesco 2003). A regulation which was recently approved by the European Commission (see Reg. 834/2007) and deals with the certification of organic food has also taken aquaculture into consideration. Consequently, there are good reasons to argue that in the very near future there will be a significant development in the supply of fresh organic fish not only across Europe, but also in Italy. A series of studies have been conducted in Italy to evaluate the technical pre-requisites and the economical feasibility of a standardized certification process for organic farming focusing mainly on sea bass (*Dicentrarchus labrax*), sea bream (*Sparus aurata*) (Uniprom 2002; De Francesco 2003) and rainbow trout (*Oncorhynchus mykiss*) (API 2007). As for the demand from local consumers, the first of the aforementioned studies evaluates the potential demand for both sea bass and sea bream and also provides an estimate of the consumers' Willingness to Pay (WTP) a premium price[7] for buying and consuming these organically farmed fishes.

Trout as a product has different marketing characteristics to both sea bass and sea bream. Trout is a freshwater fish as well as an aquaculture (breeding) product and generally this is the main reason why the consumption of this fish is relatively low. In the culture of trout, production costs[8] and consequently market prices are much lower than those for sea bass and sea bream. This may explain why domestic purchases of trout are very high and why the species is one of the fishes which are most commonly eaten by Italians, although there are strong differences along the peninsula (in Northern Italy, for example, trout counts for about 10-15% of the total consumption of fish) (Ismea 2007).

Having realised the results of the previous studies could not be extended to the trout market, it was decided that an investigation would be undertaken into the potential demand for organically farmed trout. The aim of this paper is to estimate consumers' WTP for the consumption of organically farmed trout. The paper will discuss the main results of a survey which was carried out in the Italian region of Veneto by means of face-to-face interviews, with an eye on the consumers' WTP a premium price for this

[5] In Europe the production of organic farmed trout is concentrated in France and Switzerland (round 220 t per year), Great Britain (318), Ireland (120), Germany (60), Spain (50) and Austria (10) (ISMEA, 2007).
[6] Organic aquaculture was not included either in the EU Reg. 2091/92 regarding the certification of organic food and its labelling nor in the EU Reg. 1904/99 concerning to the organic terrestrial animal husbandry.
[7] Premium price is the additional percentage charged for organic products when compared with conventional products prices.
[8] The average ex firm price for sea bass and sea bream is respectively 7 and 6.7 €/kg, whereas for trout this stands at 3.3 €/kg (Icram-API, 2007).

new product, and investigate the main consumption habits and the most relevant socio-economic factors affecting consumers' WTP.

Materials and methods

Contingent Valuation Method

Contingent Valuation (CV) is a survey-based direct method (i.e. survey by questionnaire) for an evaluation of market and non-market goods (Arrow *et al*. 1993); this method involves creating a hypothetical market situation for a given good or service (Carson *et al*. 2001) and it is also the most commonly employed technique used to estimate consumer WTP (Hanneman 1984). WTP can be defined as the difference in monetary value between consumers' surplus before and after improving a certain food product. Respondents face a hypothetical purchasing situation in which they are invited to associate WTP to a certain premium, expressed either as a sum of money or as a percentage going beyond the reference price (Carmona-Torres & Calatrava-Requena 2006). This tool allows market researchers to quantify the value consumers give to certain products by associating the value with the amount of money they are willing to pay to purchase such products (Kawagoe & Fukunaga 2001). Since 1980, there has been an increasing interest in CV, mainly in the literature devoted to environmental evaluations (Bishop & Heberlein 1979). Recently, several more references that have appeared in papers covering consumers' WTP for attributes linked to food safety and quality. These generate a supplementary support for the use of CVM, especially as many such papers deal namely with the WTP for consuming organically produced food.

Before carrying out interviews, researchers have to define the different price premiums (the so- called "starting points") and this step may be carried out according to various criteria, such as a pilot test or through an iterative selection. In this study we assume that if respondents answer questions concerning the purchase of conventional trout and their knowledge of organically produced food, they will have the pre-requisites that are necessary for defining the price they are willing to pay for organic trout. The adopted reference price is the average price of conventional trout according to the information released by the Italian National Association of Aqua-farmers (API).

Survey methodology

The questionnaire was administered to a sample of 321 individuals in some Provinces (Venice, Padua and Treviso)[9] of the Veneto Region. The sample was stratified first according to the population sizes of the various provinces considered and then by the age of the local inhabitants (the starting point being the data provided by the National Statistical Bureau). The survey was carried out in November-December 2007 and face-to-face interviews were collected near large-scale retail supermarkets, fish shops and markets. The questionnaire is divided into four sections with questions on: 1) main habits as far as the consumption and purchase are concerned; 2) knowledge and

[9] We decided to carry out the analysis in this region as the productive units for trout are mainly concentrated here than in any other area of the country (Veneto features namely 78 companies of aquaculture that count for 22% of the entire availability of such companies across the Italian peninsula; in 2007 they produced also 10,300 ^{t} of trout) (Icram-API, 2007). Another explanation for that choice derives by the fact that Northern Italy features also the highest consumption rate of trout at national level.

domestic consumption of organically produced food; 3) WTP for the consumption of organic trout, frequency and non-purchase reasons. In this section respondents were also asked to define their eventual interest in the introduction of organic trout in refectories according to recently approved regional law; 4) respondents' socio-economic characteristics.

As far as the WTP is concerned, respondents were asked to answer a dichotomous choice question which was then followed by an open-ended question.

The model

To evaluate the WTP for organically farmed trout we adopted the Amemiya (two-stage) model (Amemiya 1978, 1979), which is a generalization of the models previously developed by Tobit (Tobin 1958) and Heckman (Heckman 1979). This approach consists of two different regression models. The first regards the decision to pay or not to pay (selection stage), while the second stage refers to the sum of money consumers are willing to pay (i.e. the maximum WTP), after having made the decision to pay (outcome stage). Different sets of explicative variables can be used in the estimation of the two models, so that we also detect if the two decisions (stages) are dependent or not. The Probit model is applied to carry out the first stage of such an analysis.

In this study, WTP_i* is the propensity or ability of a respondent to pay for a particular good, i.e. a latent variable[10], $i = 1,\dots, N$ where N is the sample size, $\boldsymbol{x_i}$ a vector of k independent variables referred to i-esimo respondent, $\boldsymbol{a}$ a vector of coefficients (k x1) which remains constant within the whole sample, and η_i a Gaussian variable $\eta_i \sim N(0, \sigma^2)$.

There is generally a linear relationship between $WTPi*$ and the matrix consisting of $\boldsymbol{x}_i$ variables:

$$WTP_i* = \boldsymbol{a}'\boldsymbol{x_i} + \eta_{i.} \quad (1)$$

While WTP_i* cannot be observed, we can observe WTP and state the following relations:

$$WTP_i = 0 \qquad WTP_i* \leq 0; \ (2)$$

$$WTP_i = 1 \qquad WTP_i* > 0;$$

From the equation (1) and (2), and from the assumption made on stochastic terms, we get the probability that a respondent (drawn randomly) is willing to pay (Maddala, 1983):

$$\Pr(WTP_i = 1) = \Pr(\boldsymbol{a}'\boldsymbol{x}_i + \eta_i > 0) = \Pr(\eta_i > -\boldsymbol{a}'\boldsymbol{x}_i) = \Phi(\boldsymbol{a}'\boldsymbol{x}_i) \quad (4)$$

where $\Phi(\cdot)$ is the distribution function for a standard normal variable.

A positive (negative) sign of a coefficient in the estimated model increases (decreases) the probability to pay. Following the application of the Probit model we can obtain the inverse Mill's Ratio (MR):

[10] Latent variable are the ones we cannot observe directly, we can anyway infer their existence and availability thanks to the properties of an observed variable which has been previously directly measured.

$$MR_i = \begin{cases} \phi(\boldsymbol{a}'\boldsymbol{x}_i)/\Phi(\boldsymbol{a}'\boldsymbol{x}_i) & \text{if the respondents } i \text{ replay 'yes'} \\ \phi(\boldsymbol{a}'\boldsymbol{x}_i)/(1-\Phi(\boldsymbol{a}'\boldsymbol{x}_i)) & \text{otherwise} \end{cases} \quad (5)$$

where $\phi(\cdot)$ is the density function for a standard normal variable.

In the second stage the regression model is estimated, including MR as an independent variable:

$$WTP_i = \boldsymbol{b}'\boldsymbol{x}_i + \beta\ MR_i + \varepsilon_i \ (6)$$

β is the covariance between the stochastic terms of the equations about of the two stages (Amemiya 1978, 1979). If β =0, the decision to pay and how much to pay are independent.

Results

Consumer's Profile

The sample consists of a total of 321 individuals whose main socio-economic characteristics are shown in Table 1. As expected, 69% of the sample is made up of women, as grocery shopping is mostly a female activity. The average respondent is 48 years old and the highest frequency correspondents of people fell into 40-49 age range, followed by those that are 60 and over. As for their education, 39% of the respondents have successfully completed high school and 18% held a university or postgraduate degree. More than a half of the respondents (57%) are employed, 21% are housewives and 18% are retired. The average size of households stands at 3.6 people, the mode is a family consisting of 4 members and 51.6% of households don't include people under the age of 14. The modal income category after tax is from 20,000 to 30,000 Euro.

As for their habits in terms of consumption and purchase, 80% of respondents buy fish once per week and the majority (88%) regularly consume fish at home rather than away-from-home (12%). Respondents mainly consume fresh fish (88%) rather than frozen/deep-frozen fish unpacked (26%) or packed (18%), while only 2% of the people interviewed purchase cooked fish. With regards tofish consumers, approximately 30% of them regularly buy trout, mainly in hyper/supermarkets (52%) but there is also a relevant share of consumers who buy fish at fish shops (44%) and at the market (42%), while a mere 4% refer directly to fishermen. As far as the consumption of organic products is concerned, almost all the interviewers have some knowledge of this food category while only 6% of the people interviewed, mainly men who are on average aged 55, have no idea what organic food is. 57% of the people included in the sample are real consumers of organic products; this ratio has to be divided into: habitual consumers (47% are purchasing and consuming organic food at least once per week); occasional consumers (42%, 1-2 times per month); unusual consumers (the remaining 11%, consume organic food only a few times per year). As for the main reasons they purchase organically grown and farmed products, respondents mentioned that they are more healthful (60%) than the traditional ones; moreover, they don't contain GMO (43%). For those who are not used to purchasing organic food, this behavior derives from them not perceiving any relevant differences with conventional products (48%); moreover, the price of organic food is considered as too high (35%) and such products are also conceived as not really interesting or attractive (9%).

Table 1. Socio-economic characteristics of the sample

Gender	**Frequency**	**Percent**	**Mean**	**Std.dev.**
Male		31.5		
Female	220	68.5		
Total	321	100.0		
Age groups			**48.0**	**13.5**
20-29	21	6.6		
30-39	73	22.9		
40-49	92	28.8		
50-59	56	17.6		
>60	77	24.1		
Total (no answer: 2)	319	100.0		
Education level				
University	58	18.2		
High school	124	38.9		
Lower secondary school	91	28.5		
Primary school	46	14.4		
Total (no answer: 2)	319	100.0		
Occupation				
Employed	181	56.7		
Housewife	66	20.7		
Student	7	2.2		
Pensioner	58	18.2		
Unemployed	5	1.6		
Other	2	0.6		
Total (no answer:2)	319	100.0		
Household size			**3.6**	**1.0**
1 person	4	1.3		
2 people	49	15.4		
3 people	79	24.8		
4 people	143	45.0		
more than 4	43	13.5		
Total (no answer:3)	318	100.0		
Household with people aged 14 and under				
0	163	51.6		
1 person	75	23.7		
more than 1	78	24.7		
Total (no answer: 5)	316	100.0		
Province of residence				
Venice	97	30.5		
Treviso	105	33.0		
Padua	116	36.5		
Total (no answer: 3)	318	100.0		
Income level				
< 10.000	7	2.6		
10.000-19.999	56	20.9		
20.000-29.999	98	36.6		
30.000-39.999	59	22.0		
> 40.000	48	17.9		
Total (no answer:53)	268	100.0		

WTP and demographic characteristics

43% of respondents are willing to purchase organic trout with an average price of 8.1 euro (2.6 euro of *premium price*[11]) and a median price of 8 euro. Analyzing the kind of products trout consumers prefer, it emerges that 70% prefer more transformed fish, particularly fillet of organic trout (90%), smoked fillet (26%) and hamburger of organic trout (10%).

As for the frequency at which purchases of this new product occur, 53% of consumers are ready to buy it 1-2 times per month, while 21% would buy it more often, i.e. once per week.

The remaining 57% of respondents are not interested in purchasing organic trout. The disinterest of respondents that more or less regularly consume conventional trout products derives from the fact that the organic version is not considered any better than the traditional one and also by a general diffidence towards the certification and real goodness of organic food. As for those respondents who do not consume conventional trout, they wouldn't buy organic trout because they simply do not like that kind of fish (58%). At least 41% of the sample would introduce the organic trout in refectories (even though 30% of these consumers aren't willing to purchase organic trout by and for themselves). An interesting interaction has to be noted between the premium price (€/kg) consumers are willing to pay for purchasing and consuming organic trout and their socio-demographic characteristics (Table 2). As far as the age of the consumer is concerned, we are able to observe that as age increases, the premium price expected to be paid decreases. To go into even more detail, people included in the age group up to 44, show a greater readiness and willingness to pay extra for organic trout. The higher the education level of the consumer is, the higher the willingness to pay is too. Household size and its composition also affect the WTP; in particular larger households – including people aged under 14 - are related to the highest value registered for *premium price*. The WTP is also higher in people in employment and there is a notable difference in the average values of the premium price if you take into consideration the professional situation of the respondent (2.9 €/kg for employed people vs. 2.3 €/kg for housewives and retired people). Intuitively, consumers with higher incomes are much more inclined to pay extra for organic trout.

Results of regression models

The two regressions from the Amemiya model were first estimated using all the variables of interest (for the complete list of independent variables see Table 3), then a stepwise robust regression was also carried out (the cut-off value $\alpha = 0.05$). Following Alberini *et al*. (2005), income was introduced into the regression model specifying two different variables. The first is denoted by income and is equal to the mean of each income category, in cases where this information was not provided by the respondent we put a 0; the second variable, denoted by missing income, is a dummy variable (a value of 1 was added in cases where people being interviewed didn't state their annual income – i.e. 17% of the sample -, 0 in all other cases).

[11] In our study, the *premium price* is the difference between the amount of WTP that respondent is willing to pay and the average conventional trout price, i.e. 5.5 €/kg according to the information released by the Italian National Association of Aqua-farmers (API).

Table 2. Average *premium price* vs socio-economic features of the respondents

Gender	**WTP**	**interv.**	**Age**	**WTP**	**interv.**
Female	2.6	90	≤ 44	2.9	53
Male	2.7	42	From 45 to 60	2.5	50
Total		132	> 60	2.5	29
			Total		132
Education Level	**WTP**	**interv.**	**Household size**	**WTP**	**interv.**
Primary school	2.3	14	1-2 persons	2.4	18
Lower secondary school	2.4	37	3 persons	2.5	41
High school	2.7	51	4 persons	2.6	50
University	3.0	30	more than 4 persons	3.1	22
Total		132	Total		131
Household with people aged 14 and under	**WTP**	**interv.**	**Occupation**	**WTP**	**interv.**
0	2.5	78	Employed	2.9	74
1 person	2.8	28	Housewife	2.3	28
2 persons	2.9	17	Pensioner	2.3	26
More than 2 persons	3.4	7	Other	1.9	4
Total		130	Total		132
Annual income category	**WTP**	**interv.**	**Province**	**WTP**	**interv.**
≤ 19.000	2.5	13	Venice	2.4	34
20.000 - 29.000	2.3	42	Treviso	2.7	46
29.000 - 39.000	3.1	28	Padua	2.7	50
40.000 - 49.000	2.5	20	Total		130
≥ 50.000	3.1	8			
Total		111			

The software STATA was used for analysis. Stepwise results are presented in Table 4.The first stage of the model (Probit regression) shows the increasing probability of obtaining a WTP if the interviewee has a university degree, likes trout, eats fish often at home would buy organic fish and prefers transformed products, would introduce organic trout in refectories or there aren't people aged under 14 within the family. If the interviewee eats usually frozen/double-frozen fish (packed or unpacked) and no fresh fish, the probability of getting a WTP for organic trout diminishes.

The *MR* coefficient which was estimated after the second stage is statistically significant, so the two stages are dependent. The main determinants of the *premium price* are the willingness to buy organic trout, and in particular transformed products, living in Padua or Treviso, unlike Venice, having a family with more than two boys/girls aged under 14, being in favour of the introduction of organic trout into refectories. Moreover, in the case where the income increases by 1 euro, the premium price increases by 0.0187 euro. Finally, for those who have a good knowledge of organic foods, are often buying frozen/double-frozen fish packed, are 47-59 years old and unemployed or students, a reduction of their respective WTP has been estimated.

Table 3. List of independent variables

Independent variables	
never	1 = never buying fish; 0 = otherwise
once a week	1 = buying fish only once a week; 0 = otherwise (reference category)
many times per week	1 = buying fish more than one time per week; 0 = otherwise
home	1= usually eating fish at home; 0 = otherwise
away	1= usually eating fish away-from-home; 0 = otherwise (reference category)
fresh	1= usually eating fresh fish; 0 = otherwise (reference category)
frozen fish unpacked	1= usually eating frozen/deep-frozen fish unpacked; 0 = otherwise
frozen fish packed	1= usually eating frozen/deep-frozen fish packed; 0 = otherwise
cooked	1= usually eating cooked fish; 0 = otherwise
trout	1 = usually baying trout; 0 = otherwise
super/hypermarket	1 = generally buying fish in super/hypermarket; 0 = otherwise (ref category)
fish shop	1 = generally buying fish in a fish shop; 0 = otherwise
fish market	1 = generally buying fish in a fish market; 0 = otherwise
fisherman	1 = generally buying fish directly from fisherman; 0 = otherwise
organic food	1 = knowing organic food; 0 = otherwise
buy organic food	1 = buying organic food; 0 = otherwise
organic fish	1 = would buy organic fish; 0 = otherwise
transformed	1 = preferring buy transformed fish; 0 = otherwise
menu1	1 = he/she would introduce organic trout in the refectories; 0 = otherwise
menu2	1 = he/she wouldn't introduce organic trout in the refectories; 0 = otherwise
menu3	1 = he/she hasn't young people in family; 0 = otherwise
menu4	1 = he/she doesn't know; 0 = otherwise (reference category)
Socio demographic variables	
Sex	1 = being male; 0 = otherwise
Age ≤ 38	1 = ≤ 38 years old; 0 = otherwise
Age 39 – 46	1 = 39- 46 years old; 0 = otherwise
Age 47 – 59	1 = 47-59 years old; 0 = otherwise
Age ≥ 60	1 = ≥ 60 years old and over; 0 = otherwise (reference category)
Padua	1 = living in Padua; 0 = otherwise
Treviso	1 = living in Treviso; 0 = otherwise
Venice	1 = living in Venice; 0 = otherwise (reference category)
Primary	1 = having attended primary schools; 0 = otherwise
Secondary	1 = having attended secondary schools; 0 = otherwise (reference category)
University	1 = having a university degree; 0 = otherwise
Employed	1= being employed; 0 = otherwise (reference category)
Housewife	1= being a Housewife; 0 = otherwise
Pensioner	1= being a Pensioner; 0 = otherwise
Other job	1= being Unemployed/Student/other; 0 = otherwise
comp 12	1 = family with 1-2 persons; 0 = otherwise
comp 3	1 = family with 3 persons; 0 = otherwise
comp 4	1 = family with 4 persons; 0 = otherwise (reference category)
comp >4	1 = family with more than 4 persons; 0 = otherwise
young 0	1 = family with no young under 14; 0 = otherwise (reference category)
young 1	1 = family with one young under 14; 0 = otherwise
young 2	1 = family with two youngs under 14; 0 = otherwise
young >2	1 = family with more than two youngs under 14; 0 = otherwise
Missing income	1 = respondents do not state their income category; 0 = otherwise
Income	The mid-point of each income category; 0 if respondents do not state their income category
Mill Ratio	Inverse Mill's Ratio

Table 4. WTP determinants

Independent variables	First stage[*]	Second stage[**]
home	0.9288 (0.4486)[a]	
frozen fish unpacked	-0.7936 (0.3588)	-0.3868 (0.1908)
frozen fish packed	-1.0766 (0.3399)	
trout	1.1230 (0.3125)	
organic food		-1.2691 (0.3241)
organic fish	1.8712 (0.3671)	1.0156 (0.2198)
transformed	1.3717 (0.2617)	0.8464 (0.2104)
menu1	1.4340 (0.3010)	0.8519 (0.2203)
menu3	1.4935 (0.3546)	0.5396 (0.2007)
Treviso		0.3853 (0.1622)
Padua		0.4376 (0.1637)
University	0.6848 (0.3490)	
Age 47 – 59		-0.3593 (0.1600)
Other job		-0.5767 (0.2782)
young >2		1.2330 (0.4955)
Income		0.0187 (0.0069)
Missing income		0.7401 (0.3296)
Mill Ratio		-0.6093 (0.2800)
constant	-3.8382 (0.6215)	0.5785 (0.4269)

[*] Number of obs = 240; Pseudo R2 = 0.6283; Log pseudolikelihood = -61.82979.
[**] Number of obs = 240; Adjusted R-squared = 0.52416.
[a] Robust Std. Err. in brackets.

Discussion

The main results of this research may be summarized as follows.

Potential consumers of organic trout amount to 43% of the sample. The figure is relevant when compared with the number of usual consumers (29%).

The consumption of trout is quite decisive for the purchase of organic trout, and a pre-existing consumption of organic food (in particular of organic fish) is even more important; the decision to purchase organic trout is strongly linked to the importance given to safe food.

WTP for organic trout is related to specific socio-demographic features of the consumers e.g. education level and income, living in a household with boys/girls aged under 14.

The *premium price* for organic trout is on average 2.6 €/kg. This result compares well to other studies, such as De Francesco (2003) who have estimated a *premium price* equal to 2.25 €/kg for sea bass and sea bream.

On average WTP is equal to 8.10 €/kg. If we compare the average selling price of the trout (5.5 €/kg) and the average *premium price* for organic trout (2.6 €/kg), we can argue that the selling price of organic trout may be augmented by up to 47%. This increase in price may even cover the supplementary production costs involved in the farming of organic trout. The increase in production costs of organic sea bass and sea bream has been estimated as equal to 30%.

It is important to note that this result has been obtained in a virtual market, i.e. in absence of competition from other companies; secondly the selling price of trout is low in comparison to the prices of other types of fish.

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Use of narrow-clawed crayfish (*Astacus leptodactylus* Esch.) in recreational and commercial fisheries and aquaculture in Bulgaria

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Abstract In Bulgaria three freshwater crayfish species are present as native: *Astacus leptodactylus* Esch., *Astacus astacus* L. and *Austropotamobius torrentium* Schrank. All of them are under some form of protection, and are included in various legal documents. Bulgaria is among the few countries in Europe, where there are no introduced freshwater crayfish species. Crayfish are raised in ponds up to a marketable size or used for re-stocking of natural water bodies in the country. This study presents the results from research on the gonad development, fecundity and the rearing of narrow-clawed crayfish – one of the most important crayfish species in the country. This investigation was carried out on spawners and juveniles, reared under controlled conditions in tanks or ponds. The efficient management of crayfish should be aimed at an optimal increase and the ecologically friendly use of the stock in nature and the enhancement of astaciculture.

Introduction

Freshwater crayfish are a valuable biological resource, which is of substantial significance both from an economical and an environmental point of view. Bulgaria is one of the few European countries where there are no introduced freshwater crayfish species (Zaikov & Hubenova 2007). Three indigenous species are found within the countries borders: narrow-clawed crayfish *Astacus leptodactylus* Esch., noble crayfish *Astacus astacus* L. and stone crayfish *Austropotamobius torrentium* Schrank (Bulgarkov 1961; Souty-Grosset *et al.* 2006; Zaikov & Hubenova 2007). Each species is under some form of legal protection (Table 1), and in Bulgaria this is regulated by the Fisheries and Aquaculture Law. The latter two species, the noble crayfish and the stone crayfish, are included in the Convention on the Conservation of European Wildlife and Natural Habitats, Bern (1979).

Regarding the quantitative and qualitative evaluation of existing stocks of freshwater crayfish, the country is significantly lagging behind other European countries, where such monitoring has traditionally been implemented for many years. In Bulgaria recreational fishing for crayfish is done on a very limited scale. It is practiced by a small number of people using crayfish traps, or catching crayfish by hand in shallow areas of lakes, small rivers and streams. The Fisheries and Aquaculture Law states that anyone who owns a fishing license can catch crayfish during the permitted season (15 May - 15 October), with a daily limit of 50 crayfish. The cost of an annual fishing license is 13 EUR.

Table 1. Legal protection of crayfish species in Bulgarian water bodies

Species	Form of protection
Narrow-clawed crayfish, *Astacus leptodactylus* Esch.	Seasonal prohibition on capture from 15October to 15 May. Only crayfish over 80 mm in size are allowed to be caught. The use of electricity, bottom trailing and dragging, sedative substances and explosives are not allowed for catching crayfish.
Nobile crayfish *Astacus astacus* L.	The Fisheries and Aquaculture Law prohibits their capture, movement, transport and trade throughout the year.
Stone crayfish, *Austropotamobius torrentium* Schrank	The Fisheries and Aquaculture Law prohibits their capture, movement, transport and trade throughout the year.

In commercial practices crayfish are caught from natural populations in the large water basins of the country. The capture of crayfish for commercial purposes requires a special license, which is issued for one year at a cost of 150 EUR. The license is only valid for a specific region and the holder of the license is not allowed to catch crayfish in water basins outside those included in the license. Only five commercial crayfish fishing licenses have been issued in the country, indicating that very few people (or at least very few people with the correct permission) are occupied in the business.

In Bulgaria there are no aquaculture facilities that have been specifically designed and constructed for the culture of crayfish. In some of the small to medium sized reservoirs where fish are reared, narrow-clawed crayfish are also caught. These have reproduced naturally without any special care. These catches represent approximately 20 ^{t} of the annual marketed catch (Zaikov & Karanikolov 2000; Zaikov 2001; Zaikov & Hubenova 2007), however there are no official statistics on the quantity of produce sold. The crayfish are sold at wholesale prices of 3 to 4 EUR per kilogram, and in retail stores the price reaches 7-8 EUR per kilogram.

Of the 3 discussed species, the narrow-clawed crayfish *A. leptodactylus* Esch., is of the greatest economical importance for the country as it represents a resource which to a certain extent is exploited for recreational, commercial and aquaculture purposes. In recent years it has been the subject of intense study in Bulgaria, mainly focusing on the production of one year old crayfish in aquaculture, which could be used to restock some natural water bodies, or reared up to market sizes in fish farms.

In this article the results of research on the reproductive potential of the narrow-clawed crayfish are presented. Its incubation and rearing to one-summer-old in aquaculture conditions is also investigated to indicate the feasibility of using them for the restocking of inland water bodies and extensive culture.

Materials and methods

In this study juvenile and sexually mature individuals were used, reared all year round in earthen ponds.

In order to determine the minimum size at which male narrow-clawed crayfish reach sexual maturity, one-summer-old crayfish (*n* = 93) with body weight 1.52-19.50 g were studied during the months of August, September and January. The analysis was made on the basis of microscopic observations on the maturity stage of the testis. After dissection the testes were preserved in 4% formalin and prepared for paraffin inclusion. Sections 5-6 µm thick were coloured with hematoxylin and eosin. The microscopic observations were carried out with a Nikon MICROPHOT-SA. For female individuals the time sexual maturity was reached was determined on the basis of macroscopic observations on one-summer-old individuals (*n* = 52), with body weight 9.47 to 19.44 g, during the autumn-winter period (November-December). The deposition of eggs on the pleopodal legs of the crayfish was taken as a marker for sexual maturity.

In the determination of the fecundity of female crayfish the following indicators were recorded: absolute (number of ovarian eggs) and working (number pleopodal eggs) fecundity, and GSI, %. Absolute fecundity was determined for 27 sexually mature crayfish with average body weight 38-40 g and body length 11 cm in September. After dissection the ovaries were weighed, preserved in 4% formalin, and then the number of ovarian eggs of each individual was counted. The working fecundity (number of pleopodal eggs) was determined in 71 sexually mature crayfish in the month of May. The pleopodal eggs with embryos, just prior to hatching, were removed with tweezers from the pleopods of the females, and were counted separately for each individual. Correlations between the number of ovarian and pleopodal eggs, and some external body features were established.

In order to determine the reproductive potential of the male narrow-clawed crayfish the following indicators were recordeded: period for mass copulation, rate of participation of the males in the reproductive process, interval between two consecutive copulations of a single male crayfish. Eight variants were tested with different proportions of male (n=24; BW, g 43.25 and TL, cm 10.82) to female (n=92; BW, g 31.23 and TL, cm 10.5) individuals – from 1:1 to 1:8.

In order to determine the influence of varying incubation conditions on hatch rates, eggs were placed in hatching incubators which were in turn placed into tanks or directly into earth ponds. The hatching incubators are wooden boxes with 50 individual chambers (10 x 8 x 8 cm) and in each chamber is placed a single female crayfish with eggs at the “eye spots” phase of development. For the incubation in tanks a total of 270 females with an average weight of 31 g were placed in to 6 hatching incubators in 2 tanks. The larvae produced, were grown in the tanks up to a strong stage (30 days old) and were fed with boiled egg yolk and zooplankton. For the incubation of embryos in ponds, hatching incubators were placed directly in to two earth ponds (0.14 ha and 0.4 ha). 330 and 258 females were stocked respectively with an average weight of 34 g.

In order to determine the influence of the stocking density on the growth and survival rate of the crayfish up to a strong stage (30 days after hatching), 3 different stocking densities were tested: 196, 392 and 784 individuals m^{-2}. Crayfish juveniles with an initial body weight of 30.4 mg were reared in tanks and fed zooplankton. The growth and survival rate were recorded.

The influence of the type of feed on the growth and survival rates of crayfish up to 30 days after hatching was established with the use of 4 types of food offered *ad libitum*: zooplankton, carp pellets, meat meal and soy-bean meal. The crayfish juveniles with initial body weight of 30.4 mg were reared in tanks at stocking density of 4 ind.l^{-1}. The following indicators were measured and recorded: growth rate, specific and daily growth rate and survival rate.

Narrow-clawed crayfish were reared up to one-summer-old in earth ponds at two different stocking densities (stocked with 10 day old juvenile crayfish). They were reared in polyculture with 5 day old bighead carp larvae. The crayfish and bighead carp were fed ground sunflower grain and wheat during the vegetation period.

Results

Maturity

Male crayfish reared in earth ponds reached maturity at an average age of 6-7 months for individuals with body length over 6.4 cm. In histological sections, spermatozoa in the testis (Fig. 1) were observed as well as changes in the sperm ducts that allow the passage and deposition of spermatozoa in the lumen (Fig. 2). The smallest female crayfish which had reached maturity at one-summer-old and which had pleopodal eggs, were of a body length of 7.0 cm. The average working fecundity established for that group was low – 38.8 pleopodal eggs per individual.

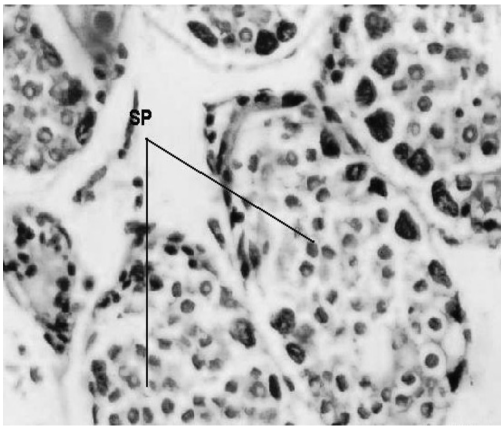

Figure 1. Cross-section of the testis of one summer old crayfish with body weight over 10 g (4 months old, end of September). Testis cysts containing spermatozoon (SP), HE, magn.x200

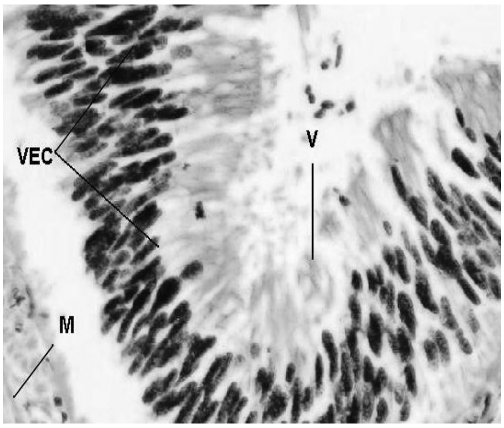

Figure 2. Cross-section of the efferent tubule of one summer old crayfish with body weight over 10 g (4 months old, end of September). The muscle fibres (M) and vacuolized epitelial cells (VEC), containing vacuoles (V) are visible in the wall of the seminal duct, HE, magn.x200

Fecundity

The absolute fecundity (number of ovarian eggs) of the narrow-clawed crayfish reared in aquaculture is 371.56 oocytes and it varies between 196 and 639 (Table 2). The gonadosomatic index is 2.56 %. The average working fecundity is 162.7 pleopodal eggs, and it varies between 11 and 538 (Table 3). With an increase in body weight, the number of pleopodal eggs also increases and their numbers were highest in the weight group of over 70 g. The absolute fecundity is positive correlated to the body weight ($F=8.0454BW^{1.0672}$, r = 0.8307, n = 27) and body length ($F = 1.2679TL^{2.3512}$, r = 0.6267, n = 27). Significant correlation was also observed between the number of pleopodal eggs and the body weight and length and with the carapace length and width (Figs 3-6).

Table 2. Absolute fecundity of narrow clawed crayfish in aquaculture

n	Body weight, g	Total length, cm	Ovarian weight, g	GSI, %	Oocyte number
27	38.39+9.59	11.39+1.03	0.98+0.35	2.56+0.75	371.56+124.1

Table 3. Working fecundity of narrow-clawed crayfish in aquaculture

Weight groups	*n*	Body weight, g	Total length, cm	Number of pleopodal eggs
up to 30 g	28	22.93±1.07	9.49±0.17	104±64.68
30 to 50 g	39	37.35±0.79	11.25±0.08	184.9±91.97
50 to 70 g	2	56.51±6.65	13.2±0.71	304.5±115.26
over 70 g	2	82.62±14.9	14.75±0.78	410.5±180.31
Average		33.48±12.86	10.71±1.36	162.7±104.1

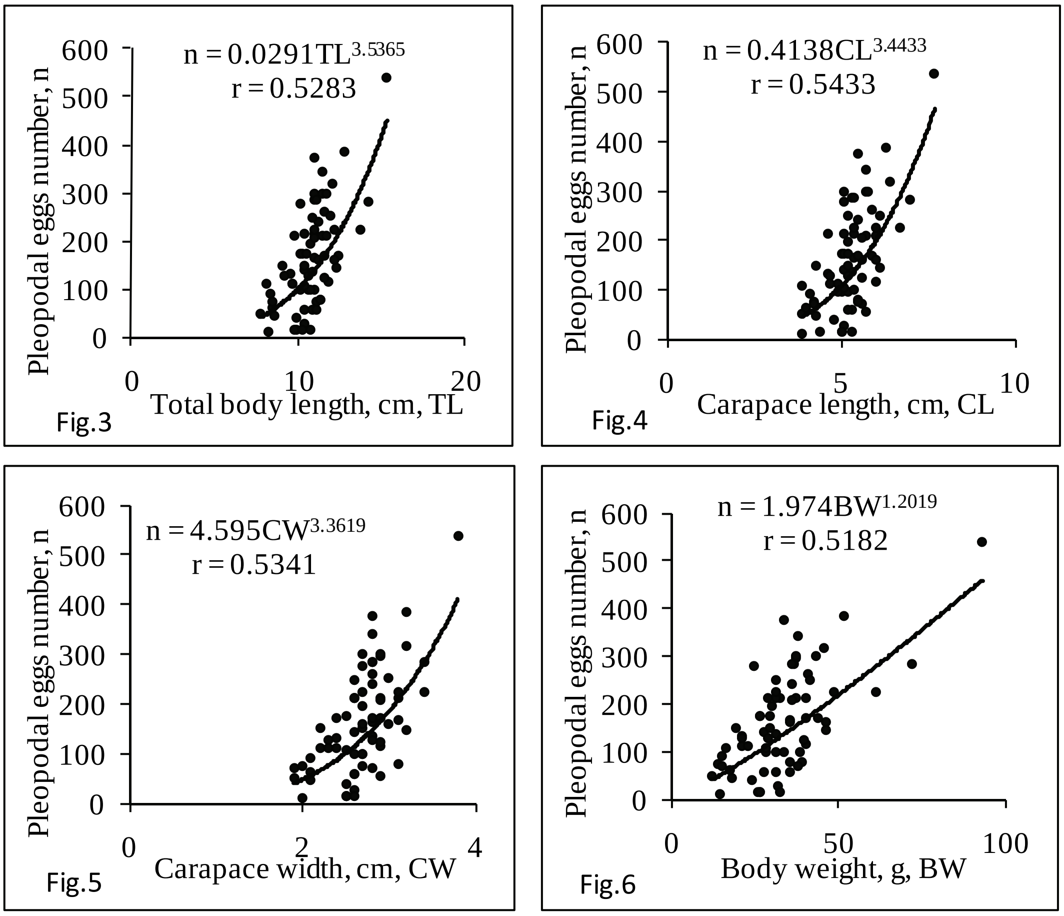

Figure 3. Relationship between fecundity (plepodal eggs) and total length (TL), carapace length (CL), carapace width (CW) and body weight (BW) in *A. leptodactulys*

Reproductive potential of male crayfish

The reproductive process of the narrow-clawed crayfish begins with the deposition of a spermatophore on the body of the females, ventrally-caudally on the cephalotorax at the base of the first to third pair of walking legs. It was established that a single male crayfish can place a spermatophore on 8 female individuals, i.e. to inseminate them. In the majority of cases two copulations occur without an interval between them or within 1-3 days and are independent of the tested proportions of males to females.

Egg incubation

The results obtained from the egg incubation in tanks are shown in Table 4. In the two test variants with different numbers of female individuals, in one tank an average of 133 to 154 crayfish larvae were obtained from one female, with a hatch rate of 85-88 %. The survival rate of the crayfish juveniles up to the 30 days age was 45-47 %. The eggs incubated in the hatching incubators placed in ponds, resulted in a lower hatch rate in the range of 65-70%.

Table 4. Results obtained from egg incubation in tanks

Features	I tank	II tank
Density of female crayfish, ind.tank^{-1}	150	120
Average number of pleopodal eggs from 1 female	150	180
Total hatched juveniles.tank^{-1}	20,000	18,500
Hatchery rate, %	88	85
Survived juveniles up to 30-days	9,400	8,300
Survival rate of juveniles up to 30-days, %	47	45
Survival rate of females, %	98	95

Fry Densities and Feeding

When rearing crayfish up to an age of one month at different stocking densities, survival rate was within 31.9 to 67.5 %, with the highest values recorded at the lowest densities (Table 5). The highest survival rate is correlated with the highest average body weight of 108.4 mg.

When crayfish juveniles were fed with various types of food (zooplankton, carp pellets, meat meal, soy-bean meal), the highest survival rate of 71.88 % was achieved with zooplankton feeding, which correlates with the highest body weight at the end of the 30-day rearing period - 89.93 mg (Table 6).

Pond rearing of summerlings

The results obtained from rearing crayfish up to one-summer-old, at different stocking densities, in ponds are shown in Table 7. The highest yield of 764 kg.ha^{-1}, and highest survival rate of 52%, were achieved with an initial stocking density of 210 000 ind.ha^{-1}.

Table 5. Growth and survival rates of crayfish reared to one month old at different stocking densities

Density Replication	784 ind.m^{-2}		392 ind.m^{-2}		196 ind.m^{-2}	
	1	2	1	2	1	2
Initial body weight, mg	32.6	35.6	33.4	30.3	30.8	36.5
Growth rate, mg	39.2	46	60.8	56.4	76.7	71.9
Final body weight, mg	71.8	81.6	94.2	86.6	107.5	108.4
Survival rate, %	31.9	36.9	50	52.5	67.5	62.5

Table 6. Growth and survival rates of crayfish reared to one summer old on different diets

Features	Zooplankton	Carp pellets	Meat meal	Soy-bean meal
Survival rate, %	71.88	68.13	50.43	48.12
SGR, %.day^{-1}	3.56	3.2	2.25	2.12
DGR, mg. day^{-1}	1.99	1.75	1.2	0.95
Final body weight, mg	89.93	80.42	61.88	58.91

Table 7. Main results from rearing crayfish up to one-summer old age in ponds

Density ind.ha^{-1}	Pond 1	Pond 2
Crayfish juveniles	27000	210000
Herbivorous fish juveniles	150000	100000
Survival rate %		
Crayfish juveniles	38.7	52
Herbivorous fish juveniles	33.3	55.7
Yield kg.ha^{-1}		
Crayfish juveniles	115	764
Herbivorous fish juveniles	900	557
Total yield	1015	1321

Discussion

The period in which the narrow-clawed crayfishes reach sexual maturity depends on a number of factors, the most important of which are the volume and quality of the water and feed, the temperature conditions and those related to somatic growth. The different areas of *A.leptodactylus* distribution are characterized by different climatic conditions that determine the age and indirectly the body size at which the crayfish reach sexual maturity. Under the conditions found in Bulgaria, the size at which narrow-clawed crayfish reach maturity (males over 6.4 cm; females over 7.0 cm), and are able to take part in the reproduction in the first winter of their life (Hubenova *et al.* 2004), are near the sizes indicated by other authors for various other regions. Alechnovich & Kulesh

(1996), Burba (1996), Kulesh & Alechnovich (1997) reported that in the Eastern distribution areas of *A. leptodactylus* (Belarus, Lithuania and from Karelia to the Caspian Sea) the females with a length 68-75 mm and the males with a length of 67mm are sexually mature. In Western areas (Switzerland) the body length of the crayfish, when they take part in the reproduction for first time, is 73-76 mm (Stucki 1999). In Turkmenistan the minimum length of mature crayfish is 75 mm and in Poland is 83 mm.

A main reproductive indicator, directly linked to the sustained development of the various natural and cultivated populations of the narrow-clawed crayfish is fecundity. The number of ovarian eggs (absolute fecundity) has been the focus of many studies (Koksal 1988; Alekhnovich & Kulesh 1996; Kulesh & Alechnovich 1997; Hosseinpour & Karimpour 1999; Harlioglu & Turkgulu, 2000). Absolute fecundity directly affects the number of individuals in any water basin, and to a great extent is specific to the organisms inhabiting the different water bodies, and the results obtained vary widely, with a range from 60 to 1628 oocytes (Koksal 1988; Alekhnovich & Kulesh 1996; Hosseinpour & Karimpour 1999). The values that were established for the absolute fecundity of the narrow-clawed crayfish, reared in aquaculture in this study, were within the range of other authors indicated for different latitudes. Compared to data for the absolute fecundity of the narrow-clawed crayfish in some natural populations in the country (dam-lake Kardzhali and dam-lake Pyasachnik) (Hubenova, Vasileva & Zaikov 2002; Vasileva *et al.* (2006 a), the absolute fecundity of the crayfish reared in aquaculture is higher. This is most likely due to the sufficient quantity of natural food in the ponds, during the period of the oocytes formation in the ovary (Holdich & Lowery 1988; Koksal 1988).

Working fecundity of the narrow-clawed crayfish fluctuates in a wide range, with variations from 0 to 280 pleopodal eggs (Cherkashina 1970, 1975; Alekhnovich & Kulesh 1996; Hosseinpour & Karimpour 1999). The data reported on the working fecundity of the narrow-clawed crayfish, reared in aquaculture, are comparable with the data for populations, inhabiting the southern regions of the range of the species (Cherkashina 1970, 1975; Hosseinpour & Karimpour, 1999). However, the working fecundity of the cultivated individuals is lower compared to that of the natural populations in dam-lake Pyasachnik (Hubenova *et al.* 2005; Vasileva *et al.* 2006a), likely due to the higher crayfish densities in the ponds, which could result in higher losses of eggs.

An important factor for sustaining natural populations or for predicting the number of crayfish juveniles from aquaculture is the proportion of the absolute and working fecundity. In this study it was determined that the absolute fecundity is 55% higher than the working fecundity, which is also supported by other authors (Jarvelkung 1958; Momot 1967; Lindqvist & Louerkari 1975; Lahti & Lindqvist 1983; Huner & Lindqvist 1991; Hubenova-Siderova *et al.* 2000), who indicated a proportion of 50-68 %.

The ratio of males to females in the brood stocks and the optimal utilization of the reproductive potential of the male crayfish are of significant interest both from a theoretical and practical point of view. Cukerzis (1989) points out the fact that a single male can copulate with 2-3 female crayfish. According to Fedotov (1993) up to 5 the females can be mated, in most cases however the number is no more than 3. The same author recommends a male to female ratio of between 1:2 and 1:3. Arrignon (1981) states that for commercial purposes *A. leptodactylus* can be reared at a density of 50 ind.m^{-2}, with a male to female ratio of 1:3, and Sevilla (1988) considers this to be the maximum limit at which progeny can be sustained. The data from the present research show that a single male crayfish is able to place a spermatophore on 8 female individuals (i.e. to inseminate them), which allows a significant decrease of the number of males in the brood stocks (Vasileva *et al.* 2006b). Mass deposition of spermatophores on the female's body is observed for a relatively short period of time - 5 days, when the water temperature reaches 7.5-8^0 C, which is in accordance with the values indicated by Koksal (1988) and Aidin (1998).

Various methods are applied in the incubation of crayfish eggs (Koksal 1988; Ackefors & Lindqvist 1994). The incubation method applied in this study of placing hatching incubators in tanks is highly efficient, possibly due to the degree of control that can be exerted over the incubation process. The newly hatched crayfish enter tanks where they start to feed on zooplankton, which is considered the most appropriate food for growing larvae in the early stages of their development (Nefedov & Naumova 1978; Austin, Jones, Stagnitti & Mitchell 1997). The survival rate of brood crayfish (95-98%) and the hatch rate (85-88%) are high, and this allows the production of a large number of larvae. When the hatching incubators were set in ponds the survival rate of the brood stock and the hatchery rate were lower compared to the incubation of the eggs in tanks. The main reason for this is the occurrence of the ectocommensal *Epistylis sp.* (Zaikov *et al.* 2000) on the crayfish and embryos, and also mechanical damage on eggs incurred during the catching of the brood crayfish (silting up and stripping of the eggs).

The growth of crayfish during the early stages of their development is directly related to the stocking density and the choice of appropriate foods, matching their physiological requirements (Struzynski & Niemiec 2001; Ulikowski & Krzywos 2004). The correlation between the initial stocking density and the survival and growth rates of the narrow-clawed crayfish juveniles has been studied by Koksal (1988), Ulikowski & Krzywos (2004), Ulikowski & Krzywosz (2006), Mazlum1 & Kemal (2007). Within the range of densities tested in this study, there is a tendency for the growth and survival rates to be decreased with increased stocking density, which is in line with the information from Ulikowski & Krzywos (2004), Ulikowski & Krzywosz (2006), Mazlum1 & Kemal (2007). Johnsson & Edsman (1998) point out the risk that at higher densities molting crayfish are more vulnerable to intra and inter-specific predation and this vulnerability increases with non simultaneous molting.

The results from the experiment carried out for feeding the crayfish juveniles up to a strong stage, with four different food types, confirm the fact that live zooplankton is an adequate food resource for many hydrobionts, including the juvenile narrow-clawed crayfish (Zaikov *et al.* 2000). This type of food is closest to their natural diet, and allows a high growth rate to be achieved. The highest recorded values for the growth and survival rate during feeding with zooplankton are close to those recorded by other authors for similar experiments with larvae of *Cherax destructor* (Austin *et al.* 1997) and *Cherax quadricarinatus* (Jones 1995). The closest results to the variant where zooplankton was used for food were achieved when the crayfish were fed with carp pellets with a protein content of 32 % and fat content of 8%. This makes pellet feed a suitable substitute to natural food, when there is only a limited quantity in the water body. The values for the survival rate in the different tests are similar to that recorded for the growth rate. The crayfish fed with zooplankton and pellets have the highest survival rate and growth rate (71.88% and 68.13% respectively), while in the other two feed tests it is lower (48-50%). The results show that out of the tested types of food, the zooplankton and pellets meet to the highest extent the physiological demands of the juveniles, so these methods of rearing result in the highest survival rates.

The results from rearing crayfish up to one-summer-old in ponds show the possibility of achieving high yields (764 $kg.ha^{-1}$) with a low food conversion ratio (1.6-1.9). The final weight of the crayfish (7-12 g) do not vary much with the different densities and are close to those indicated by Cherkashina (1978) – 6.5 g, when a similar stocking density was tested. The growth of aquatic vegetation (mainly *Chara* sp.) in the basin with the highest crayfish density had a positive effect on survival rate, and produced a relatively good growth rate. According to Koksal (1988) besides being a source of food, this type of plant plays a significant role in increasing the survival rate, as it offers shelter during moulting. This decreases the occurrence of cannibalism, especially at higher densities.

In conclusion, aquaculture seems to represent an important tool for production of juvenile crayfish. Both one-month-old juveniles and one-summer-old crayfish can be reared up to marketable sizes in specialized farms, or used for stocking natural water bodies to ensure the sustainable development of natural populations.

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The role of women in fisheries and aquaculture in Turkey

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Abstract This review examines the participation and roles of women within the fisheries and aquaculture sector in Turkey, looking at their direct involvement in fishing and fish production as well as their indirect association with related activities (Marketing and distribution, processing, administration, management and public sectoral work, research, education and training).

Women represent approximately 50% of Turkey's population and 25% of the labour force. More than 120,000 people were fully engaged in fisheries activities in 2006. Studies have shown that of all the various fishing sectors, participation of women was highest in fish processing (approximately 70%) followed by marine aquaculture and inland aquaculture. Although there is limited data on women's roles in the Turkish fisheries sector as a whole, women are known to play only a very minor role in fish capture (1.93%). This participation is usually in the form of small scale activities on lakes or as support to sea going spouses. Where women are employed in the aquaculture sector (12%), they are mainly involved in hatchery and live food units. Women also play an important role in administration, fisheries research, education and training as reflected by the numbers of female graduates employed in such fields. The marketing of fresh products for local markets was found to be predominantly carried out by men. Women are also temporarily and permanently involved in activities such as fish vaccination and the construction and manufacture of nets.

Introduction

Turkey, situated at the junction of two continents, has three percent of its landmass (Thrace) in Europe and 97 percent (Anatolia) in Asia. This large peninsula is surrounded by three major water-bodies; the Mediterranean Sea, the Aegean Sea and the Black Sea. In addition the Sea of Marmara, a large inland sea is located within the countries borders. Its mainland coastlines comprise: 1695km on the Black Sea, 2805 km on the Aegean Sea and 1677 km on the Mediterranean Sea. Along these coasts and around inland water bodies there are many locations deemed as favourable for fisheries activities, owing to favourable geographic positions, climate, water resources (Table 1) and topography (Yildiz 2004).

In 2006 the total fishery production was 661.991 t, with 80% originating from marine and inland fisheries (including crustaceans and molluscs) and 20% from aquaculture. This value represents 6% of the total world fishery production. The Turkish marine fishing fleet, licensed by MARA (Ministry of Agricultural and Rural

Affairs) consists of more than 18,000 sea going vessels, and a further 3000 in inland waters. It is known that more than 120,000 people are fully engaged in fisheries and aquaculture activities. However, the employment data for the fisheries sector is not sex desegregated so the proportion of women within this figure is unclear. There is also no published data on the roles of women in the fisheries sector (Anon 2007).

Table 1. Fisheries Resources in Turkey (MARA 2006)

Production Areas	Number	Size (ha)	Length (km)
Natural Lakes	~200	~906.118	-
Dam Lakes	223	409.841	-
Ponds	1000	28.800	-
Rivers and Streams	33	-	177.714
Seas	-	24.607.200	7.816
TOTAL		25.951.959	

In Turkey, women constitute around 50% (35,209,723) of the total population (70,586,256) and approximately one-fourth of the labour force (26.5%)(Anon 2007). This study will review the participation and roles of women in the fisheries and aquaculture sector as well as related activities using data form MARA records, sector studies, OECD reports and related websites.

Where are the women in fisheries?

It is important to acknowledge from the outset that the gender issues surrounding the participation and roles of women in both capture and aquaculture sectors are not unique to fisheries. The fisheries sector, like many sectors in Turkey, is seen as mainly male dominated. The role of women in fisheries can be summarised as follows: (Fig 1)

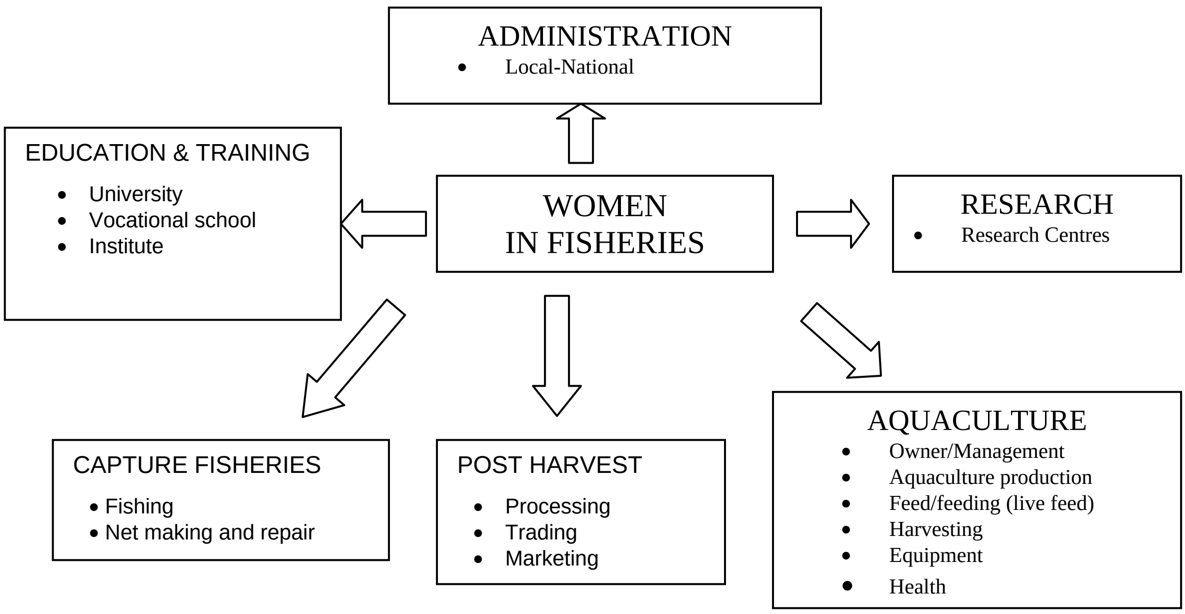

Figure 1. The schematic summary of the women in fisheries and aquaculture in Turkey

Women in capture fisheries

In many regions of the developing world men and women are engaged in complementary activities in capture fisheries. In Turkey however, women play only a very small part in fish capture with very few working on vessels. According to MARA records, only 1.93% of all licensed fishers are women. Of these, most women are employed in small scale fishing enterprises on lakes or they may play a supporting role to seagoing spouses in larger scale activities. Women commonly work part time as fishers alongside their spouses in the early morning and then doing other activities such as house keeping, childcare, animal husbandry and agriculture for the remainder of the day. The relative proportions of men and women licensed to fish in marine/inland waters and the regional distributions of this licensing are shown in Figure 2. In inland waters the proportion of women operators is 1.8% whilst in marine waters it is 1.9%.

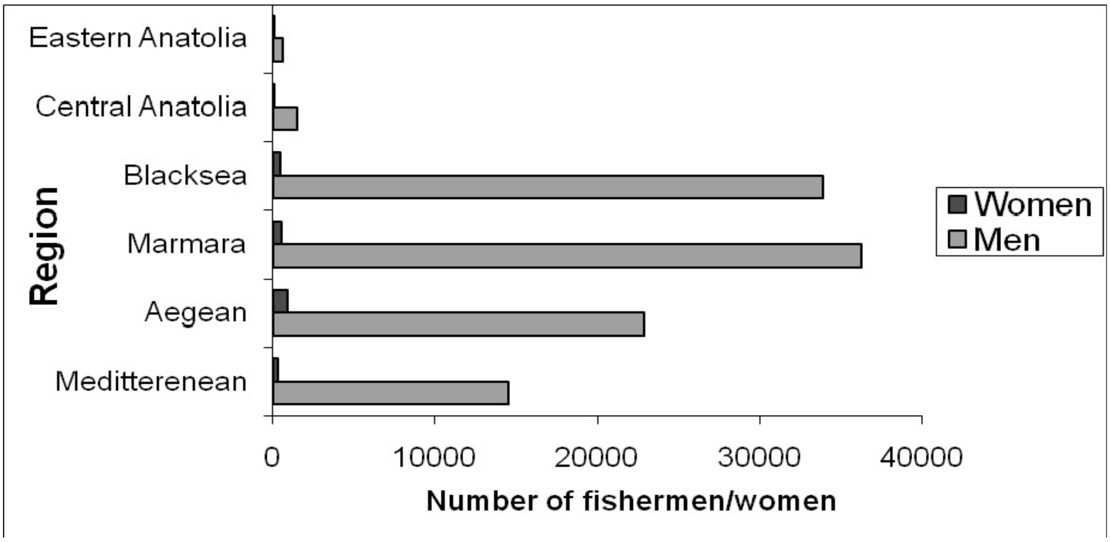

Figure 2. The amount of licensed fisher women and men in 2007 according to inland, marine fisheries and region.

Women in aquaculture

The role of women in aquaculture, like their role in the rest of the economy, is shaped by the changing division of labour in society. With the unprecedented growth of aquaculture and the diminishing fish harvests of recent years, aquaculture appears to be a promising route to achieve food and nutritional security in developing countries (FAO 2004). It now represents the fastest growing food sector in the agricultural industry (FAO 2006). Where women are employed in aquaculture they are predominantly involved in actual production than managerial roles. Women rarely hold senior management positions in the aquaculture sector and men have more promotion opportunities. Jobs in aquaculture are widely perceived as being dangerous and uncomfortable for women. As a result women have a low representation in the sector (12% of aquaculture workforce), are usually in jobs of lower importance and often on a temporary basis (FAO 2006). Despite similar working hours and conditions, women’s salaries are lower than their male counterparts in the private sector.

Women who own or mange fish farms are extremely few in numbers (39 out of 1,197 fish farm owners are women) according to available data. However, there are some large aquaculture companies that keep no record of the numbers of women employed and their specific roles. In their role as technical staff, women are often responsible for hatcheries and live food units. In addition, women often play a role in other activities such as research, feeding and harvesting and fingerling production for stocking into ponds and cages. In marine culture, vaccination of fish is also carried out by women labourers that generally work on a part time basis, without insurance and are paid either seasonally or daily. The numbers of technical staff employed in aquaculture over the last eight years is shown below (Figure 3).

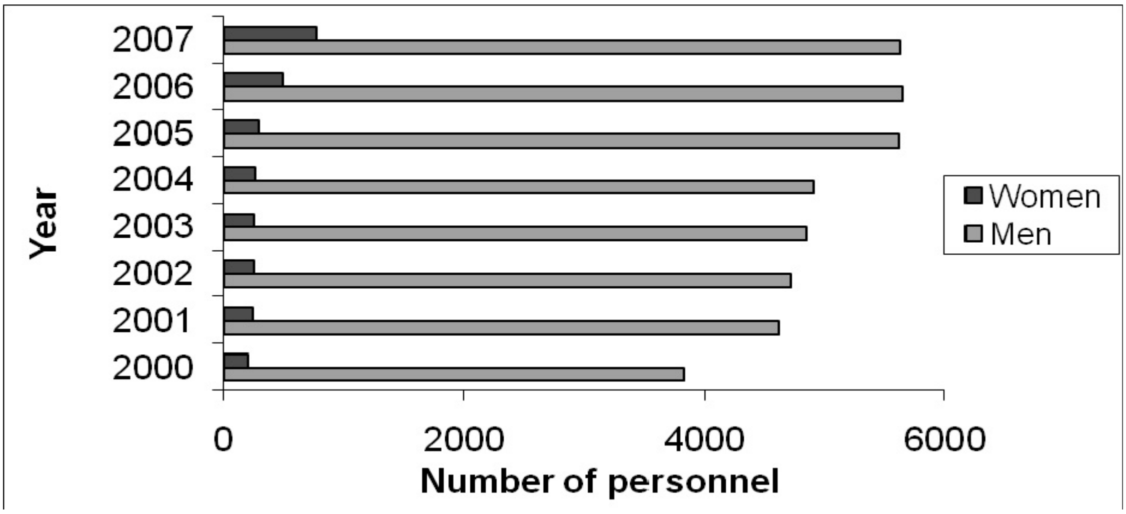

Figure 3. The number of women and men in Turkish aquaculture.

Women in post harvest activities

The handling, processing, and marketing of fish products are essential complementary functions of all food production systems. Processing of aquatic products is considered to be women's work. Women have always predominated in the fish processing sector on small-scale private, cooperative, or industrial levels (Fig. 4). Many factories have a preference for women, as they are considered better handlers and processors of fish. There is no discrimination in salary; on the contrary, women usually earn more than men, as processors are paid a basic salary plus a percentage per kilo of processed product. Although women represent the majority of technical posts in the industry (about 70%), they are rarely able to break into the male dominated ranks of senior administration or factory management. Women do not play an important role in the wholesale and gross marketing of fresh products in the major provinces because of the unsuitable working hours. Indeed, the fish markets in Turkey are mainly male dominated and no recorded data has been found on the number of workers in the fish markets. But there are still some women in the fishery departments of large supermarkets.

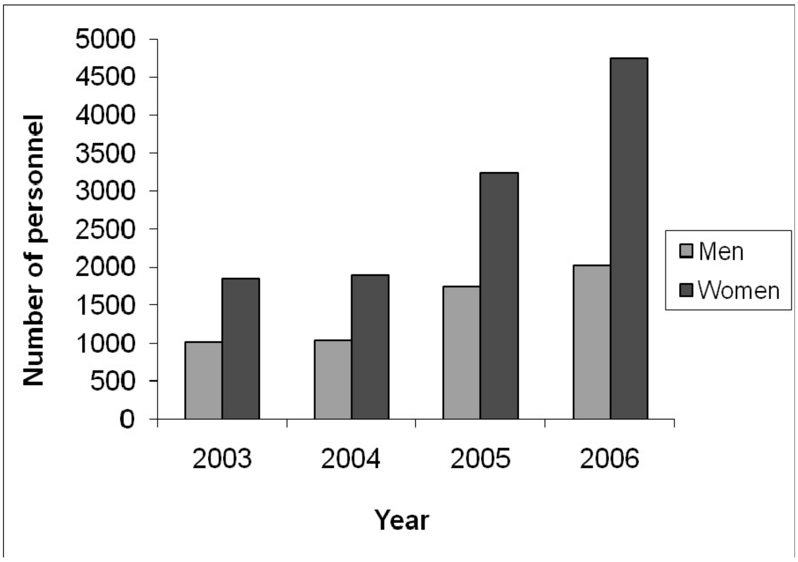

Figure 4. The number of women and men in the fish processing sub sector.

Women in research, education and training

As of 2007, there was 762 academic staff in employment in the fisheries faculties and departments of Turkish universities. Of this total, about 215 staff are female and half of them are educated to at least PhD level. The number of graduate students from Fisheries faculties is estimated around 9,500 and 40% of this number are women. Women play an important role in administration and fisheries research, reflected in the numbers of female graduates in fisheries related fields. 38 % percent of the female employees are in administration in MARA and another 13% in four research institutes. The rest perform miscellaneous office jobs.

More women are found in administrative roles than in all other activities. As far as educational qualifications of female employees are concerned, a similar pattern of distribution of educational qualifications is found among males.

Based on the data made available to this study, it appears that more and more women are studying in the fisheries faculty. However, they are involved in different sectors such as financial, marketing, and other governmental institutions and private sectors not related to fisheries.

Conclusion and Recommendations

Women's participation in fisheries and aquaculture can be taken into account by planners and policy-makers. Based on the key findings of the report, some proposals for improving women’s positions in the fisheries sector in Turkey are made here:

- Provide opportunities for a professional education
- Promote jobs with stability and future prospects, and promote equal pay for equal work.
- Improve working conditions

- Provide training courses that permit women to expand into work activities currently dominated by men.
- Improve the educational levels of women.
- Equal access to credit and participation in market development for women is needed to consolidate their position as traders.

In conclusion, fishery and aquaculture can play a key role in the contribution of women to the rural economy, rural development of Turkey and provide an extra income for their families. Women can be trained for small scale enterprises such as micro algae and ornamental fish production to provide additional income for the family. The effectiveness of fisheries and aquaculture should be increased to elevate women’s economic liberty and family income. New financial instruments should be developed and promoted to increase the contribution of women to the sector.

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Conflict of interests between commercial and recreational fishing in Annecy Lake (France)

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Abstract The management of fishery in Lake Annecy, France were examined. Two groups of fishermen share the resource: recreational and professional fishermen. The development of the recreational fishery creates conflicts with commercial fishery and both types of fishery generate heavy pressure on the resource; some species survive because of stocking of young fish. Although there are regulatory instruments for each category, implementation of regulatory policy is difficult because of tension between the two groups. Economic analysis revealed three important points: (i) stocking of young fish was unfavourable to commercial fishermen; (ii) an atypical fish market in Annecy; (iii) problems related to enforcement of regulations on the lake. Implementation of new regulatory instruments is proposed to resolve these conflicts.

Introduction

Competition between recreational angling and commercial net fishing is prevalent in Lake Annecy, France (Balland 2004); the resource is fully exploited and cannot withstand extra fishing effort without being threatened. The sport fishery has gained such importance (1200 boat licences and 600 angling licences for recreational angling) that commercial net fishery has become marginalised (4 commercial fishermen since 1998). Also, fishing of species like char, *Salvelinus alpinus* L., is maintained only because of intensive stocking of young fish. Regulations (set up by Prefectural Decrees) are defined for commercial and recreational activity and are implemented since the late 1990s to control aggregated fishing effort. The implementation of these restrictions has caused discontent and conflict between commercial and recreational fishermen (Genty & Robert 2000). Fish wardens have been assigned to implement rules. A compulsory system of fish logbooks (for both groups) has been introduced since 1986. It permits a complete inventory of the resource and the fishermen (Gerdeaux 2006). The resulting statistics are useful to determine the level of pressure applied to the resource. The species distribution (principally char, and whitefish, *Coregonus lavaretus L.*) between each group is unequal and creates tension: char yield is unfavourable for commercial fishermen, as they focus on harvesting more whitefish. Although the new regulations are more equitable based on scientific input, and reduced tension between both groups, new conflicts broke out in May 2007 and recreational fishermen accused the commercial fishermen of overfishing whitefish. A group labelled “Angry recreational fishermen”, was set up and petitioned for the abolition of commercial fishery in Annecy Lake (Cheul 2007). In response, articles were published in French gazettes on “Should commercial fishery be maintained in Annecy?” This paper examines the importance of the commercial fishery, and examines whether commercial fishing should be maintained on the lake.

This study discusses the functioning of a fishery exploited by two types of agents whose interests are divergent: profit versus recreation, net fishing versus angling; a recurrent problem found in many fisheries (Arlinghaus & Cooke 2005; Cooke & Cowx 2006, Brown 2004; Coleman 2004; Kearney 2001, 2002). It also considered the argument of Gomez & Tenet (1998) that recreational fisheries generate higher surplus than commercial activity, while acknowledging that they did not take into account all the actors implied in the commercial social surplus, e.g. the restaurants.

Review of catch and markets

Information was collected from the annual compulsory and voluntary fishing logbooks. Thanks to that statistics we know the evolution of the resource stock and the behaviours of both recreational and commercial fishermen. In order to complete this inventory on Annecy lake fishery, and to have precise details on the commercial activity, several interviews have been done with recreational and commercial fishermen, but also with restaurants, hotels, fish shops, supermarkets during the year 2007.

Regulatory instruments and distribution of resource

The principal fishing norms are the following: fishing seasons (fishing is strictly prohibited during reproduction, i.e. winter), protected areas and species, quotas on harvest for recreational fishermen (8 fish per day per species for char and white fish), mesh size for commercial fishermen and minimum landing size (26 cm for char, and 38 cm for whitefish). The price of fishing licences are (year 2007): 105 Euros for a boat licence, 68 Euros for onshore fishing for recreational activity and 1050 Euros for commercial fishermen.

Char and whitefish are the main target species (although trout, pike and crayfish are caught), and these create the conflicts between recreational and commercial fishermen. Fish harvesting is shared equally between the two groups. However, more indepth analysis suggests char production is quasi-exclusive to sport fishing (5 t for recreational activity and 500 kg for commercial activity in 2005), and that whitefish is harvested more by commercial fishermen (11 t for commercial activity and 5 t for recreational activity in 2005) (Fig. 1).

Distribution of the costs

Due to technical constraints on commercial fishermen, char harvesting is low; the number of nets and their size do not favour this type of fishing. Char fishing is done at depths > 30m, where they cannot use their nets. It may also explain the low output of char fishing for commercial fishermen. However, char is the most profitable fish in the lake. Commercial fishermen would like to increase their gain, but they do not seem to have the financial and technical means to do so. Fishing of char is possible only because of stocking of young fish. Each year about 100 000 juveniles are released into the lake. Each group invests in replenishing the stock of the young fish: 80% of this finance comes from sport fishing, the remainder from commercial sources. Apparently, the sport fishermen harvest more than they invest in char, compared with commercial

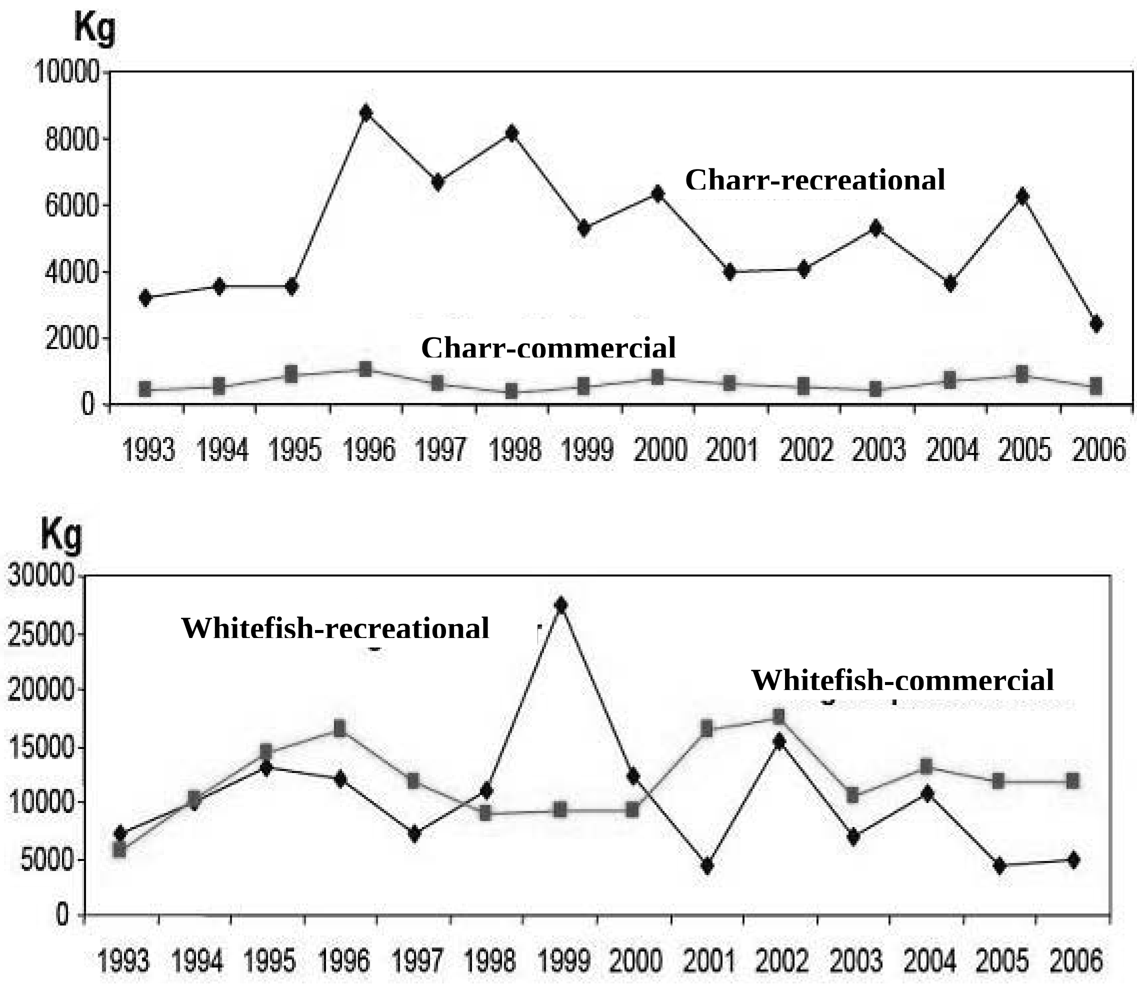

Figure 1. Production of char (upper) and whitefish (lower) for each type of fishermen (purple line corresponds to professional harvesting; blue line corresponds to recreational fishermen)

fishermen. Recreational fishermen have the resources for stocking the young fish, and they have used it to claim their actual share. This unequal share is caused by technical constraints and not quantity limits. Commercial fishermen are interested in increasing their contribution to stocking but only if they obtain better fishing gears. One alternative might be to modify their fishing methods; for instance one could decrease the mesh size, and commercial fishermen could then satisfy their demand for char. However, this production chain is unfavourable for commercial activity because char is very profitable, mainly because supplies are low. The sport fishermen use their higher stocking input to limit commercial exploitation and justify the asymmetrical distribution of harvest that affects directly the profitability of the commercial fishery in terms of markets. Indeed the local community in Annecy (hostels, restaurants, fish shops) depends on the commercial fishery, and vice versa. The stocking of young fish thus represents one cause for conflict.

Analysis of the fishery market

The fish from Annecy Lake is a differentiated product, commercialized in a market with imperfect competition. On the one hand, fish from Annecy lake distinguishes itself from the other products because to its geographical label that guarantees the origin of the commodity `` Wild fish from Annecy Lake – 2700 ha, 4 professional fishermen". It guarantees a very high quality of fish (the fish is sold very fresh and non-eviscerated), while fish coming from rival lakes are eviscerated and sold in higher quantity.

In terms of supply, professional fishermen from Annecy Lake have a high market power, considering there only four (prefectural decree), and thus the competition in Annecy lake is low. The price of fish does not vary on total harvest, and individual supply is fixed. Demand is also very high, especially for char fish. There are five types of customers: the restaurants, the fish shops, a seafood wholesaler, private individuals and supermarkets. Whitefish is also a profitable commercial product, since it is caught in higher quantities and sold at a good price; professional fishermen harvest about 30 fish daily. The catch is sold fresh and instantly on the quayside.

In terms of market, the suppliers, i.e. professional fishermen, create a rationing scenario, because catch of the four fishermen cannot satisfy the demand. This rationing problem might be explained by prices versus quantities effects. Either the fish price is too low: if the price increases the demand will decrease, the supply is insufficient. The fishermen don’t, however, have the gear to increase the total production and there is substitution from other lakes, particularly Lake Leman where production is high. The low price of fishes from Leman Lake threatens Annecy fishermen.

One other feature is that the four fishermen don’t have the same sales objectives: two sell their catch to the seafood wholesaler, at a low price (5 € kg^{-1} for whitefish whilst the others (Type 2) supply the rest of the demand at a higher price (40 € kg^{-1} for char and 13 € kg^{-1} for whitefish to private individuals). This price discrimination is justified for two reasons (Figure 2):

SEARCHING COST (transaction costs): the Type 2 group devotes more time to find customers, and bears additional costs compared with type 1 (delivery, clientele, etc.). A few customers, such as restaurants, prefer to deal with type 2. They are willing to pay for assured delivery of the quantity and quality of fish.

QUEUE EFFECT. For Type 1, the only customer is the fish wholesaler while Type 2 satisfies the residual demand that permits it to increase the value of the harvest. This latter type has no guarantee that they will sell all their fish, but they are unable to meet the residual demand. This queue effect permits them to command high prices. They favour sale to restaurants (and individuals) that have a higher willingness to pay for Annecy fish. Often fish shops cannot satisfy demand and they lose customers; thus they secure customers through a waiting list to inform customers when Annecy fish are available.

Rationing problem

The direct sale of fish to restaurants and individuals represents an additional cost in terms of effort by commercial fishermen (compared to the sale to fish wholesaler), but it is also an advantage in terms of profits. The value added is made essentially on the

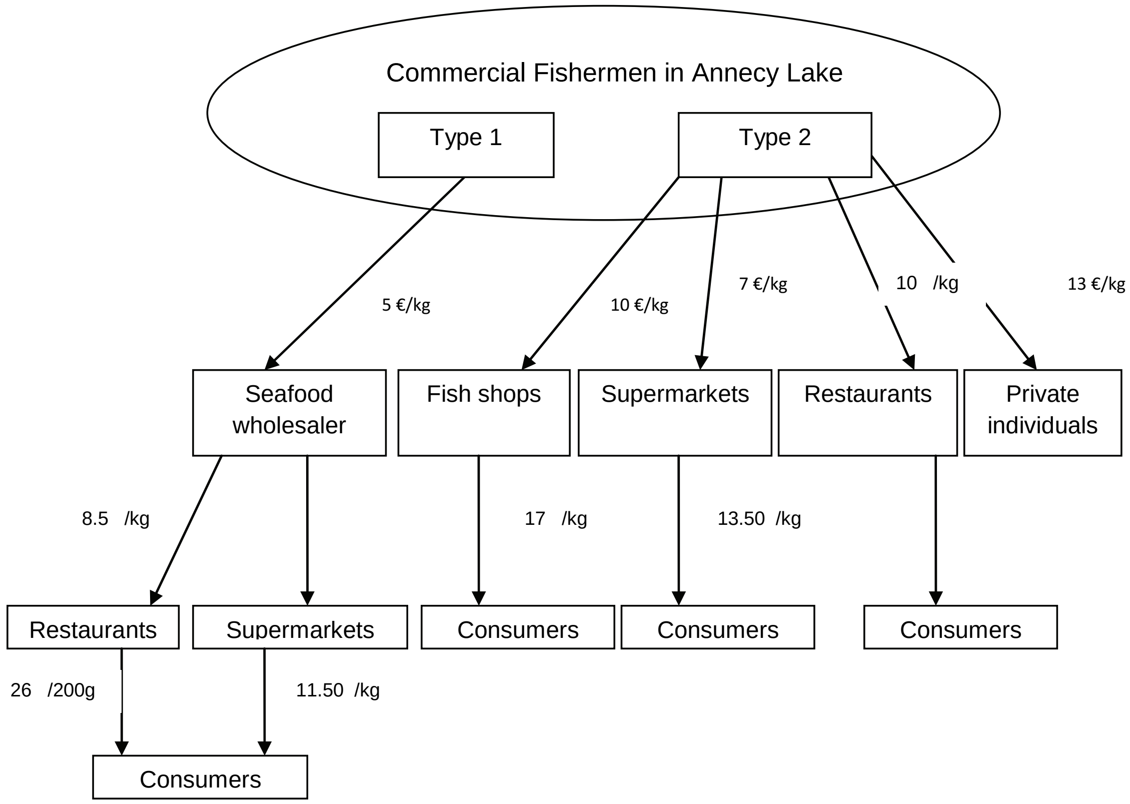

Figure 2. The different actors on Annecy Lake fishery market. Pricing is for whitefish.

restaurant and private individual sales. Some fishermen (Type 2) increase the fish value as much as possible, but are not able to satisfy the whole demand (in particular fish shops and supermarkets). Thus, the rarity and the notoriety (in terms of quality) of the Annecy fishery increase prices. The principal competitor to commercial activity is sport fishing. Professional fishermen would prefer to increase their output of char, which is very low at present, but recreational fishermen have the advantage. Annecy Lake fishing remains an attractive occupation only if fishermen split up the demand and practice discriminatory pricing. However, some fishermen explain that their occupation is not viable, and they think the fishery could be more profitable if the authorities would permit them to fish with more sustainable and effective gears (particularly for char). They believe that it would also avoid fishing traffic. On the whole, if the demand increases, prices will automatically increase, new entrants would like to enter the commercial fishery until the supply meets demand. However, this fundamental economic principle does not work for Annecy Lake because the number of professional fishermen is bound and fixed to four, and entrance of new fishermen is strictly prohibited. The supply level is constant and hence lower than demand.

Black market

The existence of a black market might be justified by sport fishermen having high incentives to sell fish: the price is high, daily quota is also high (8 fish per day per species), and supply is low (particularly for char). Balland (2004) called these clandestine fishermen the Undeclared Professional. For instance, in the US, commercial fishermen are sometimes in competition with the illegal production sold by sport fishermen. During controls, fish wardens catch recreational fishermen in the act with boats equipped with navigation radars (Coleman 2004). In Annecy Lake, a small number of recreational fishermen fish commercially. The fish market can also be justified by the incentives of restaurants to buy fish from recreational fishermen so that they do not pay taxes.

Char has a high market value and represents an asset for local restaurants. The professional harvest is low and uncertain (for instance sensitive to climate variation), thus some sport fishermen are really encouraged to sell their surplus fish. However, Jean Falquet declared ``Don't believe all that stories. For some sport fishermen, fishing is not only a recreation…" (Cheul 2007b), but in June 2007, a restaurant in Annecy was involved in a lawsuit because it had illegally bought fried fish from a non-commercial fisherman (Cheul 2007a). The fish logbook gives transparency at the stock level and technique of fishing, but they are not systematically maintained and it is difficult for the committees to verify sport fishermen logbooks, partly because they are understaffed. Four years before, a full time salaried employee was appointed to control and monitoring fishing rules. Today, only one part-time warden does the supervision on Annecy Lake, so there is little enforcement. During a general meeting, recreational fishermen denounced the lack of fish wardens and the lack of supervision. Professional fishermen also remarked the controls were quasi-ineffective and they could sell their harvest on the black market for a higher price. Increased surveillance and increased fines are the best way to avoid this problem of the black market

Inter- sector conflicts

Regulations are established for each group of fishermen including: fishing season, daily and annual quota (for recreational fishery), the size of catch, fishing gear for sport fishermen, mesh size (for commercial fishermen), and number of professional fishermen (no limit for the number of recreational fishermen). There are also implicit regulations, such as: the price of a fishing licence, and replenishment of stock of young fish. Even if there are norms, fishing regulatory instruments are not suitable, and do not take into account: (i) high fishing pressure and high mortality rate of the released fish, (ii) growing conflict between professional and recreational fishermen, (iii) growth of sport fishery. The fishing system is not so complex in principle: the area is limited and there are few species of fish. It might thus be easy to implement rules of extraction. However the share of resources between both groups is difficult to determine. On the one hand, one must regulate extractions rules, and on the other, one must manage the conflicts. Rules need to be defined with caution: it is important not to favour (or to be prejudiced with) one group to the detriment of the other group. Norms should be based on sustainable and efficient development on the resource, but should be also shared fairly through negotiations between both groups.

Decreasing the quota of the recreational fishermen and implementing a quota for commercial fishermen could be an efficient measure. According to logbook statistics, 20% of recreational fishermen harvest 80% of the aggregate recreational quantity (Gerdeaux 1991). The implementation of a daily quota is efficient only if the actual quota is reduced by half (Gerdeaux 1996). The best way to reduce this effective resource pressure is to intervene on the 20% of diligent fishermen. Gerdeaux proposed the following alternative: either a limited number of fishing days per week (for instance four days allowed per week, and each recreational fisherman would choose which day in the week he/she would like to fish). But it may generate high monitoring costs, and its implementation may also be difficult. A bi-weekly quota besides the daily quota could be set, for instance 32 fishes for 15 days. The implementation of a quota for professional fishermen might also be a good way to control conflicts between the groups. More precisely, this quota could be effective at reducing the whitefish production, which is higher for the commercial fishermen. These quotas for recreational and professional fishermen would decrease the fishing yield of each species, and would make the share more equitable.

Sport fishing gear may be improved to decrease mortality of the released fishes. The mortality rate is difficult to assess. On the whole, 60% of catches are released by recreational fishermen (Fisheries and Oceans Department, 2002). However, an unknown proportion of these die after release (Cooke *et al.* 2002). To avoid the mortality of the released fishes, the fishing gear might be better adapted to do less harm to released fish. An alternative barbless hook may replace the present hook that is used. However recreational fishermen might be hostile to this new fishing gear, since it will decrease their chance to catch fish. If the barbless hook is implemented in the lake, one can maintain the actual quota, since fishermen might have a limited range and mortality of released fish will decrease.

The mesh size regulation (for commercial fishermen) is also an efficient way to regulate resource extraction; a 2 mm increase in mesh size delays the entrance of whitefish in professional fishery by 6 months. It is thus possible to change the share of the resource, and the change might be adequate because it has a direct impact on the professional’s welfare.

The number of professional fishermen is limited to four. If this number is lower it would not be possible to publish catch statistics. On the contrary, the addition of one commercial fisherman was deemed to have a negative effect on fish stocks in Annecy. There is no limit on the number of recreational fishermen, but it is stable and limited to 1200 boat licences. An efficient regulation could be reducing the fishing pressure by limiting access to recreational fishermen. Prohibiting fishing seems particularly difficult to justify and to implement, although in some regions of France, permits are restricted and available only to the local population (residents in Alsace, North of France).

If the principal objective is to decrease the number of sport fishermen, one can increase the price of fishing licence. Indeed, increasing the cost of a licence is a good way to limit entry. However, this regulation might discourage sport fishermen who don’t come very often to the lake, and might have little impact on the “passionate” or “performing” fishermen, and thus have little consequence on resource extraction (20% of sport fishermen harvest 80% of the total production). Moreover, the increase in fishing licence price might be unreasonable, i.e. the licence must not imply problems of equity in limiting access to lower the revenues.

The monitoring or enforcement of fishing rules is inefficient on the lake. Authorities might be able to implement credible threats, such as fines or sanctions that could dissuade clandestine fishermen to sell fishes on the black market, and also illegally to restaurants that buy fish illegally. This fine might have not only a positive effect on fishing pressure but also a restorative effect. For instance the fine would be paid to increase stocking of young fish; to assure implementation of this regulation, fishing controls are necessary. The Annecy Lake is state property, the resource is threatened, and thus it is important that authorities control fraudulent activities.

There are also implicit regulations, such as replenishment of the stock of young fish. We saw that sport fishing invests 80% in replenishment of char stock, hence why they justify the high harvest of char. A shift in contribution of each type of fishermen is an important parameter in fishery management. For instance, if commercial fishermen were allowed to invest more in stocking young fish plus fair gear, their production will increase, and could satisfy demand. Also, to decrease the pressure and the conflicts on whitefish harvesting, one could invest in stocking this species of fish. However, stocking whitefish is for the moment too costly and not efficient.

This descriptive study gives a glimpse of the origins and consequences of fishing pressure and conflict in Annecy Lake. As for many other cases of recreational and commercial cohabitation, the market is specific (particular context: species and different fishing areas), but conflicts that stem from this are worldwide. We understand that, due to the growing pressure on recreational fishing, regulations should maintain commercial fishing in Annecy Lake (the turnover of restaurants, hostels, fish shops, depend on this fishery). It might be interesting to prove the efficiency of the above regulatory scenarios with the help of an economic theoretical model. The utility function of a recreational fisherman might depend on quality and quantity of fishing like Andersen (1980; 1993). Adding the commercial fishery, we could study the impact and the implementing cost of these regulatory instruments (Sutinen & Johnston 2003, Pereira & Hansen, 2003). More specific to Annecy lake, we could introduce a limited offer (exogenous number of fishermen), and study how to neutralize the black market.

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Fisheries management in Turkish lagoons

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Abstract Turkey, as a country, has great potential for fisheries and aquaculture; with 8333 km of coast line, many rivers with 177 714 km total length, nearly 900 000 ha of natural lakes and 300 000 ha of dam lakes. In 2002 Turkey had 627 847 t total fisheries production, and it shows with its annual production as one of the most important fishing countries in the region. Turkey has 72 lagoons along the 8333 km long coastline. However, in recent years, due to increases in the tourism facilities, unconsciously and uncontrolled utilisation, disposal of industrial and domestic waste to the lagoons and siltation, many lagoons today are not utilisable. The majority of irrigation systems which have been constructed, or are under construction, are in the productive deltas which also possess large lagoons. Besides this lack of environmental awareness, lagoons have remained as discharge places for used and polluted waters. At the end of these studies, various management models are proposed for the Turkish lagoons.

Introduction

General view

Total fisheries production in Turkey increased from 662103 t in 1992to 500 260 t 2002. The main part of Turkish fish production comes from the fishery catches (Table 1). In 2006, catches reached over 533 048 t, strongly dominated by marine catches which contributed in total wild fish supply for around 80.6% of national total fisheries production.

Aquaculture is a relatively young industry in Turkey; it started with rainbow trout culture in the early 1970s and little happened in terms of sea farming until 1985 when gilthead sea bream and sea bass culture started in the Aegean Sea. Today both freshwater and sea farming play an increasingly important role in the production of fishery products. In 2006 its share of total fishery production was around 20 % by volume. The sector can be characterised by limited species and system diversity, small farms, a production oriented approach and in the case of sea farming an export dependent market.

Aquaculture is an important economic activity in the coastal and rural areas of many countries. It offers opportunities to alleviate poverty, creates employment, helps community development, reduces overexploitation of natural aquatic resources, and contributes towards enhancing food security. It is estimated that the aquaculture sector in Turkey provides employment for around 25 000 people.

Natural condition

As a county bordered on three sides by the seas, Turkey provides very rich sources in relation to fisheries potential with its lakes, ponds, dam lakes, rivers and spring waters. With the shores extending 7816 km. and rivers running 177 714 km, its sea and inland water resources have a surface area greater than that of its forests and nearly equal to that of agricultural lands. There exists a total water area of around 26 million hectares which is suitable for fishing and aquaculture (Table 2).

Table 1. Total fisheries production in Turkey (2006)

Production	Volumes (t)
Marine catches	488,966
Freshwater catches	44,082
Total catches	533,048
Freshwater aquaculture	56,694
Marine aquaculture	72,249
Total Aquaculture	128,943
Total Production	662,103

Table 2. Fisheries resources of Turkey (Source: The Ministry of Agriculture & Rural Affairs)

Marine Resources		Length (km)	Surface Area (ha)
Black Sea, Aegean sea and Mediterranean,		7144	23,475,000
Sea of Marmara, Bosphorus and Dardanelles		1189	1,132,200
TOTAL		8333	24,607,200
Freshwater Resources	Number	Length (km)	Surface Area (a)
Natural Lakes	200	-	906,118
Dam Lakes	159	-	342,377
Ponds	750	-	15,500
Rivers	33	177,714	-

Lagoons along the Turkish coastlines of Turkey

Lagoons are a class of estuary linked by the common characteristic of having a single or more restricted connection to the sea. At present, no adequate classification scheme exists which is based on quantifiable characteristics that would enable lagoons to be ordered according to biologically and hydrodynamically relevant data (Miller *et al* 1990).

The importance of wetlands, of which lagoons are fully entitled representatives, is fully acknowledged and needs no re-statement here. Their economic value stems from their direct economic use, indirect use through environmental services, and non-use or preservation value (Barbier 1989). The latter are gaining substantial existence value and a greater heritage value, due to the destruction of the past and present degradation of Mediterranean wetlands (Hollis 1992).

The Turkish lagoons as a whole represent a complex of approximately 36 000 ha with outstanding importance for wildlife, an under-exploited fishing potential and severe threats from pollution, silting and human activities.

The coastline of Turkey is about 8 300 km in length and is traditionally divided into four marine zones; all of them dotted with lagoons.

Black Sea Lagoons

The Black Sea is a semi-enclosed basin whose inshore waters present estuarine characteristics, significant pollution loads and high hydrodynamic state. Along its southern border, salinity ranges between 16 and 18 ppt, rarely exceeding 21 ppt. Surface water temperatures show a winter minimum of around 7˚C and a maximum of around 25˚C in summer. Surface waters are very dynamic, with main currents flowing from west to east.

The Turkish coast does not have large lagoons, the only exception being the lagoon system at the outlet of the Kızılırmak River, and the only delta area along the southern border of the Black Sea.

There are 14 lagoons in the Black Sea coast. Their overall surface area is 3 130 ha with a yearly fish production of about 131 t, which is almost completely produced by the lagoon complex of Bafra, where unit production is about 56 kg/ha^{-1}.

Lagoons of the Sea of Marmara

The Sea of Marmara is a small-enclosed basin linking the Black Sea to the Aegean Sea. Salinity is less than 30 ppt due to the Black Sea waters flowing from east to west. During the summer, pure seawater enters through the Dardanelles Strait. Surface temperatures range from approximately 6˚C in winter to around 24˚C in summer. There are 12 lagoons along the Sea of Marmara and their overall surface area is 2 650 ha.

Lagoons of the Aegean Sea

The Aegean coast stretches from the border with Greece southward to the Dalaman Peninsula, which is conventionally used to delineate the border with the Mediterranean Sea. It is an oligotrophic full strength saline sea with a complex coastline profile dotted with many islands that create complex current patterns. Salinity is typically around 38 ppt.

Due to their limited number, major rivers that flow into the Aegean have only local effects in reducing salinity in the estuarine areas. On average surface temperatures are higher than in the Black and Marmara Seas and increase from north to south, from around 11˚C in winter to around 24˚C in summer. Pollution and high nutrient levels occur in a limited number of places, the industrial zones of Izmir and Dalaman in particular.

The Aegean coastline is the richest in terms of lagoon number, area and fish production. There are 28 lagoons along the Aegean coastline and their total surface area is about 20

000 ha with yearly catches of about 562 t. Two lagoons – Bafa and Köyceğiz – account for 60% of the total area.

Mediterranean Sea

The Mediterranean Sea along the Turkish coasts presents a fairly stable salinity of 39 ppt and the highest surface temperatures found in the whole Mediterranean Basin. Summer temperature is around 28˚C, whereas in winter it is around 18˚C. There is a small increase in the temperature averages along the coast from west to east.

Like the Aegean, it is a true oligotrophic sea with the lowest productivity among the Turkish marine areas. Industrial pollution shows a peak in the Iskenderun Bay, İçel and, to a lesser extent, Antalya, due to the discharges of their industrialised area. Other sewage inflows also come from the major tourist centres and the proliferation of large holiday housing settlements.

The lagoons along Turkey's Mediterranean coast are mainly found in the delta areas of the only two major fluvial systems of this coast: the Meriç River, near Silifke, and the Seyhan and Ceyhan Rivers in the Cilician Plain (Çukurova).

Going from north to south, there are 17 lagoons making up a total area of 11 600 ha and an overall production of 183 t in 1995.

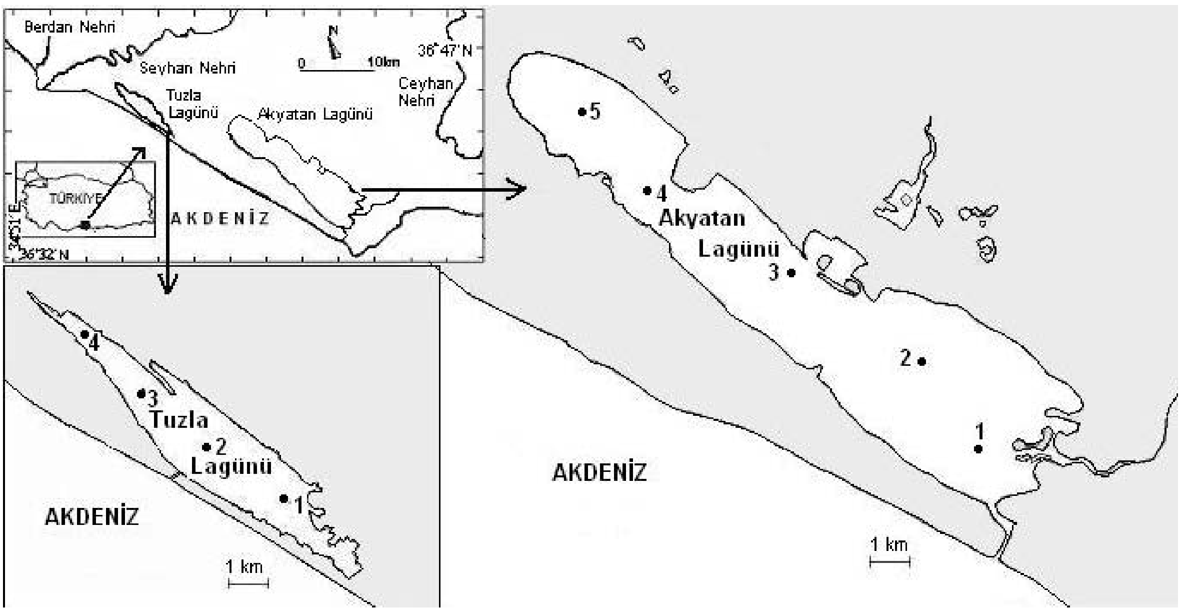

Figure 1. Akyatan and Tuzla Laoons in Mediterranean coastline.

Protected lagoons of Turkey

NATIONAL PARKS

NP.1 Dilek Peninsula and Menderes Delta National Park (Dilek Yarımadası Menderes Deltası Milli Parkı). Park since 1966, in 1993 it includes the Menderes Delta area. Main lagoons: Karina Gölü (= Dil Gölü) , Mavi Gölü, Kara Göl.

NP.2 Gelibolu Peninsula National Park (Gelibolu Yarımadası Tarihi Milli Parkı). One lagoon: Anafarta Gölü.

NP.3 - Bafa Gölü; declared on 8 July 1994.

SPECIALLY PROTECTED AREAS

SPA.1 - Göksu Deltası. It includes the lagoons of Akgöl and Paradeniz; total area 4 350 ha; declared on 2nd March 1990; incorporated in the list of Ramsar Treaty on l7 May 1994.

SPA.2 - Köycegiz Gölü ve Dalyanı.

SPA.3 - Patara. It indudes the lagoon of Gelemiş Gölü; total area 19 000 ha; declared on 18th January 1990.

NATURE CONSERVATION AREAS

NCA.1 Yumurtalık Gölü: declared on 8 July 1994; total protected area: 16 430 ha.

NCA.2 Sarıkum Gölü: declared 30 July 1987; total protected area: 785 ha.

WILDLIFE CONSERVATION AREAS

WCA.1 Kızılırmak Deltası (Samsun): declared Site for the Preservation and Reproduction of Waterfowl on 1979; it includes Cernek Gölü; protected area: 13 125 ha.

WCA.2 Simenlik Gölü (Terme): Declared Site for the Preservation and Reproduction of Waterfowl on 1975; protected area: 16 043 ha.

WCA.3 Homa Dalyanı (Izmir): declared Site for the Preservation and Reproduction of Waterfowl on 1980; it comprises Homa Lagoon and Çamaltı Salt Marshes (Çamaltı Tuzlası); protected area: 8 000 ha.

WCA.4 Akyatan Gölü (Adana): declared Site for the Preservation and Reproduction of Waterfowl on 1987; protected area: 7 500 ha.

WCA.5 Gökçeada (Çanakkale): declared on 1988; protected area: 28 204 ha.

WCA.6 Seyhan Nehri ve Tuz Gölü (Adana): declared Site for the Preservation and Reproduction of Waterfowl on 28 December 1995; protected area: 5 796 ha.

SITE AREAS OF THE REGIONAL COUNCILS FOR THE PROTECTION AND CONTROL OF NATURAL AND CULTURAL HERITAGE (SA):

SA.1 Samsun, Merkez : Kızılırmak Deltası, I. Derece Doğal Sit Alanı: decision No.1908/21 April 1994.

SA.2 Sinop, Merkez : Sarıkum Gölü, I. Derece Doğal Sit Alanı : decision No. 1198/21 November 1991.

SA.3 Kırklareli, Demirköy : İgneada, Mert, Erikli, Hamam Gölü : decision No.944 / 11 July 1991 and 1683/24 November 1994.

SA.4 Edirne, Enez: Dalyan, Işık Taşaltı Gölleri, decision No.2232/17 March 1995.

SA.5 Edirne, Enez: Karagöl ve Bataklığı, decision No.1908/7 February 1992.

SA.6 Edine, Keşan: Tuzla Gölü (Gala), decision No.1733/10 February 1994.

SA.7 İstanbul, Küçükçekmece: Soğuksu Çiftliği, İç & Dış Kumsal, decision No.9509/13 November 1976 (GEEAYK).

SA.8 Sakarya, Adapazarı: Poyrazlar Gölü Doğal Sit Alanı, decision No.2916/16 January1993.

SA.9 Çanakkale, Biga: Güvenalan$_1$ Hoyrat Gölü, decision No.2211/13 January 1995.

SA.10 Çanakkale, Çardak: Doğal Sit, decision No.2441/27 May 1995.

SA.11 Çanakkale, Gökçeada: Adanın Tamamı Sit Alanı, decision No.2813/16 November 1992 and 2135/11 November 1994.

SA.12 İzmir,Dikli: Çandarlı, Dalyan Gölü, Bakıçay, decision No.4274/10 March 1993.

SA.13 Muğla, Köyceğiz: Kaunos Antik Kenti Dalyan, decisions No.3722/27 March 1990; 2342/15 November 1994.

SA.14 Antalya, Kaş: Patara Antik Kenti, Gelemiş Köyü, decision No.719/20 June 1987; 1273/14 April 1990 and 4933/17 June 1995.

SA.15 Adana, Yumurtalık: Yumurtalık Lagünü, decision No.1609/19 November 1993.

Management of Turkish lagoons

Classification criteria

The main activity in Turkish lagoons is traditional fishing, which is carried out in 43 lagoons, representing 64% of the total surface. Different types of nature and wildlife protection have been declared for an outstanding 83% of the lagoon surface, amounting to 23 water bodies. However, the ban on this activity in protected areas is not fully enforced.

Current fishery management of the Turkish lagoons

The same model of traditional fishery management is currently adopted by almost all Turkish lagoons where this activity is still in use. The only notable exception is the lagoons of the Kizilirmak Delta, where the need to keep their freshwater characteristics does not allow the adoption of a permanent pass and the use of a fixed fishing trap.

Lagoon fisheries are usually managed as follows: From June to January, the fishermen trap the fish inside the lagoon by closing the fishing barrier; a fixed trap usually made of a paling framework and marsh reed and fences placed at the lagoon mouths to the sea. The fishermen do this when they believe that enough fish have entered the lagoon, then catching the fish trapped in commences immediately after the closure of the barrier.

Beside the fishing barrier, different kinds of stationary or moving nets may also be employed to make catching quicker and more complete. Inside the lagoon, fishermen mainly use stationary gear such as trammel nets, long lines and fyke nets.

From an ecological point of view, the lagoon fish stock is an exclusive function of the following factors; natural recruitment and the lagoon's natural capacity to entrain and retain the colonizing stages that immigrate. To summarize, this management scheme exploits the lagoon as a simple fishing trap, representing merely a basic level of lagoon exploitation for fishing purposes. By definition and for the considerations given below, this practice involves several constraints to the optimal use of the lagoon environment and its fish resources.

The traditional structure has several limits hampering its present functionality. As it stands, it will not be able to meet any increased fish production resulting from possible improvement measures:

- the structure as a whole is poorly selective, allowing the capture of undersized fish;
- its maintenance costs are high in terms of workforce and materials, which should be replaced every year;
- the total fish holding capacity of the standard fishing chamber is less than 10 m^2 since the largest part of it is taken up by a deep V-shaped slide entrance for fish, which frequently forces the fishermen to fish in overcrowded conditions, causing damage to the fish and reducing implicitly its market value;
- the reed fences are not a suitable barrier against the blue crabs, which enter the capture chamber and eat the fish trapped inside, which cannot escape attack;
- its home-made construction does not make the "kuzuluk" a suitable tool for catching eels due to their ability to escape loose barriers;
- walls of the catching chambers are made of reed fences and rusted iron grids with rough surfaces which may damage fish skin after prolonged stocking, thereby reducing their commercial value.

Moreover current regulations on the use of the fishing installation does not really prompt a strict control of fish flows into and out of the lagoon, for the following main reasons:

- when the barrier is open, juveniles can enter the lagoon and adult fish can return to the sea;
- there are no special side entrances to allow fingerlings to move towards the lagoon;
- there are no enclosures for the temporary stocking of undersized fish that become trapped in the fishing installation which are not suitable for the market.

Need of rehabilitation

The lagoons are usually shaped by the interactions between sedimentation processes of both marine and fluvial origin and hydrological factors such as wind driven currents inside and along-shore currents outside the water body, which contribute to them being characterized as highly dynamic environments. Left undisturbed, these processes generally lead to the lagoon's gradual disappearance by silting up, followed by the creation of new lagoons as a result of the new sedimentary and dynamic patterns. This natural evolution of the lagoon environment could be greatly affected by man-made activities, which play a key role either in providing stability or in accelerating their extinction.

At present the destruction of a lagoon is generally acknowledged, but lagoons are nevertheless subject to a string of threats that makes them prone to ecological disasters and to an uncertain future.

The Turkish lagoons visited during the surveys have been classified according to the major risks their ecology faces and categorised according to their apparent need of rehabilitation. The selected parameters are:

- absence of freshwater: no permanent inflow apart from rain and run-off;
- absence of sea water: pass usually silted up or absent;
- shallowness: a water depth of less than half meter;
- submerged vegetation: a dense mattress of aquatic plants in the whole water column spread across more than 50% of the total area;
- sedimentation: an active process, whether from the freshwater inflows, floods or sea movements;
- pollution: risk of contamination by agrochemical, industrial waste waters and domestic sewage;
- new settlements: the area is affected by a considerable building activity;
- floods: risk of flood during the rainy season from nearby river or drainage network.

Most of the lagoons along the Turkish coastline would benefit from some rehabilitation intervention. For a large number of lagoons the pace of their environmental degradation and the importance of preserving the existing activities, as well as their rich wildlife, suggest that rehabilitation measures are not only necessary, but indeed pressing.

Need to enhance the fishing production

With few exceptions, all lagoons show a downward trend in their landings. If we add to this the once productive but now abandoned lagoons, the overall situation of lagoon fishing appears dire: the average unit production is less than 25 kg ha^{-1}. Without including Köycegiz Lagoon, which alone accounts for about 40% of the total lagoon catches, this figure falls to only 17.5 kg ha^{-1}.

Even if we allow for the likelihood that the producers' declared landings are below the actual figures, overall production is far lower than the average potential of the Mediterranean lagoons, which is estimated to be at about 57 kg ha^{-1}. This gap becomes even greater when compared with the average production of lagoons managed according to the advanced criteria of valliculture, well above 100 kg ha^{-1}, not to mention the much higher output of integrated valliculture, where intensive fish farming is introduced.

Management models for lagoons

The application of the management models outlined below does not include the creation of the rehabilitation works recommended to restore or protect the lagoon environment. Their implementation is largely independent of the vocational exploitation of the lagoon and is based mainly on considerations concerning its existence, both present and future.

The management models for the Turkish lagoons are as follows:

- environmental conservation,
- environmental conservation plus traditional fishery,
- traditional fishing,
- adapted valliculture (extensive and semi-intensive lagoon *farming),*
- adapted integrated valliculture (extensive, semi-intensive and intensive aquaculture),
- recreation,
- research,
- education,
- research and education.

The lagoons of Turkey have been arranged according their potential suitability to the above mentioned models.

Environmental Conservation

This model applies to lagoons where the protection of their rich wild fauna is a priority and local inhabitants do not claim the need to exploit the environment for fishing or other uses. The water body is therefore managed as a wildlife preserve where the only human activities allowed should be surveillance, scientific research and education. The opportunity of giving space to ecological tourism along watched nature trails should be encouraged, provided that wildlife is not disturbed, particularly during the breeding seasons.

Environmental conservation and traditional fishery

This model applies to those lagoons where the protection of their rich wild fauna remains a priority, while at the same time there is a well established local fishing activity that causes negligible disturbance to wildlife. Water management should give priority to the preservation of favourable habitats for migrating and nesting birds, as well as the associated fauna and flora. Control of water level and quality of freshwater inflow require the greatest attention to prevent alterations that would hamper the particular characteristics of these environments.

The traditional fishing activities practiced in these lagoon systems should be maintained and upgraded by means of low impact technologies, such as increased stocking of target fish and more selective fishing equipment. Rehabilitation interventions, if necessary, should be aimed at creating or preserving favourable environmental conditions for both the target fishing species and the natural components.

The lagoons that may enter this category of management model are many water bodies to which some protection status is already granted.

Traditional fishery

Where wildlife and other natural characteristics are not prioritized and where more sophisticated fishing management forms cannot be applied for economic reasons, traditional fishing becomes the eligible choice.

Generally speaking, the creation or maintenance of a lagoon environmentally favourable to fish also helps the conservation of its wildlife; in some well known cases even to excess, for instance the numbers of fish-eating birds increase with the increase in the fish population. Average production figures remain in the lower limit of the production range for lagoon environments.

The present practice could be upgraded by improving the fixed capture devices and the fish juveniles stocking management. More selective fishing practices that prevent the killing of under-size fish should be adopted. The model is a sort of simplified valliculture, mainly because a proper water management system, one of the most typical features of valliculture, cannot be implemented. The greater the control over the environment, the better the final output. Specific training is also recommended for the local fishermen.

Adapted valliculture

The most advanced management of Mediterranean lagoons takes its name from the Italian word "valli", which means embanked portions of a usually brackish-water lagoon. This technology actually developed in the coastal wetlands along the northern Adriatic coasts in the last half century. Average yearly production is between 100 and 150 kg ha^{-1}.

Since the valliculture model foresees a closer control on fish and the environment than in the case of the traditional lagoon fishing, its application requires the fulfilment of more specifications that can be summarized as follows:

- the introduction of systems for a complete management of water supply and circulation by means of sluice gates; as a consequence the modification of certain water quality parameters;
- the close control of fish migratory movements by means of hydraulic control and the operation of the fishing installation;
- the selective fishing of sizes and species by means of the fishing installation;
- the stocking of live fish to overcome dangerous climatic conditions;
- the temporary stocking of seed fish of selected species under controlled environmental conditions;
- the introduction of live organisms as an integration to the natural diet of selected species.

The main diverging points from the "original" model, under the prevailing conditions in Turkish lagoons, are:

- the control of sea water by means of sluice gates;

- the control of fresh water by means of sluice gates, due the conflict involved with agriculture and justifying the importance of fisheries;
- the optimization of the lagoon water circulation by means of an internal network of ditches, since they are hardly economically justified.

The adoption of this tailored valliculture model requires first of all the modification of the applicable fishing legislation.

Integrated aquaculture

The rising running costs together with the decline of production have forced the extensive aquaculturists to look for alternative solutions aimed at increasing their landings. The actions undertaken to complement the extensive aquaculture (valliculture) production can be summarized as follows:

- give priority to the farming of valuable species: mainly bass for climatic reasons, but also bream and eels, according the practice of intensive farming in either concrete tanks or earth ponds placed in separate sectors;
- introduce only the hatchery-reared seed fish of selected species;
- enhance the lagoon's natural productivity by discharging the effluent of the intensive sector into the water body;
- introduce fingerlings and yearlings of bream to avoid the risk of their wintering since they reach a marketable size already at the end of the first rearing season;
- culture of new species, in particular extensive and semi-intensive shrimp farming in earth ponds, intensive fattening of salmon and sea trout; the latter two take place only during the cold season and use the facilities of the intensive sector that are not used at that time for bass and bream (which are wintering in dedicated facilities);
- work the pond bottom by means of appropriate machinery to aerate and oxidize it and to release the nutrients trapped in the sediments;
- improve the wintering facilities so that even the extreme climatic conditions that may take place - however rarely - can be faced (introduction of artificial heating devices);
- semi-intensive ponds for a polyculture of selected species, usually bream and mullet.

These innovative practices could raise the production by well over 200 kg ha^{-1}, depending on the size of the intensive sector and that of the semi-intensive ponds.

Discussion

Various actions are available for increasing fish output in lagoons at a sustainable level. They should take place under conditional circumstances, highlighted by a careful integrated management plan and after an impartial environmental impact application and cost-benefit analysis.

Applicable models for fish production enhancement

The enhancement of traditional fishing and the introduction of sustainable aquaculture practices is one of the most powerful means for preserving the lagoon environment from major damage while making a renewable use of the available resources.

Environmental conservation and traditional fishing

It entails issues common to each model suggested, since it is widely accepted than the creation or maintenance of a lagoon environment favourable to fish also helps the conservation of its habitat and wildlife.

In applying this model priority should be given to those interventions aimed at the protection of the wildlife and the peculiar features of the ecosystem.

Fishermen should be trained on the naturalistic importance of the lagoon environment and local authorities should encourage their participation in all initiatives concerning lagoon wildlife management, including sharing the benefits of possible ecotourism activities.

Where possibilities exist for upgrading the traditional fishing activity, these should be enacted using low-impact technologies. The fishing installations should be modernised once their economic feasibility is assured. Actions to introduce forms of extensive and semi-intensive aquaculture should be applied to the recovery and preservation of the biological diversity. This model is applied to the lagoons of the Goksu River Delta.

On the other hand, where special environmental conditions severely limit changes, consideration should be made of substantially maintaining the traditional fishing practice. Main interventions should be focused on the preservation of the water quality and water balance of the wet area. Only limited measures to sustain the fishing activity should be implemented and, once its feasibility is ascertained, the controlled introduction of hatchery-reared selected species might be allowed. This model is applied to the lagoons of the Kizirilmak River Delta.

Integrated aquaculture

Once it is duly tailored to the specific conditions of some Turkish lagoons, the integrated aquaculture model should be applied as a suitable means to reshape the aquaculture enterprises managing the lagoons.

The enterprise production is then enhanced through the combination of different forms of intensive and semi-intensive farming. The extensive lagoon culture is then to be enhanced by a careful combined management of the intensive aquaculture outputs: quality seed fish, energy content of the effluents, modem infrastructure and marketing schemes. Under these circumstances, the technical and economic feasibility of a highly efficient fishing installation and an improved water exchange are justified by the high rentability of the model. This model is applied to Akyatan Lagoon.

Adapted valliculture

Where the size and richness of the lagoon, the attitude of fishermen toward aquaculture practices and the climatic conditions permit, introduction of modified Italian valliculture schemes are recommended. Provided it is economically feasible, a careful fresh water regulation should be achieved that will allow water quality in the lagoons to be governed.

Modern fishing installations and infrastructures should be implemented. A diversified exploitation of available water bodies and a sound dosing of quantitative proportions among species should be assured by a careful control over natural migratory movements of fish, *in situ* hatchery production of seed fish, and temporary stocking of valuable undersized stocks under controlled conditions. This model is applied to the lagoons of the Meric River Delta.

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The state of inland fishing in Lithuania

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Abstract Over the last 11 years, commercial fishing enterprises caught on average between 1500 and 1700 ^{t} of fish in inland waters of Lithuania. The main share (75 %) of commercial fish catches was landed from the Curonian Lagoon. Catches in the Kaunas Lagoon, rivers, and lakes amounted 7 – 8 %, 10 – 11 %, and 5 – 6 % of the total fish catches, respectively. Amateur fishermen catch approximately 1350–1500 ^{t} of fish per year. The current situation in inland fisheries shows that there are a number of urgent issues which need attention: the social importance for local communities of the, relatively small, commercial catches in inland water bodies (1); the need for improvements in the rationale for the allocations for the restoration of fish resources (fish restocking) (2); the need for more scientific investigations into fisheries (3); statistical data on fish catches in inland waters do not reflect the real situation and so there is a need for improved methods of collecting information on fish stock exploitation (4); the conflict between amateur and professional fishers persists (5); fish stock protection and control is insufficient (6); poaching has not yet been eradicated (7); the development of commercial and amateur fishery and fishing tourism is not suitably coordinated (8). Taking into consideration the problems posed, the structure of inland fishery in Lithuania is to be reconsidered in the nearest future.

Introduction

Both commercial and recreational fisheries are conducted in inland waters of Lithuania, as in those of other European countries. The significance of commercial fishery in inland waters has been declining recently, due to many factors, while the recreational fishery has been rapidly expanding. Four main branches of the commercial fishery have been traditionally undertaken in Lithuania, according to the fishing type and structure of inland water bodies, i.e. river, lake, water reservoir and the Curonian Lagoon fisheries. At present, commercial fishing is carried out only in the lower reaches of the Nemunas River where mainly (about 90 %) smelt *Osmerus eperlanus* (L.) is landed and eels *Anguilla anguilla* (L.) are caught in the estuary. Commercial fishing is banned in other rivers of the republic. The majority of lakes where commercial fishing is conducted are small and the consequent small fish catches there are more suitable for amateur fishing practices. It is therefore possible to forecast that commercial fishing is likely to persist only in large lakes in the near future, in line with long-established traditions of the commercial fishery. The Curonian and Kaunas Lagoons have the largest commercial fish catches. Fish resources in these water bodies are and will be exploited intensively and sustainably.

In 2004, catches by Lithuanian commercial fishing enterprises in various water bodies amounted to 160 665 ^{t}, with catches in inland waters constituting a comparatively small share of 1595 ^{t} (i.e. about 1 % of the total catch in Lithuania).

The Ministry of the Environment performs regulatory functions as well as those of policy implementation on the restoration (restocking), preservation and monitoring of fish resources in inland waters. Functions performed by the Ministry of Agriculture include: implementation of the general European Union and Lithuanian fishery policies; regulation and policy implementation on the restoration (restocking), preservation and monitoring of fish resources in marine waters; research into pisciculture and fisheries; development of aquaculture. Fishing in Lithuania is regulated by the fishery law and rules for commercial and amateur fishing.

Professional fishery in Lithuanian inland waters

Statistical data on commercial fishery in inland waters are presented in Table 1. Over the last 11 years commercial fishing enterprises caught from 1500 to 1700 tones of fish in inland waters on average. The main share (75 %) of commercial fish catches was landed from the Curonian Lagoon, catches, which almost doubled over a decade. The fishery in the Lagoon is intensive, but fish stock exploitation is sustainable. The Curonian Lagoon is a eutrophic water body of high biological productivity, predominantly inhabited by populations of bream- zander- smelt (Gerulaitis *et al*. 1994). That is one of the basins of the Baltic Sea which has the most abundant fish resources. There commercial catches had amounted to 60 – 80 kg/hectare for many years (Maniukas 1959). According to official statistics, in 1992 – 1996, after the restoration of Lithuania’s independence, a significant decline was recorded in commercial catches which could be explained by the reorganization of fishery economics and for political reasons (Lithuanian fishermen could no longer fish in the central part of the Lagoon belonging to Russia). Yet, even then fish catches in the Lagoon were larger than in all inland water bodies. Since 1996, with improvements in the recording of fish catches, fish hauls have been increasing and have exceeded 1000 tones.

Thirty three species were recorded in commercial catches, which, as in previous years, were dominated by roach and bream. In 2000 – 2005 roach constituted 36 % and bream 28 % of commercial catches. Landing of smelt was also quite abundant in recent years; they made up 13.5 % of total catches. Zander (6.8 %), perch (3.4 %) and ruffe (2.7 %) were also common in catches. The share of vimba in catches increased significantly and amounted to 3.5 %. Due to decreased water contamination, landings of vimba, twaite-shad, sea-trout and salmon as well as those of predatory fish have been increasing. Catches in the water area belonging to the Kaliningrad region were larger and varied from 2000 to 2400 ^{t}. In summary, the abundance of the majority of the main commercial fish populations has not changed significantly over the last years, although, fishing intensity, as measured by commercial catches, has increased (Repečka 2006).

Catches in the Kaunas Lagoon varied from 61 to 230 ^{t} per year, constituting 7 – 8 % of the total amount of fish caught in inland waters on average. The majority of fish species in the Kaunas Lagoon have been very intensively exploited recently. To reduce fishing intensity in the Kaunas Lagoon, it was recommended to ban commercial fishing at weekends and holidays. The number of bream fishing nets has been decreased, bream catch quotas are being reduced, and the minimum mesh-size of fishing nets has been consistently increased. In 2005 the quota for the total catch (160 ^{t}) in the Kaunas Lagoon was introduced. We expect these measures to reduce the impact of commercial fishing on fish resources in the Kaunas Lagoon and to help preserve stocks of these fish.

Until 1970 fishing was conducted in the large rivers of Lithuania – the Nemunas, Neris, Šventoji, Baltijos Šventoji, Nevėžis and Minija. Commercial catches amounted to 430 – 450 ^{t} per year (Bružinskienė & Virbickas 1988). In larger rivers, salmon, sea-trout, asp, bream, roach, smelt and other valuable fish species were caught using various fishing methods. However, commercial catches continued to decrease due to water contamination, dam construction and decrease in fish resources. Lately, river fishing has been restricted to the lower reaches of the Nemunas River and to catching eels migrating from lakes to rivers. On average, 10 – 11% of the total fish catch in inland waters are landed from rivers. The dynamics of fish catches in rivers has remained stable over a number of years, with 163 – 199 tones of fish being caught on average. The year 2004, was an exception with a catch of only 94 ^{t}. Smelt from the lower reaches of the Nemunas River made up over 90 % of hauls in rivers. Eels migrating from lakes constituted only a small part.

Fish caught in lakes make up 5 – 6 % of the total amount of fish caught in inland waters. In general, due to the imperfections in the reorganization of fishery structure, co-operation, stock exploitation and stocktaking systems, catches in lakes have decreased drastically. On average, over the last 10 years fish catches dropped from 113 to 34 tones (Table 1).

Table 1. Fish catches (^{t}) by Lithuanian commercial enterprises

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Curonian Lagoon	652	784	1053	1167	1095	1258	1096	1313	1292	1237	1168
Kaunas Lagoon	61	81	103	104	148	112	106	142	139	230	150
Rivers and polders	93	84	175	178	168	175	178	199	163	94	190
Lakes and water reservoirs	113	126	100	83	85	59	69	58	64	34	39
Total	919	1073	1431	1532	1497	1605	1449	1711	1657	1595	1547

In total, almost 3 thousand people catch fish in Lithuanian waters using commercial fishing gears. However, the income earned from this business is often insufficient to meet the basic needs of family members and to guarantee social security. This situation is caused by the fact that the majority of commercial fishing enterprises are small-scale, with low investment capacity and competitiveness. Under current commercial exploitation conditions, it is difficult to make a profit in an average Lithuanian lake. The situation in the coastal zone of the Curonian Lagoon and the Baltic Sea is similar. The value of the total annual production in inland waters reaches only about €1.0 million, with the annual value of fish produced by a single fisherman annually being less than €570. These figures clearly show that the current orientation of inland water fisheries towards small-scale commercial fishing is unsustainable.

Recreational fishery

Recreational fishing is allowed on most water bodies in Lithuania. Recreational fishing is regulated by rules of amateur fishing which specify permissible fishing tackle and methods. These include the use of spinners, rods, fishing nets and creels as well as underwater fishing tackle. Fishing of some rarer and protected species in rivers is carried out under license. This includes fishing for salmon in restored salmonid rivers, as well as fishing for sea-trout, vimba, lamprey and smelt in extremely productive rivers or river spots in which there are abundant resources. Owners of water bodies are entitled to organize licensed fishing in water bodies under their ownership. Licensed fishing is also carried out in some protected territories where shoals of fish accumulate and where ordinary fishing is prohibited or restricted. License-holders must observe rules of licensed fishing.

The large number of anglers has a great impact on Lithuanian fish resources. Unfortunately, stocktaking of catches by amateur fishermen has always been very approximate. For instance, in 1989 a member of the Lithuanian Society of Hunters and Fishermen caught 10.5 kg of fish per year on average. The number of such members in that year amounted to 95 thousand. Hence, their total haul must have been 997.5 tones. According to the data of the investigation carried out by V. Žiliukienė in 1994 (personal report), in lakes, an angler used to catch 1.68 kg of fish on average per day. Recent studies have proved that the daily fish catch has not changed much and varies from 1 to 2 kg on average. As angling intensity has been increasing recently, the total amount of fish caught is now very large. According to the data provided by scientists, amateur fishermen catch approximately from 1350 to 1500 ^{t} of fish per year. The number of people going fishing actively (i.e. spending money on this form of recreation) in Lithuania is about 0.3 million. Anglers of the country spend €20.5 million per year on fishing. The amount of money circulating in the recreational fishery is much larger than the total sum of money circulating both in the commercial fishery and aquaculture. It is possible to forecast that when the living standard in Lithuania reaches that of Western Europe, the yearly service market in Lithuanian recreational fishery will be estimated at €200 million EURO.

Scientific research and monitoring

As a result of the intensified exploitation of fish resources, scientific research and monitoring has become extremely important. Scientific investigations and monitoring are carried out in most water bodies, especially in those where intensive commercial fishing is conducted. However, as we have noted, these investigations have not always been coordinated among various institutions. All investigations can be classified according to their scope and objectives into monitoring studies and purposive scientific investigations. Monitoring studies are long-term, complex and are conducted following coordinated and agreed methods. Purposive scientific investigations are performed when it is necessary to investigate water bodies or fish populations, when unforeseen problems of one or another kind arise, when it is necessary to answer questions promptly and then make proper decisions. In Lithuania investigations and monitoring of the state of commercial fish populations and resource exploitation are conducted continuously.

Conclusion

In the very near future, commercial fishing will persist only in main water bodies – large lakes, the Curonian and Kaunas Lagoons and the lower reaches of the Nemunas River. 92 % of the lakes in Lithuania have areas of less than 50 hectares and so this has a potentially very large impact. Amateur fishing will get priority in most water bodies. .

To summarize, the current situation in inland fishery proves that there are a number of urgent problems that need solving in the future:

1. Commercial catches in inland water bodies (with the exception of the Curonian and Kaunas Lagoons) are not large, but are socially important for the local inhabitants.

2. There is insufficient rationale for allocations for the restoration of fish resources (fish restocking).

3. There is insufficient scientific research into fisheries.

4. Statistical data on fish catches in inland waters do not reflect the real situation and the system of collecting information on fish stock exploitation is imperfect.

5. The conflict between amateur and professional fishers persists.

6. Fish stock protection and control is insufficient and poaching has not yet been eradicated.

7. The development of commercial and amateur fishery and fishing tourism is not suitably coordinated.

Taking into consideration the problems posed above, the regulation of Lake Fisheries is to be reconsidered in the near future. It is proposed that commercial fishing should not be conducted in small lakes (with an area of less than 50 hectares). According to the project, only specialized commercial fishing, i.e. fishing of those species that are not caught by amateur fishermen (smelt, vendace, bleak, ruffe, etc.) is to be carried out in lakes with areas of between 50 and 200 hectares. Commercial fishing could be carried out in lakes larger than 200 hectares, with the fishing intensity dependent on the lake type, stock size and allocated fishing quotas. No fishing using commercial fishing gears will be conducted in rivers, with the exception of the lower reaches of the Nemunas River and fishing of eels migrating from lakes.

In conclusion, it is forecasted that, during the 2007 – 2010 period, catches landed in inland waters using commercial fishing tackle will amount to 1830 – 1870 ^{t}, 1350 ^{t} of which will be caught in the Curonian Lagoon, 160 ^{t} in the Kaunas Lagoon, 200 ^{t} in rivers and polders and 120 – 150 ^{t} in lakes (Kesminas 2005). Catches are to grow only in lakes, with other water bodies being sustainably exploited.

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Recovery programmes for endangered freshwater fish in Flanders, Belgium

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Abstract In Flanders, several fish species are endangered due to water pollution and habitat deterioration. However, water quality is improving and efforts are being made to restore habitat quality, allowing natural recovery of several fish species. For other species, an integrated approach for protection and recovery of their populations is required. Fish stocks are built up with respect to genetic origin. Mathematical models were developed and used to evaluate habitat suitability. Reintroduction is considered when both water quality and habitat are suitable. Appropriate measures in relation to habitat demands of fish are being taken with relevant partners involved in integrated water management; stopping biodiversity loss and the EU Habitats Directive are the policy frame for these measures. The angling sector also finances scientific research as part of the fish permits proceeds.

Introduction

In Flanders, of 40 freshwater fish species, about 15 species are considered to be endangered and another 5 species are considered to be extinct (Red list of Fish Species in Flanders 1998, Research Institute for Nature and Forest, http://www.inbo.be). Possible reasons for this decline are poor water quality and habitat deterioration. Water quality has been negatively influenced by domestic and industrial wastewater and run-off water from agriculture and traffic for several decades. In the 1980s, water quality was so poor that several rivers contained few or no biological life. However, since the 1990s serious efforts have been made in wastewater treatment and the impact of domestic wastewater on the quality of Flemish surface waters has gradually decreased since. By the end of 2006, domestic wastewater treatment covered about 66% of all households (Van Steertegem 2007).

Since the early 1960s Flemish watercourses have been straightened into channels and fragmented by weirs and dams strongly reducing the overall habitat quality and obstructing fish migration. Since the 1990s an increasing number of river restoration projects have been carried out. Additionally, in several watercourses habitat structure has improved naturally. Furthermore an inventory of fish migration barriers of principal waterways has been made by the Flemish Environment Agency (www.vismigratie.be), and a programme for solving these migration barriers has been developed. According to this programme 14% of all migration barriers have been solved by 2006 and numerous projects to enhance fish migration are planned and will be carried out in the future.

Since water quality and habitat structure diversity are gradually improving, new opportunities arise for the recovery of rare and endangered fish species. The Agency for

Nature and Forests of the Flemish Authorities, responsible for the management of fish stocks and the freshwater fisheries policy in Flanders, exploits these opportunities to protect and enhance fish populations in Flanders.

Methods

Flanders, the northern part of Belgium, is a densely populated region in the central part of Western Europe, inhabited by about six million inhabitants on an area of 13 522 km^2. The principal rivers in the two major river basins in Flanders (Meuse and Scheldt) are depicted in Figure 1.

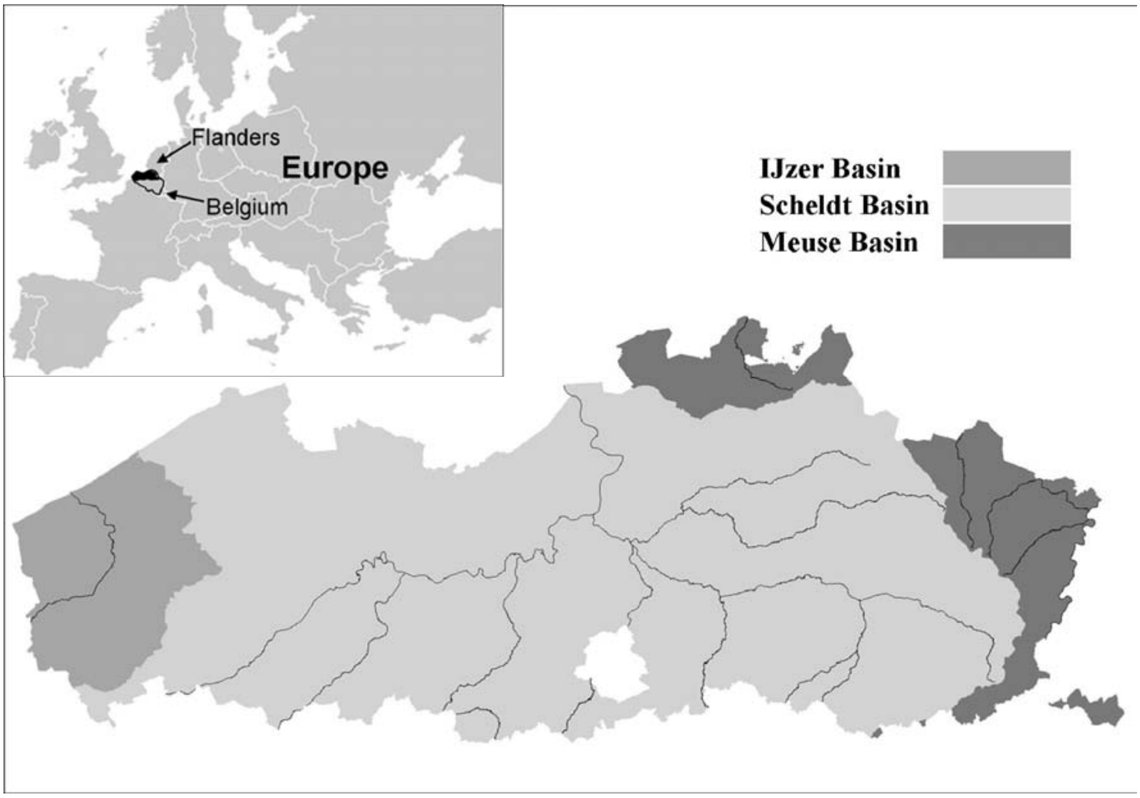

Figure 1. Principal rivers in the two major river basins in Flanders (Meuse and Scheldt).

The principles and objectives of biodiversity as pointed out in international agreements and Conventions and European legislation such as the Habitats Directive (92/43/EEC), the Water Framework Directive (2000/60/EC) and the Eel Regulation (2007/1100/EC) are the policy framework based on which the Agency for Nature and Forests carries out a sustainable management of fish stocks in Flanders. The watercourse management itself is the responsibility of several external partners, spread over different levels of local and regional interest. To maximize the chances of recovery for freshwater fish, the Agency has developed a systematic step by step approach in the form of Fish Protection Programmes and Fish Recovery Programmes. The scientific input of these programmes is guaranteed by the Research Institute for Nature and Forest, an independent research institute of the Flemish Authorities.

Fish Protection Programmes

Fish Protection Programmes aim to protect populations of threatened and rare fish species by the conservation and management of their habitat. Due to water pollution and habitat loss these populations are generally small and scarce, and very often have a distribution limited to the upstream parts of the rivers. Most of these species are listed on Annex II of the Habitats Directive. Furthermore, a few species have a naturally low occurrence, e.g. barbel, *Barbus barbus* (L.) and minnow, *Phoxinus phoxinus* (L.). For these species required habitat is scarce in Flanders due to geographical conditions. Therefore Fish Protection Programmes primarily aim at species which have low abundance because of human influences.

The first step in each Fish Protection Programme is to investigate both historical and actual distribution of a species and its current status. The actual distribution is digitalized into a geographical information system allowing quick and easy access to distribution maps. Secondly, general ecology, habitat demands and eventual bottlenecks are examined. Based on these data, scientific models are developed to evaluate the habitat suitability of Flemish watercourses for the species in question. In addition genetic research provides necessary information of the genetic diversity of the available stock of the species. Very often this diversity is rather poor due to habitat fragmentation causing genetic processes such as inbreeding. Therefore measures for protection and enhancing genetic variation in natural broodstock are undertaken. Removal of migration barriers and creation of spawning and nursing habitats in the river are the two most practiced measures. Based on habitat research, specific recommendations for the management of watercourse sections for the species are discussed with the different watercourse managers. Finally, fish populations are regularly monitored to evaluate success of measures undertaken. When needed, additional measures are taken. Fish Protection Programmes have been developed for amongst others, bullhead, *Cottus gobio* (L.) and brook lamprey, *Lampetra planeri* (Bloch). Some of the proposed measures for these species are very specific for a local river section.

For instance, for brook lamprey in the River Abeek, an adjusted aquatic weed removal schedule involved the description of different methods of weed removal to be used in different sections of the river. In some sections, aquatic weeds are naturally scarce and hence weed removal was discouraged. For other sections it was proposed to limit the removal of aquatic weeds to just one river bank and to alternate the right and left river bank in respectively even and uneven years, and to limit the period of weed removal from the last week of June to the third week of July. Also it was agreed to stop the clearing of sludge in the River Abeek because of the detrimental impact on the larvae of brook lamprey which live in the river bottom.

Fish Recovery Programmes

While Fish Protection Programmes involve species for which natural recovery still is possible, they are specifically carried out for species for which natural recovery is either impossible due to the lack of nearby source populations, either very unlikely to happen on the medium long term due to the presence of migration barriers or to the small population size of nearby populations. Therefore reintroduction is considered as a policy measure to obtain self-sustaining populations.

Typically, a Fish Recovery Programme starts with a preliminary study in which the feasibility of the Recovery Programme is investigated by collecting the available scientific data on the species and relating these to the policy framework. If the opportunities for a successful reintroduction are good, the preliminary study is followed by a detailed multi-disciplinary research and management program, which consists of seven major parts based on the IUCN guidelines for reintroductions (http://www.iucnsscrsg.org/reintroduction.html).

ECOLOGY

Different aspects of ecology of the target species are investigated (e.g. Dillen *et al*. 2004). In a reference situation where the species is still present in normal abundances, relevant variables concerning water quality, spawning habitat, juvenile, sub-adult and adult habitat are measured and linked to population densities of the respective life stage by comparing habitat availability with habitat use. Based on these data, scientific models are developed to evaluate the habitat suitability for the species by estimating the population densities in certain parts of a watercourse.

EVALUATION OF REINTRODUCTION SITES

In a selection of Flemish rivers all habitat variables were measured and used to developed models to assess habitat suitability for the species (e.g. Dillen *et al*. 2008a). Since this approach allows determination of which watercourse sections are suitable and which is not, a list of potential watercourse sections for reintroduction of the species can be made. Furthermore, since the models determine which variables are responsible for low habitat suitability, it is possible to formulate specific recommendations for habitat improvement. However, if habitat is unsuitable due to natural habitat change since extirpation, it is decided not to reintroduce the species in that habitat rather than trying to adjust habitat structure. Ecology of species has been studied and evaluation of reintroduction sites has been done for chub, *Leuciscus cephalus* (L.), dace, *Leuciscus leuciscus* (L.) and burbot, *Lota lota* (L.). Burbot has become extinct in Flanders since the 1970s. Natural occurrence of dace is nowadays limited to only a few small relict populations in two river basins. Recently chub was only found in the River Meuse. Historical data show that all three species where omnipresent in almost all Flemish river basins before 1930, indicating a very rapid decline.

For each of these three species, habitats suitable for reintroduction were indicated and measures to enhance other habitats according to the needs of the species were taken. One of the most frequently proposed measures is the input of large and of small woody debris. Woody debris deflects the current resulting in the formation of meanders, a heterogeneous sedimentation and a diversified pool-riffle pattern. It may also enhance the formation of undercut river banks. Allowing the colonization of river banks by common alder *Alnus glutinosa*, (L.) and European ash, *Fraxinus excelsior* (L.) provides shaded areas and prevents erosion of river banks naturally. It also enhances formation of undercut river banks by fixating the river bank from collapsing.

POPULATION GENETICS

Ideally the genetic composition of the source population used as brood stock for reintroduction should be closely related to the original native stock and show similar ecological characteristics to the original population. Furthermore, genetic variation in the brood stock should be as high as possible to avoid genetic deterioration of reintroduced populations. Therefore Evolutionary Significant Units (ESU) and Management Units (MU) are determined on which genetic management of populations is based both for brood stock as for natural populations. In Flanders, this has been studied for northern pike, *Esox Lucius* (L.), brown trout, *Salmo trutta fario* (L.), chub and burbot (Maes *et al*. 2003; Van Houdt *et al*. 2003; Van Houdt *et al*. 2005a; Van Houdt *et al*. 2005b; Van Houdt *et al*. 2006).

AVAILABILITY OF SUITABLE RELEASE STOCK

For a successful reintroduction a stock must be guaranteed available on a regular and predictable basis. Therefore artificial breeding of fish in aquaculture is applied to obtain a sufficiently high number of individuals, thereby reducing the need to disturb wild populations. Since most target species are not available in commercial hatcheries, aquaculture techniques were developed within the hatchery facilities of the Flemish Authorities (Shiri Harzevili *et al*. 2003; Shiri Harzevili *et al*. 2004; Vught *et al*. 2003a; Vught *et al*. 2003b; Vught et al. 2008). Within these hatcheries, eggs are fertilized and hatched resulting in fish fry which are grown in earthen ponds during their first summer before release in nature. This process has been studied and optimized for northern pike, brown trout, dace and burbot. More recently, a study was initialized to optimize the artificial breeding of chub.

REINTRODUCTION

Young-of-the-year fish obtained from the Flemish hatchery facilities are then reintroduced into a small number of selected watercourse sections with suitable habitat by releasing them at low densities (e.g. 30 individuals/100 m river length). Since many fish species happen to spawn only after they have reached a certain age, and some species may fail to spawn in some years, stocking is repeated for several consecutive years to obtain a self-sustaining population. Typical densities of release average between 1500-3000 individuals per watercourse per year. In Flanders, reintroduction has been carried out for chub, dace and burbot. Chub has also been reintroduced about 15 years earlier but in different watercourses. Restocking, here defined as replenishing existing natural populations which are on a decline with fish of a similar genetic constitution, is done for northern pike and brown trout.

MANAGEMENT PROGRAMME

Scientific recommendations resulting from previous research components of the Fish Recovery Programme are discussed with relevant partners to obtain an appropriate watercourse management considering the specific needs of the species. Very often the appropriate management implicates a change of method for removing aquatic weeds and riparian vegetation or a change of method for removing sludge from the river bottom. All these activities generally have a negative impact on fish populations, especially on endangered species, and proposed measures aim to reduce this impact to an absolute minimum. Since most rivers in Flanders are situated in agricultural or inhabited regions it is rather exceptional not needing to adjust water management. Other measures are for example the safeguarding of surveyed spawning sites, the creation of vegetated buffer sites along the river banks to diminish erosion or detrimental effects of pesticides or fertilizers, restoring lateral connectivity and reducing the overflow of superfluous wastewater which happens to occur when the capacity of sewer systems is exceeded. Finally, besides water managers, the local population and all relevant interest groups such as anglers are well informed about the Fish Recovery Programmes and the ecological interactions to facilitate dialogue between the different stakeholders.

EVALUATION OF RECOVERY

The outcome of each Fish Recovery Programme is monitored by fish stock assessment and evaluated. Whenever necessary, reintroduction strategy or water management measures are adjusted. The information of evaluations is regularly published both in scientific as in popular literature. Currently the outcome of the latest reintroductions of burbot, chub, and dace are being investigated. Previous reintroductions of chub in different watercourses have already been studied in the past.

Results

Fish Protection Programmes

The distribution and abundance of Flemish fish populations is well documented by several monitoring and fish research programmes (Dumortier *et al*. 2005; Dumortier *et al*. 2006). Digital maps are now available with the distribution of each endangered species. This information, together with suggested measures for watercourse management, is then incorporated in river basins management plans which in turn are discussed with the relevant partners. Fish Protection Programmes in the different river basins in Flanders are listed in Table 1.

Table 1 distribution of different fish species for which Protection Programmes are proposed or being implemented for all Flemish river basins. Concerned fish species are brook lamprey, *Lampetra planeri* (Bloch), bullhead, *Cottus gobio* (L.), spined loach, *Cobitis taenia* (L.), weatherfish, *Misgurnus fossilis* (L.), bitterling, *Rhodeus sericeus* (Bloch), stone loach, *Barbatula barbatula* (L.) and schneider, *Alburnoides bipunctatus* (Bloch).

Species River basin	*L. planeri**	*C. gobio**	C. taenia*	*M. fossilis**	*R. sericeus**	*B. barbatula**	*A. bipunctatus*
Brugse Polders						x	
IJzer	x		x		x	x	
Leie					x		
Canals of Ghent							
Upper Scheldt	x	x				x	
Lower Scheldt		x					
Dender	x	x				x	
Dijle	x	x					x
Demer	x	x					x
Nete	x	x	x	x			
Meuse	x	x	x	x			x

* Species of annex II of the Habitats Directive.

Fish Recovery Programmes

Recovery programmes have been set up and are currently being carried out for three rheophilic species: burbot, chub, and dace. For each species the habitat use and preference for different life stages (age 0+ and age 1+ or older) have been studied and habitat suitability models have been developed. Furthermore spawning habitat requirements have been studied by literature, or, when the available information was too scarce, by a field study in a natural reference situation. Water quality demands of each species were investigated by comparing existing fisheries data from reference situations with water quality data.

For each of the three species an evaluation protocol was set up as a tool to assess suitability of watercourse sections for the species. Each protocol thus evaluates watercourse suitability based on water quality, available habitat for different life stages, and spawning habitat.

An example of how this protocol was used is given for the burbot. For this species water quality is evaluated by three variables: percentage of oxygen saturation, biological oxygen demand and ammonium-nitrogen. Habitat suitability for sub-adult and adult burbot is evaluated by the developed habitat suitability model in which the most important habitat variable was the presence of undercut banks. Spawning habitat and larval and juvenile habitat was determined by three variables: a relatively low stream velocity (< 10 cm s^{-1}), presence of overhanging cover (trees and bushes on the river bank) and the presence of aquatic vegetation (both submerged and emerged vegetation). The protocol was used to assess 10 different Flemish watercourses for their suitability for the burbot. When either water quality requirements or habitat demands for one of the life stages or for spawning were not fulfilled, it was decided not to reintroduce the burbot in that particular watercourse section. Instead, measures were proposed and discussed with watercourse managers to improve habitat suitability. Finally, it was decided to limit the first reintroduction to three different watercourses in which all demands were fulfilled, so that the outcome of reintroductions could easily be assessed. A similar approach was used for dace and chub.

The next step in the Recovery Programme is to optimize artificial spawning under hatchery conditions, which has been successfully carried out for burbot and dace, and is now being investigated for chub. Also, genetic studies have been carried out for burbot, chub and dace and proper source populations for the breeding programme have been selected.

Chub was the first species for which a recovery programme was started. From the early 1990s reintroductions were carried out for consecutive years in the Nete basin and in the River Zwalm. A self-sustaining population of chub is now present in most of the Nete basin and, consequently, reintroductions of chub in the Nete Basin were stopped since about 8 years. Figure 2 shows the gradual expansion of the population of chub in the River Grote Nete in time and space. In the River Zwalm a self-sustaining population of chub has been established after only one year of reintroduction.

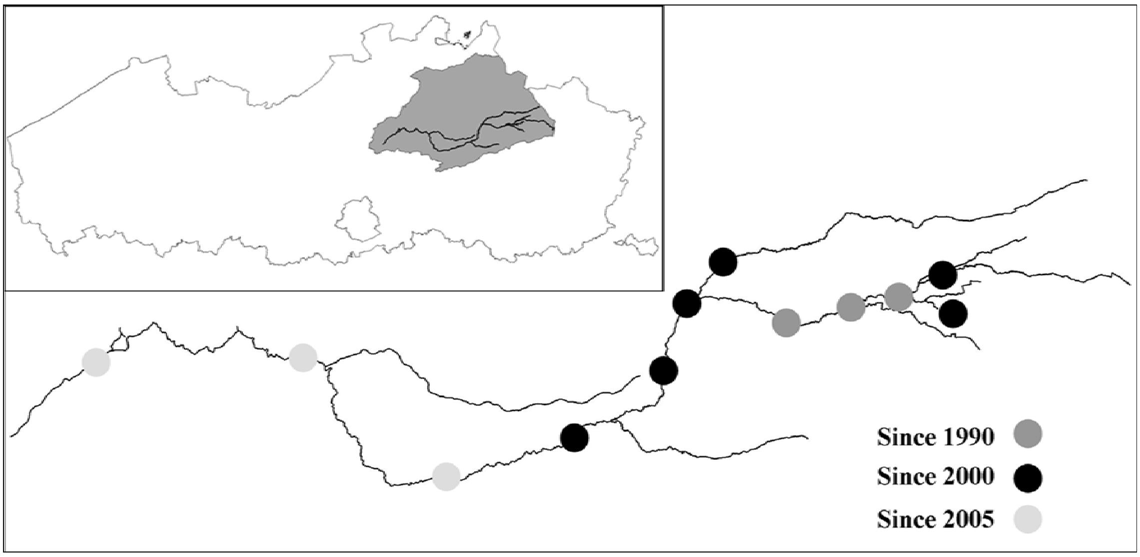

Figure 2. Expansion of the population of chub in the River Grote Nete in time and space.

Discussion

Fish Protection Programmes

Although distribution of bullhead is still limited to only a few small tributaries, its local population sizes generally are high (Vandelannoote *et al*. 1998). Recently two populations of bullhead were found in tributaries where the species had not been observed for many years. However, in another tributary, an illegal diffuse pollution of manure decimated the bullhead population which still recovering.

Evolution of brook lamprey is rather difficult to follow since this species is much more difficult to capture. Brook lamprey is now slowly recolonizing a watercourse section in the River Sassegembeek that was organically polluted up to 2005, but measures have been taken to stop this pollution. Both adult and larval brook lampreys have been observed since water quality in this river section improved. However, since most measures in these Fish Protection Programmes have only recently been taken, possible effects on bullhead, and brook lamprey populations might not yet have reached their full extent and further monitoring of populations is required.

Fish Recovery Programmes

Scientifically based Fish Recovery Programmes can establish self reproducing populations. The rapid establishment of a self-sustaining chub population in the River Zwalm after only one year of reintroduction is rather exceptional, and, based on other experiences with chub reintroductions, reintroductions have to be repeated for several consecutive years for about a decade. This implies that reintroduction broodstock must be guaranteed available on a regular and predictable basis for several consecutive years.

Burbot reintroductions have now been carried out for three consecutive years in the rivers Grote Nete, Maarkebeek and Bosbeek. Preliminary recaptures of burbot have shown good survival and growth of individuals (Dillen *et al*. 2008b), but spawning and survival and growth of eggs and larvae is yet to be investigated since recaptured burbot had not reached full maturity. Within a few years the success of the current reintroduction programmes can be evaluated.

Watercourse management

Based on the principles of integrated water management, the necessary management measures to protect and enhance populations of endangered species are carried out in harmony with the different functions of the watercourse and in consultation with the competent water managers.

The required management measures for fish species are not always feasible because of practical, budgetary or technical reasons. For example, in agricultural areas mowing of water vegetation or clearing of sludge is often applied to maintain certain water levels. In inhabited areas, water quantity management is mainly focussed on local flood prevention by maintaining safe water levels. On a local scale, agreements for specific watercourse sections are made between the responsible fish stock manager (Agency for Nature and Forests) and the relevant water managers with respect to the different functions of the watercourse. Most of the time these agreements contain an adaptation to the mowing or clearing regime. Concrete agreements are included in the contract specifications with the firms who carry out the maintenance of the watercourses. Additional specific agreements are possible on a local scale. In the example of an adjusted management of the River Abeek to protect brook lamprey, a local commission has been set up in which representatives of the Agency for Nature and Forests, the competent water managers and local farmers are united to discuss and approve concrete agreements. Local farmers and water managers in this commission are given specific information about life cycle and ecological demands of brook lamprey so that they understand the necessity of specific measures and agreements. This approach results in a high local and social support for biodiversity measures. On the other hand local farmers and water managers have the assurance that the local commission can be rapidly summoned and undertake countermeasures when problems with water levels should arise. Since the setup of this local commission and the agreed measures have been put into practice eight years ago, water levels have been stable within safety levels. Additionally, in 2008 the Flemish Environment Agency started the rehabilitation of the River Abeek, including the construction of fish migration facilities and several improvements of the structural diversity of the watercourse. Fish stocks will be assessed in the future to evaluate the effect of the different measures with particular interest in populations of bullhead, brook lamprey, dace, chub and burbot.

The approach of adjusting maintenance programmes of watercourses to protect and enhance populations of endangered fish species reconciles the different ecological and socio-economic targets between the different stakeholders even though these targets sometimes might appear contradictory.

Angler involvement

In Flanders, anglers need to purchase a permit to fish in public inland waters. This permit is to be renewed on a yearly basis. The proceedings of these fish permits are allocated to the Fisheries Fund of the Flemish Authorities. This fund is used to enhance public inland fisheries and to protect and enhance populations of endangered fish. It is managed by the Agency for Nature and Forests which comes under the Flemish minister responsible for inland fisheries. Representatives of angler associations can submit proposals for the appropriation of a part of this fund. Furthermore, this fund finances the scientific research needed to recover and protect fish stocks in Flanders. Each angler thus contributes to the recovery of fish stocks. The fund also finances information campaigns on fisheries legislation and on Fish Protection Programmes. For example, each angler receives a free brochure with relevant information about fisheries legislation and policy and about ecology of endangered fish species. This increases the awareness and support of anglers for specific Fish Protection and Recovery Programmes.

Future developments

The Water Framework Directive demands that a good surface water status has to be achieved by 2015. For artificial and heavily modified bodies of water a good ecological potential and good surface water chemical status has to be reached. For fish migration, specific targets are set in Flanders. In execution of the Water Framework Directive for each of the 11 river basins in Flanders management plans are implemented. Further steps in wastewater treatment will be taken the next years. All these measures will result in an improvement of ecological quality of watercourses in Flanders. Together with measures taken in the Fish Protection and Recovery Programmes a significant amelioration of fish stocks is expected in most river basins in Flanders. Recently, The Agency has prepared eel management plans according to the Eel Regulation.

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The impact of the new EU fish health regime arising from Council Directive 2006/88/EC on ecological interactions of aquatic animals in Europe

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Abstract Aquatic animals in aquaculture production businesses, 'put and take' fisheries and those in the wild exist within the same ecosystem and their health and welfare is interdependent. Though the health controls established alongside the single market in 2001 introduced the first Europe wide controls for aquaculture health, there were many opt out clauses. The new regime arising from Council Directive 2006/88/EC which will operate from 2008 across all EU member states will require a much more structured approach with authorisation and registration of aquaculture farms, dealers, transporters and processors. By 2009 this will result in a public register of aquaculture production businesses across Europe accessed through an EU portal facilitating trade whilst ensuring health and other controls are taken into account. This paper discusses the measures arising from the regime, particularly the data streams this will generate and how they might be utilised, the role of government in minimising risks from the interactions between wild and farmed stocks to control disease and the use of codes of practice to drive up industry standards in areas such as bio-security. The new controls also offer the potential to help inform those charged with governance of other controls in the aquatic environment such as the Water Framework Directive (Council Directive 2000/60/EC) and the Habitats Directive (Council Directive 92/43/EEC) and there will be an opportunity to discuss this through the workshop.

Introduction

Though there have been European controls for fish health since the single market was created in 1992 through Council Directive 91/67/EC there has been no Europe-wide requirements for the registration or authorisation of aquatic production businesses. In the UK there has been a registration system for fish and shellfish farms since 1985 and a database of farm related information has become an essential part of understanding how trade operates and for informing our risk based approach to controls on trade. The controls essentially apply to sites holding species susceptible to the diseases listed in Council Directive 91/67/EC, knowledge of trade (movement and mortality records) and their disease status become compulsory when zones or farms wish to be declared free of certain diseases allowing live fish to be traded freely with sites of equivalent health status. Similar controls on imports from third countries and trade with the rest of Europe are constrained by these health requirements under current arrangements. Across most of the EU this information is not in an easily shared and analysable format and thus prevents sharing of this valuable knowledge base.

Since the creation of the single market and the first EU fish health regime under Council Directive 91/67/EC the EU has enlarged to 27 Member States and aquaculture has expanded to include a greater range of species and farming environments. There has also been agreement on the World Trade Organisation trade rules aligned to OIE (world organisation for animal health) manuals for methods, which need to be taken into account to eliminate challenges under these agreements. This directive anticipated a review of its implementation in 1996 and resultant protracted review has resulted in a new Council Directive 2006/88/EC on animal health requirements for aquaculture animals and products thereof and on the prevention and control of certain diseases in aquatic animals, which comes into effect on 1st August 2008.

The new Aquatic Animal Health Directive 2006/88/EC

This Directive covers health controls for crustaceans in addition to fish and bivalve molluscs and requires the authorisation of all aquaculture production businesses, including farms and cropping waters across the EU. Member states are also required to authorise 'put and take' fisheries but may by derogation choose to register them instead.

Under the new directive Member States must maintain a good overview of the disease situation in their aquaculture production businesses and controls applied to trade should be risk-based basis taking account of the risk aquaculture sites pose to wild stocks. Details of sites, their locations, species, health status and farm type should be on a public register by August 2009 and accessible through an EU portal. The location data includes a requirement for GIS (Graphical Information Systems) coordinates allowing accurate mapping. Similar EU requirements for a public register will apply to data under the Alien Species Regulation (Council Regulation (EC) No 708/2007) and under the Feed Hygiene Regulations (Regulation (EC) No 183/2005). Under the UK Better Regulation agenda it is important that where these sites/businesses are the same the information is both joined- up and not in conflict.

There will be conditions for authorisation including the requirement for records to be kept for movements of aquatic animals (both live and dead) on and off sites and of mortalities. Furthermore a general requirement for notification of suspicion of disease outbreaks of any of the enlarged list of diseases extends this responsibility to anyone with such a suspicion.

Discussion

The information held by Member States on the aquatic animal trade is often held within several government agencies, which often operate independently, and an integrated picture is not available across the various aquatic production business areas and in some only at a regional level. The new Directive in generating a requirement for a public register available through an EU portal ensures this data becomes available more generally to trade and government alike is able to inform Member State policy development. Such a detailed data structure holds the promise of a system where scientifically based risk assessments can be made based on the nature of the business and their activities. These in turn can inform decisions on governance whether these are driven by environmental controls, on biodiversity grounds or those for aquatic animal health.

In the UK we have developed such a multi agency system in house over the last eight years and this is currently being adapted to capture all data items related to risk and provide all the deliverables for the public register. It provides a platform for various related government agencies to share their data in one server based live system accessible across the Internet through permission-controlled access. The system has proved very popular with trade partners as it permits online applications and we are currently looking to adapt the system to incorporate data traditionally held at the farm level. This could permit for example single entry of data on movements and mortalities by farmers either directly on the system or a sub-data system where data is electronically transferred from existing farm control programmes. Such systems offer the promise of well-informed policy development for the future and improved governance of the aquatic environment.

References

Council Directive 91/67/EEC of 28 January 1991 concerning the animal health conditions governing the placing on the market of aquaculture animals and products

Council Directive 2006/88/EC of 24 October 2006 on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals

Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora

Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene

Optimization of freshwater fisheries in Russia

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Abstract Improving the regulation and organisation of Russian freshwater fisheries needs to be addressed urgently. This should be completed with all aspects of social, economic and environmental needs in mind. In view of the limited availability of inland fishery resources in the country, fishing is regulated by means of a Total Allowable Catch (TAC) this is an adopted strategy that can protect fish populations, if calculated correctly and if the regulation is adhered to. However there is currently increased competition for resources as the number of fishing companies and individual fishermen has gone up, leading to reforms in legislations as control has become more difficult. Catches of species such as sturgeon, white fish, salmon, and pike perch mostly exceed TAC volumes. Other species, including roach and perch are harvested within their TAC limits, leading to changes in biocenoses. In order to ensure the preservation of fish stocks, the allocation of TACs should be calculated annually based on current fish populations, the number of users and fishing gear for each individual water body.

Introduction

The total amount of freshwater fisheries in Russia is made up of 22.5 million hectares of lakes, 8.9 million hectares of reservoirs and more than 525 000 km of rivers. These resources are far from being fully exploited; only 44% of lakes, 40% of reservoirs and 7% of rivers are used in fishing industry. At present, a considerable part of potentially important fishery water bodies are not used. In most cases, the reason for this lack of use is low productivity and a low number of valuable fish species, the existence of which would make development of these areas more profitable. Conversely, in other areas, there is a large number of highly productive water bodies located in other regions, but these have underdeveloped infrastructure and therefore, the cost of transportation to and from these areas exceed the value of catch.

At the end of 1980s freshwater fish catch in Russia (excluding the Volga river region) reached 120 000 t yr^{-1}. In reality, the total catch, including poaching and recreational fishing, reached 200-220 000 t yr^{-1}. In 2006 the official fish catch amounted to 65 000 t yr^{-1}, while the actual fish catch reached 180 000 t. The reason for the general decrease in catch volume is economical, in particular the increase in the cost of petroleum. This leads to the abandonment of distant freshwater resources previously used as fisheries, to an increase in the use of reservoirs located in areas with more developed infrastructure. Fishing in districts in Russia that are heavily populated, results in the resources becoming increasingly exposed to pressures which can lead to them being over exploited to a point where, production potential is decreased and an intensification of fishing efforts does not increase the volume of the catch.

In comparison to the decrease of fish resources noticed in the European part of Russia, which is the most populated area, there is a progressive increase in the use of fisheries resources in Siberia and in the Far East of the country. An extension of regulated fishing to the unused and underused reservoirs would provide an opportunity to raise total fish catch to approximately 300 000 t yr^{-1}.

Limited resources of reservoir fisheries that are situated in the European part of Russia need to have reductions in their use. That is why at present all types of fishing within Russia contribute to a total allowable catch (TAC). TAC is an adopted strategy of exploitation, calculated to be a biologically safe quantity of fish to be caught based on the current condition of fish reserves. According to the laws of Russia, TAC is set up every year for each particular type of fish in a particular reservoir. To follow TAC recommendations, constant monitoring volumes harvested is necessary in order to prohibit catch after overstepping the limits.

Scientific research into freshwater fishery resources and the calculation of TAC in Russia is part of combined research that is under the control of 15 research institutes that have 19 affiliated structures. These organizations annually conduct research into 68 of the largest and most intensively exploited fishery waters. These include; 28 reservoirs with a total area of 3.6 million hectares, 28 lakes with total area of 10 million hectares and 22 rivers with total length of 38 500 km. Locations where there are smaller fishery waters under lower exploitation pressures are studied every few years. For the last decade TAC has been constantly estimated for more than 600 stocking units (i.e. water bodies) for 77 freshwater fish species.

However, the formation of new economic relationships in the mid 1990s in Russia and growing competition for resources have led to a considerable increase in the number of fishing companies, therefore, controlling their catch has become practically impossible. Numerous reforms of fishing regulation structures have resulted in the complete destruction of a previously effective monitoring system of fish catch. As a result the amount of actual fish catch volume that is uncounted for by official statistics, has increased dramatically, making official statistics for total catch and species diversity unreliable.

At present fishing in most of the exploited reservoirs is aimed at catching valuable species such as sturgeon, salmon, whitefish, pikeperch and large bream. As a general rule, fishing companies and fishermen do not declare the catch of these valuable fish species because the actual amount of valuable fish caught exceeds the volumes approved by the TAC. On the other hand, the catch of less valuable fish species such as roach, perch, crucian carp, is lower than TAC recommendations. This situation within a fishery has a negative impact on the ichthyofauna and lowers the fishing status of reservoirs.

The biggest lake in the European part of Russia is Ladozhskoye, which is a good example of this. In 1998 the percentage of whitefish, sparling, pikeperch and bream caught averaged 85%. In 2001 it was 80% and decreased to only 64% in 2007. In the same years, the percentage catch of less valuable fish species averaged 15-20% and it has increased up to 25-30% since then. The situation is similar with fishing in other large water bodies. For example, in 1985 catches of roach and crucian carp in Cymlyan reservoir averaged 25.3% of the total fish catch. In 2006 this increased up to 50%. From 1982 to 2006 the catch of pike in Rybninskiy reservoir reduced by 4.2 times. In Kuybyshevski reservoir catch of pike reduced by 3.6 times, pikeperch catch reduced by 2.7 times. In Volgogradskoye reservoir bream catch reduced by 3.9 times, pikeperch by 4 times.

Between 2000 and 2006, the difference between official fish catch and TAC recommendations varied from 0.4 to 0.58 in favour of the TAC. Such noticeable difference could be explained by a considerable increase in poaching. According to economic assessments for inland freshwater reservoirs that were made at the end of 2006, the TAC predictions stood at 163 200 t yr^{-1} with a total production value for raw and frozen fish of 6.1 billion RUR, producing a profit on average of 2.48 billion RUR after the deduction of costs involved. According to official statistics, fish catch in 2006 was 61 500 t with value of 2.6 billion RUR making 0.95 billion RUR profit. As a result of this shortfall in TAC volumes, the total VAT and profit tax shortages amounted to 597 million RUR. The total loss in averaged to 864 million RUR.

There is a requirement in this situation to undertake steps to try again to put order into the industry. The existing limits to fish catch seem to be an insufficient regulation. Therefore, to support TAC further, it is necessary to introduce additional policies. This could be in the form of an annual distribution of Total Allowable Catching Load (TACL) per reservoir or part of it.

The adoption of TAC and TACL restrictions can offer the possibility for an annual calculation of the optimum number of fishermen and fishing gears for each fishery. Catch volumes for fisherman can vary greatly over many years depending on fluctuating fish populations and fishing gears available. To successfully determine TACL, there is a requirement that basic criteria be addressed and that information used, should be based on local and up to date environmental knowledge. Important criteria could include both annual calculations of catch and fishing effort (to determine quantity of fishing gear per fisherman). The definition of ‘the total number of fishermen allowed’ and ‘acceptable fishing gears’ can be linked with the allocation of fishing regions to users. This will strengthen the user’s responsibility, and reduce negative consequences of anthropogenic impacts on freshwater bioresources.

Another issue arising from freshwater fishing in Russia is the excessive use of large mesh nets. These nets catch larger individuals, resulting in the reduced reproduction potential within several populations and an increase in the number of fish that have a slow growth rate. In addition, a decrease in the use of diverse ranges of fishing gears has had a negative impact on the exploitation of fish resources, because it is impossible to catch the high diversity of fish species that live in the reservoirs. The use of scientifically recommended types and number of fishing gear would result in increased species diversity within a catch in recommended volumes. This will then help to increase the fisheries status of the reservoirs.

Conclusion

In conclusion, the implementation of the proposed methods to optimize freshwater fishing in Russia could make it possible to increase the profitability. These profits offer the financial potential to broaden the fisheries regulations and their enforcement, to increase fish reproduction by hatcheries, tap into new fishery resources and develop further research on the resources.