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Caspian Sea

GIWA Regional assessment 23

Stolberg, F., Borysova, O., Mitrofanov, I., Barannik, V. and P. Eghtesadi

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Regional assessment 23
Caspian Sea

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Executive summary

This report presents the results of the Global International Waters Assessment of the Caspian Sea drainage basin (GIWA region 23). The geographic boundary of the region is defined as the catchment area of the Caspian Sea which, entirely or partially, covers eight countries: Russia, Azerbaijan, Iran, Kazakhstan, Turkmenistan, Georgia, Turkey and Armenia. The majority of the drainage basin is occupied by the five littoral states: Russia, Azerbaijan, Iran, Kazakhstan and Turkmenistan. The transboundary waters that are identified within the region are the Caspian Sea itself and the Volga River that has a major hydrological impact on the Caspian Sea.

The assessment has been carried out by a multidisciplinary, international expert team that included representatives from each littoral country. Regional scientific centres, such as the Russian Academy of Sciences, the Iranian National Center for Oceanography, the Academy of Science of Kazakhstan, were involved in the assessment. Results were discussed with the Committee for Water Resources of the Ministry of Agriculture of Kazakhstan, the Department of Ecological Expertise within the Ministry of Environment of Azerbaijan, the Ministry of Nature Protection of Turkmenistan, and other local and regional authorities and executive bodies. Representation and active participation of international programmes and projects operating in the region, in particular the Caspian Environment Program (CEP), was also secured.

Assessment of the current situation and the historical trends of each GIWA concern determined that Habitat and community modification exerted the greatest impacts on the Caspian Sea region and was prioritised for Causal chain analysis and Policy option analysis.

The Causal chain analysis and Policy option analysis concentrated on the two issues within the Habitat and community modification concern; loss of ecosystems or ecotones, and modification of ecosystems or ecotones including community structure and/or species composition.

The four most important immediate causes were identified as:

- Pollution as a result of oil spills and agricultural discharges;
- Introduction of invasive species, such as the comb-jellyfish *Mnemiopsis leidyi*;
- Poaching of valuable species and unsustainable harvesting practices in the fishery;
- Damming and regulation of stream flow of rivers discharging into the Caspian Sea.

The most important sectors responsible for those immediate causes were:

- Agriculture (fertiliser and pesticide run-off and the construction of irrigation systems);
- Fisheries (overfishing and introduction of commercially valuable species, feeding organisms and accidental introduction);
- Industry;
- Transport;
- Energy production.

The root causes primarily responsible for the immediate causes were:

- Access to technology (bad equipment especially old oil wells and pipelines);
- Availability of cheap, but obsolete insecticides and absence on the local market of environmentally acceptable alternatives;
- Absence of facilities to decontaminate ship ballast water tanks and ship hulls;
- Poor expert advice on fish quotas, inadequacy of laws and administrative regulation and equipment for the above mentioned sectors;
- Failure to consider environmental factors when regulating the flow of streams by dams;
- Extraction of water from rivers discharging into the Caspian Sea;

- Poor public participation and environmental awareness among stakeholder groups.

Several policy options, which can be grouped according to their specific targets, were developed to address these root causes.

1. Establishment and strengthening of regulations to control environmentally damaging activities in the region. These should be focused on:
- Establishment and/or strengthening of control of the sale of prohibited chemicals at the municipal level;
- Monitoring of leaks from active and blocked oil wells and oil pipelines;
- Restructuring and institutionally strengthening those organisations responsible for the monitoring and control of fishing activities in the region;
- Implementation of environmentally sound operations of stream flow regulation.

2. Creation or refurbishment of facilities such as:
- Refurbishment of old oil wells, pipelines and old water purification systems;
- Development or improvement of devices that facilitate the migration of anadromous fishes;
- Create a facility to decontaminate ship ballast water tanks and ship hulls.

3. Socio-economic actions such as:
- Supply the local market with cheap, effective and environmentally acceptable chemicals through the provision of tax incentives rewarding the importation of these chemicals;
- Develop a system of incentives for using "green technologies".

4. Science and education such as:
- Provide ecological training at various levels, including via television programmes aimed at a broad audience;
- Ensure autonomy and independence of scientific experts from government authorities and the fishing industry;
- Conduct training of fishery inspectors and carry out further scientific investigation of the impact of fishing and the introduction of alien species;
- Build the capacity of staff responsible for the operation of dams by conducting training courses in the use of environmentally sound technology.

These policy options are intended for the scientific international community, local, regional and international decision-makers, funding bodies and the general public for consideration though, at present, there is a weak civil society, neither sufficiently organised nor powerful enough to act as a key stakeholder.

Abbreviations and acronyms

AIOC	Azerbaijan International Operating Company
BOD	Biological Oxygen Demand
CBD	Convention on Biological Diversity
CDV	Canine Distemper Virus
CEH	Caspian Economic Hinterland
CEP	Caspian Environment Programme
CIS	Commonwealth of Independent States
CITES	Convention on International Trade in Endangered Species
EQO	Environmental Quality Objectives
GDP	Gross Domestic Product
GEF	Global Environment Facility
GUUAM	Georgia, Ukraine, Uzbekistan, Azerbaijan and Moldova
HCH	Hexachlorocyclohexanes
HDI	Human Development Index
IREX	International Research and Exchange Board
ISAR	Initiative for Social Action and Renewal in Eurasia
MAC	Maximum Allowable Concentration
NGO	Non-Governmental Organisation
NIS	New Independent States
PPP	Purchasing Power Parity
SAP	Strategic Action Programme
TDA	Transboundary Diagnostic Analysis
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USSR	Union of Soviet Socialist Republics
WHO	World Health Organization

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Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the Caspian Sea region

The geographical scale of the region encompasses the water body of the Caspian Sea and the entire catchment area that influences the Sea. The major river basins included in the region are the Volga, Ural, Terek, Kura, Sulak, Samur and Sefid-Rud. The Caspian Sea region has the form of an inverted "L" with its northwest corner at 29°21'28 E and 59°31'51 N and southeast corner at 60°27'27 E and 37°16'21 N. The region includes the entire territories of Azerbaijan and Armenia, and parts of Russia, Kazakhstan, Iran, Turkmenistan, Georgia, and Turkey (Figure 1).

During the initial stages of the regional GIWA process, it was decided to focus the assessment on the geographic area where economic activities have the most significant impact on the international waters of the Caspian Sea. This area coincided with the Caspian Economic Hinterland (CEH), defined in the conducted Transboundary Diagnostic Analysis (TDA) for the Caspian Sea (CEP 2002c).

The rationale behind this approach is that:

- The Caspian Sea and its lower tributaries are the most biologically productive, biodiverse and important transboundary habitats of the region;
- Within the CEH, human activities produce the most significant impacts on the transboundary water environment;

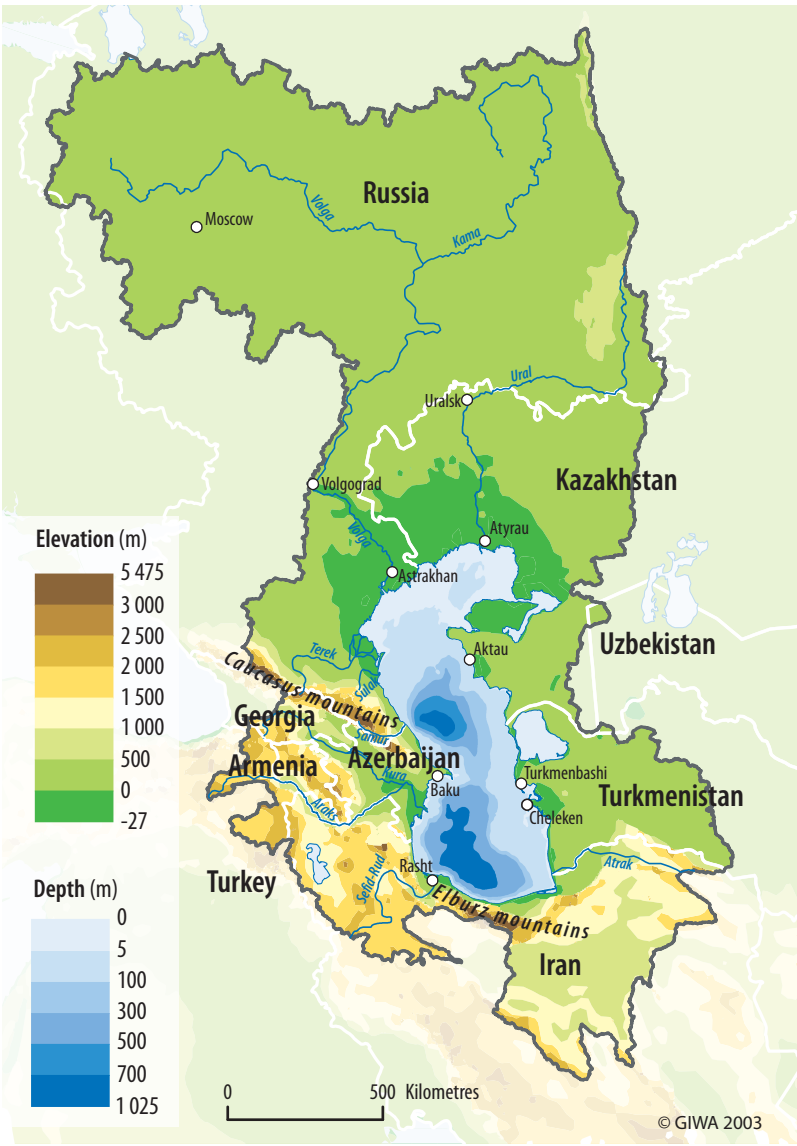

Figure 1 Boundaries of the Caspian Sea region.
Note: The data describing the depth of the Caspian Sea was obtained from the Caspian Environment Programme (CEP).

- The population and economy of the CEH are especially vulnerable to declines in the condition of the aquatic environment and, as a consequence, might be more receptive to the implementation of various policy options;
- The CEH concept provides a clearly defined and recognised area for the implementation of policy options under existing local, national and international governance structures using the current administrative distribution of regulatory responsibilities and budgets in every riparian state;
- It is difficult to collect necessary data and information from areas outside the CEH.

Figure 2 Caspian Economic Hinterland.

Within the context of the present report, the CEH encompasses the Caspian Sea itself, including its seabed and pelagic waters, freshwaters of the coastal area including the seashore, economic activities that directly influence the state of the Caspian Sea, and all land between the Sea and the first administrative line in the territory of each state. The administrative districts of each country within the CEH are: in Azerbaijan: Guba-Khachmaz, Apsheron, Central Aran, Lenkoran; in Iran: Gilan, Mazandaran and Gholestan; in Kazakhstan: Atyrau and Mangistau; in Russia: Astrakhan Oblast, Kalmykia and Daghestan; and in Turkmenistan: Balkan Velayat (Figure 2).

Physical characteristics

The Caspian Sea

The Caspian Sea is the world's largest inland water body, which extends 1 200 km from north to south and contains more than 40% of the inland waters of the world. It is located in a depression separating Europe and Asia between the latitudes 47°13′ and 36°34′ N and longitudes 46°38′ and 54°44′ E. The catchment area is 3.5 million km^2 which encompasses entirely or partially eight countries; the five littoral states Russia, Azerbaijan, Iran, Kazakhstan, Turkmenistan, and also Georgia, Armenia and Turkey that influence the Sea through river discharge. The water level of the Caspian Sea is currently positioned approximately 27 m below the mean sea level and the Sea has no surface outlets. A shipping route to the Black Sea is provided through the Volga-Don canal.

The Caspian Sea is commonly divided into three basins: the northern, middle and southern. The northern basin occupies 27% of the surface area of the Caspian Sea but is shallow, averaging only 5 m in depth (Table 1), and, as a consequence, retains only 0.6% of the total volume of the Sea. Progressing southward, the depth increases considerably. The middle basin is separated from the northern part by the Mangyshlack Shelf and occupies 38% of the surface area of the Caspian Sea and contains 36% of its volume. The remaining 39% of the surface area of the Caspian occurs in the southern basin which has a maximum depth of 1 025 m and, as a consequence, retains 63% of the total volume of water. The middle and southern basins are separated by the Apsheron Shelf, which is a continuation of the main Caucasus range.

The physical characteristics of the Caspian Sea vary considerably along its longitudinal extent (Table 1). During winter the northern part freezes while the water temperature in the southern part remains at

Table 1 Main characteristics of the Caspian Sea.

Surface area (km^2)		378 000	
Volume (km^3)		78 100	
Catchment area (km^2)		3 500 000	
Coastline (km)		7 000	
Length (km)		1 200	
Width (min-max) (km)		196–435	
Average depth (m)	North	5 (max 20)	
	Middle	190 (max 790)	
	South	330 (max 1 025)	
Average surface temperature (°C)	North	Winter: 0	Summer: 25
	South	Winter: 10	Summer: 26
Surface salinity (ppt)	North	0.1	
	Middle	10	
	South	13	

(Sources: Tacis-CEP 2001, CEP 2002c, Caspian Science Network 2003)

10 to 11°C. However, during summer, the difference in water temperature between the two parts is only 1 to 2°C. The northern basin is highly influenced by freshwater inflow from the Volga and Ural rivers and has a very low salinity while in the middle and southern basins the water is consistently brackish and varies between 10 to 13‰ (Aubrey 1994, Kosarev & Yablonskaya 1994).

In summer, the presence of an anoxic zone is a significant feature of the Caspian Sea (Salmanov 1999). Hypoxic phenomena in shallow and otherwise aerobic habitats have occurred on the surface layer of the Caspian Sea during recent decades (Salmanov 1999). Between 1987 and 1990, the oxygen levels in the northern Caspian Sea area were considered reasonable and averaged 10 mg/l. However, with the recent rise in the sea level of the Caspian, an increasing amount of organic matter is entering the Sea from the Volga River delta. Oxygen depletion now affects an area twice as large as before the Volga waterway was altered in the late 1950s and penetrates to depths of 10 m (Bukharitsin & Luneva 1994). In the northern Caspian, oxygen levels range from 4.9 to 10.6 mg/l; minimum concentration of dissolved oxygen having been established as 6 mg/l in the four former Soviet states. The oxygen content in the seawater below 400 m is 1 mg/l higher than in the waters above 400 m. The mixing caused by the inflow of Volga River waters can increase the concentration of dissolved oxygen from 1 to 9%, but dams and irrigation have reduced the volume of water discharged into the Sea. The dams on the Kura and the Volga diminish flows and create areas below the hydropower stations with increased temperatures and low concentrations of dissolved oxygen (Efendieva & Dzhafarov 1993).

In waters near the coast of Azerbaijan, the oxygen regime and concentration are also greatly influenced by anthropogenic factors, particularly by sewage discharged into the Sea. The lowest concentrations of oxygen are observed in the Baku Bay (3-5 mg/l) and the Sumgait coast (3.5-6 mg/l). On the whole, however, the oxygen regime in the water area is satisfactory, with oxygen saturation values of 95 to 125% (CEP 1998a).

Some important marine habitats near the Iranian coast intermittently experience oxygen deficits. In Gorgan Bay, the concentration of oxygen in the water varies from 2.4 to 11.1 mg/l and between 1 and 13 mg/l in the waters of the Anzaly wetland (CEP 1998b).

The water balance of the Caspian Sea is dominated by river inflow and surface evaporation. Due to changes in the balance between evaporation and river inflow, fluctuating water levels are a characteristic of the Caspian Sea (Figure 3). During the past two centuries, the sea level has been 2.5 m higher (1835) and 2.1 m lower (1977) than the present level (CEP 2002c).

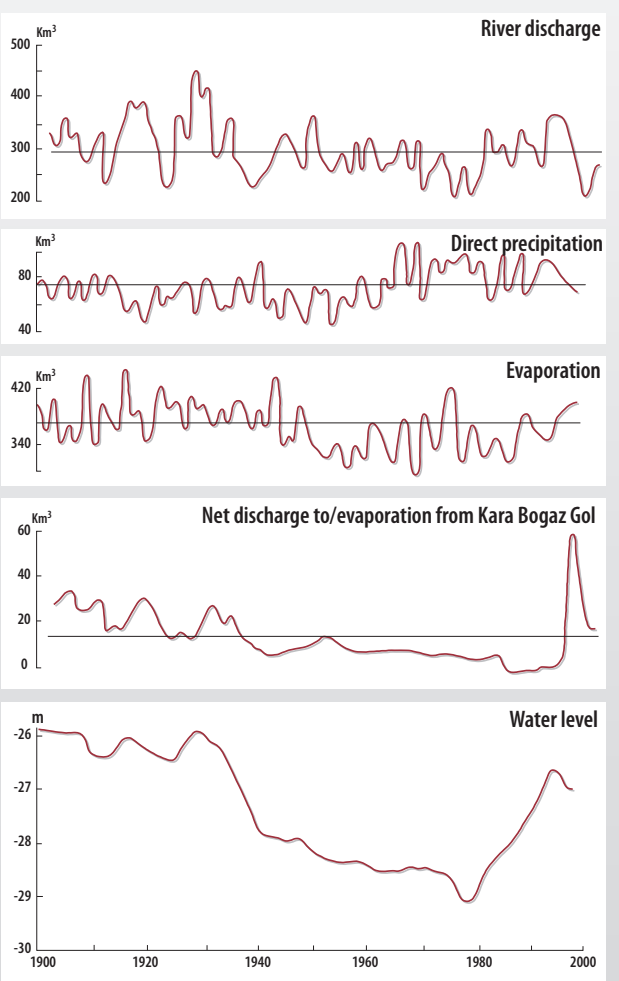

Figure 3 Changes in the elements of water balance and water level of the Caspian Sea.
(Source: Redrawn from CEP 2002c)

The surface area of the Caspian Sea may fluctuate by 10 to 20% as the sea level rises or falls. Evaporation basins also play a role in the water balance, especially during periods when water levels are high. The Kara Bogaz Gol, located on the coast of Turkmenistan close to the Kazakhstan border, is the largest evaporation basin in the region. Its surface level is nearly 3 m lower than that of the Caspian and it is estimated that the equivalent of 2 to 10 cm of water from the entire Caspian Sea evaporates from this basin each year (Vladimirov et al. 2002).

The coastline of the Caspian Sea is 7 000 km long and varied. The northern and eastern parts of the Caspian coast encompass the "Caspian Lowland desert" with sand dunes, salt deserts (solonchaks) and clay deserts (takyrs). Vegetation is sparse and dominated by salt-tolerant plants forming shrubs. Protected coastal and delta areas in the region include the Astrakhan Reserve in Russia and the Khazar Reserve

in Turkmenistan. The southern Caspian coastal zone consists of narrow lowlands, locked in between the Sea and the Elburz Mountains to the south. The lowland coastal areas are almost entirely cultivated and few natural habitats have been preserved. The narrow coastal zone progresses to the west where the Caucasus Mountains rise (CEP 1998f).

Rivers

More than 130 streams and rivers flow into the Caspian Sea and the total river inflow is estimated to 300 km^3 per year. The rivers of the northern coast (Volga, Ural and Terek) contribute 88% of the total river inflow. Inflow along the western coast stems from the Caucasus mountain rivers (Kura, Sulak, Samur and others) and accounts for 8% of the total inflow. The remaining inflow occurs along the Iranian coast (Sefid-Rud and others). Because the Elburz mountains are located very close to the southern shores of the Caspian Sea, the rivers discharging along the Iranian coast generally travel only short distances before entering the Sea. There is no permanent river inflow from the eastern coast.

The Volga River is the most important source of inflow and contributes approximately 80% of the total inflow to the Caspian (CEP 2002c). Although, many of the rivers discharging into the Caspian Sea are transboundary, the Volga River is entirely located within Russia (Table 2). It originates northwest of Moscow in the Valday Upland and, with a length of 3 700 km, it is the longest river in Europe. The Volga Delta, located on the northwest coast of the Caspian, covers 10 000 km^2 and has a width of approximately 200 km. The volume of water discharged from the Volga has large-scale natural variations that are controlled by climatic factors. However, since the 1930s, the River has been extensively regulated which has resulted in a redistribution of run-off within the year and an annual average decrease in run-off by 7% (Figure 4) (Ismaiylow & Fedorov 2001). All major rivers in the region are regulated for the purpose of providing water for irrigated agriculture and hydropower.

Table 2 Major international rivers discharging into the Caspian Sea.

River	Area of Basin (km^2)	Countries	Area of country in Basin (%)
Volga	1 551 300	Russia	100
		Kazakhstan	<1
		Belarus	<1
Ural	311 000	Kazakhstan	56
		Russia	44
Kura-Araks	193 200	Azerbaijan	29
		Iran	21
		Armenia	18
		Georgia	18
		Turkey	14
		Russia	<1
Terek	38 700	Russia	95
		Georgia	5
Atrak	34 200	Iran	69
		Turkmenistan	31
Sulak	15 100	Russia	92
		Georgia	7
		Azerbaijan	1
Samur	6 800	Russia	94
		Azerbaijan	6

(Source: International River basin register 2002)

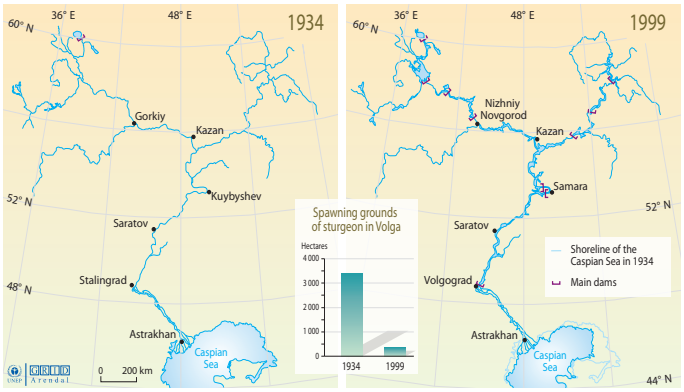

Figure 4 Regulation of the Volga River during the last 60 years.
(Source: GRID-Arendal 2003)

Climate and land use in the coastal zone

The northern coastal region has a continental climate with cold winters and hot summers, the middle part is characterised by mild winters and hot summers, while the southern coastal region has a sub-tropical climate with mild winters and warm humid summers.

The coastal zones of northern and eastern Caspian Sea are mostly arid with average annual precipitation ranging between 100-300 mm. The western coast is semi-arid while the southern and southwestern coast are humid receiving between 400 and 1 200 mm of rain per year (Figure 5). Generally, the precipitation decreases from west to east. The climate conditions largely influence the land use in the coastal region. Agricultural activities in the north and east are dominated by pastures, while the proportion of land used for crop production increases in the south and southwest (Tacis-CEP 2001). Additional crop production is found in areas where local water supply is plentiful such as in the vicinity of the rivers Volga, Terek and Sulak (Russia), Samur and Kura (Azerbaijan), and Ural (Kazakhstan).

Biodiversity and habitats

The modern Caspian Sea originated as part of an ancient, brackish Pontic Sea 5 to 7 million years ago. In the late Mesozoic and early Palaeocene,

Figure 5 Precipitation in the Caspian Sea region.
(Source: ESRI 1996)

the ancient Tethys Sea occupied the area of the present Mediterranean and the Black, Caspian, and Aral seas. During Paleocene and Neocene times, the Black and Caspian Seas were joined and separated several times. In the early Pliocene, the Caspian Sea was separated from the Black Sea for the first time and accordingly, the primary marine fauna was partly eliminated and partly modified. During the mid-Pliocene, the Caspian Sea was completely isolated from the Black Sea and, since that time, changes in the two basins, as well as their fauna, have occurred independently. The typical brackish-water fauna of the Caspian formed at this time and persists to the present day (Kosarev & Yablonskaya 1994). Occasional connection with the Aral Sea has contributed little to the biodiversity of the Caspian Sea.

Due to its long-term isolation from other water bodies, the Caspian Sea is characterised by many endemic species. Among others, the Caspian Sea harbours 54 endemic fish, 53 endemic molluscs and one endemic mammal, the Caspian seal (Table 3) (Rekacewicz & Dejouhanet 2002). The existence of shallow areas, several deep depressions, and a wide range of salinities varying from 0.1 to 13‰ provide different ecological niches which give rise to high species diversity. The highest number of endemic species is found in the middle Caspian while the greatest diversity is found in the northern part of the basin.

Table 3 Biodiversity in the Caspian Sea.

Biota group	Total number of species in the Caspian Sea	Number of endemic species	Number of alien species	Number of listed species (Red Book)
Phytoplankton	441	17	6	ND
Zooplankton	315	64+	7	10
Zoobenthos	380	190	12	20
Fishes	133	54	17	27
Marine and land mammals	125	1	3	41
Birds	466	ND	ND	63

Note: ND = No Data. Numbers are approximate since the literature is not in agreement.
(Source: CEP 2002c)

The coastal region is characterised by a wide range of habitats from vast river systems to extensive wetlands such as the deltas of the Volga, Ural and Kura rivers, the hypersaline Kara Bogaz Gol and extended wetland systems along the Iranian coast. However, due to the varying water levels of the Caspian, the coastal habitats are constantly changing. The wetlands in the region also play a role as feeding and resting areas for migratory birds. The Caspian lies at the crossroads of migration routes and it has been estimated that up to 10 million birds stop over in the region each year during spring and autumn (CEP 2002c).

The Caspian Sea is famous for its population of sturgeons which accounted for some 85% of the world's entire population at its peak in the mid-1980s. Due to the construction of dams on the Caspian tributaries, there has been a significant decrease in the area of spawning grounds for the anadromous sturgeon (e.g. Figure 4).

Introduction of alien species has occurred both accidentally and intentionally in the Caspian Sea. Between 1930 and 1970, at least nine species of fish were intentionally introduced for economic purposes. Invasive species, such as the comb-jellyfish *Mnemiopsis leidyi*, have been accidentally introduced in ballast waters transported through the Volga-Don canal from the Black Sea (CEP 2002c).

Socio-economic characteristics

Population and main urban areas

While the littoral countries are home to approximately 242 million people, only 14.7 million live in the Caspian Economic Hinterland (CEH). Of these, 6.3 million people reside in Iran, 4.1 million in Azerbaijan,

3.5 million in Russia, 0.8 million in Kazakhstan and 0.4 million in Turkmenistan (Table 4) (CEP 2002a).

At present, 60% of the CEH population are living in urban areas. More than 500 000 people reside in Astrakhan, which is the port in the Volga delta that connects Russia with the Caspian Sea. Astrakhan is also the major industrial centre in the Russian CEH focusing on paper and pulp production, fish processing and ship construction. Turkmenbashi and Cheleken are the two main urban areas along the Caspian coast of Turkmenistan. These cities constitute the centre for the national gas and oil industry and, as a result, are two regional "hot spots" for coastal pollution. Also, the Atyrau and Mangistau oblasts in Kazakhstan are dominated by the oil and gas industry.

While only 5% of the national population of Kazakhstan resides in the coastal zone, the Caspian littoral region is home to almost half of the population in Azerbaijan (Table 4) (CEP 2002a). The Apsheron Peninsula and Lenkoran Lowland are the most populated areas in the Azerbaijan CEH where 54% of the population live in three main urban centres; Baku, Gyanja and Sumgayit. Most of the national industries are located in the Baku-Sumgayit area, including the offshore oil and gas installations (CEP 2002c).

Iran has the lowest level of urbanisation in the region even though the coastline is fairly densely populated (CEP 2002a). The provincial capitals of Rasht and Sari are home to the few industries in the region (primarily food processing) which provide jobs to one-fifth of the regional population (CEP 2002c).

The rates of population growth vary between the Caspian states. While the growth rates have been positive during recent years in Iran, Azerbaijan and Turkmenistan, the population is declining in both Russia and Kazakhstan. The current demographic trend suggests that the population in the CEH will become more concentrated on the southern and eastern coasts of the Caspian Sea, turning the non-Russian population into the regional majority. With the expansion of oil and gas activities in the region, it is also likely that urbanisation will increase (CEP 2002a).

Table 4 Population characteristics of the Caspian region.

Country	Year	Population (million)		Urban population (%)	
		Country	CEH	Country	CEH
Azerbadjan	2001	8	3.3	51.7	73.8
Iran	2001	69.2	6.3	63.3	45.1
Kazakhstan	2001	14.8	0.76	55.9	66.5
Russia	2001	144.8	3.5	72.9	68.8
Turkmenistan	2001	5.2	0.4	44.5	75.7
Total in the region	2001	242	14.3	67.8	59.6

(Source: CEP 2002a)

Main economic sectors

Caspian oil and gas reserves have been the major driving force for the regional economy during the past 10 years (Tacis-CEP 2001) and international oil companies are increasingly attracted to the area. At present, prospecting for new oil deposits is being conducted in Kazakhstan, Azerbaijan and, to some extent, also in Turkmenistan and Iran. Oil related investments make important contributions to the regional economies. In 1998, investments in Azerbaijan worth 1 billion USD contributed 33% of the national GDP, and in Turkmenistan, the oil and gas sector represented more than half of the national GDP (CEP 2002c). While regional and international extraction of Caspian oil and gas is likely to increase substantially during the coming years, the access to transportation routes is problematic (Tacis-CEP 2001). Since the Don and Volga rivers constitute the main transport corridors between the Caspian, Black and Mediterranean Seas, Russia currently controls most of the oil transport from the region (CEP 2002c).

The importance of fisheries varies among the littoral countries. While the annual landings only contribute a minor part of the national economy in Azerbaijan and Turkmenistan, fishing is the second most important source of income in the Caspian region as a whole (CEP 2001). The Russian fishing fleet accounts for half the annual catch in the Caspian Sea and, as a result, fishing makes important contributions to the regional Russian economy. In 1994, the Russian Federation lost its leading position in export of the famous sturgeon caviar to Iran. Although in recent years the rights to fish in the Caspian aquatic zone of Iran have been restricted to a state owned company (CEP 2001), the processing and trade in sturgeon, sprat and herring still generate jobs for a significant proportion of the coastal population. The fishing fleet in Kazakhstan is small but slowly growing and is currently catching about 10% of the annual landings of sprat and sturgeon in the Caspian Sea (CEP 2002c).

The Caspian Sea is strategically located between Europe and Asia and therefore could become a major corridor for the transport of goods between countries and continents. Since the liberalisation of markets in the former Soviet states, trade appears to be increasing but sea transport is still small-scale. Future developments in the transport sector will depend upon improved trade cooperation between the littoral countries and the political stability in the region (CEP 2002c).

While the agricultural sector is technically underdeveloped in most Caspian states, agricultural production continues to be an important

source of income in some parts of the region and currently accounts for more than half of the regional economy in the Russian CEH (CEP 2002c). The irrigated lands outside Astrakhan's urban settlements in the Volga delta are subject to intensive rice and vegetable cultivation as well as beef and dairy production. In the Caspian provinces of Iran, the cultivation of cotton, rice, tea, olives and oranges is extensive and currently employs more than one third of the regional population (CEP 2002c).

Local tourism contributes significantly to the regional service sector in the CEH, particularly along the Iranian coastline. Each summer, millions of tourists, mostly from the capital, Tehran, visit the area and a large number of villas have been built along the Caspian coast of Iran (CEP 2002c). The tourism potential of most of the Caspian littoral states is high, but at present, the necessary infrastructure cannot be funded and the lack of water supply outside the main cities is a severe constraint. Fear of pollution and the inundation of tourist destinations as a result of sea level rise have also halted the development of the tourist sector.

Economy, health and education

There has been a general economic decline in the former Soviet countries as a result of the transition period in the 1990s. Since the introduction of market economy in the region, most of the former Soviet industries have lost their subsidies and, as a consequence, have been forced to close down. Between 1991-1997, the industrial production declined by as much as 73% in the Russian part of the region (CEP 2002c). Falling industrial production and rising inflation have resulted in increased unemployment and economic inequality in the Caspian states. In the Russian coastal oblasts, more than one-third of the labour force is unemployed, and in Azerbaijan, the unemployment is 15% (CEP 2002c). While Mangistau and Atyrau are the wealthiest oblasts in Kazakhstan, unemployment is still high in the coastal zone and a significant part of the population lives below the poverty line. Also, the Caspian provinces of Iran suffer from high unemployment. While the official figures suggest that 15% of the population is without a job, unemployment is likely to be as much as one third among the urban population (CEP 2002c).

The generally low incomes in the region have resulted in significant health problems. While the overall lack of nutrition and the inadequate access to clean water increased disease and infant mortality rates during the 1990s, the access and quality of healthcare declined in the four former Soviet states during the same period. Even if life expectancy is generally high across the region, ranging from 66 years in Russia and Turkmenistan to 71.2 years in Azerbaijan, the average age fell slightly during the past decade. Iran stands as an exception in the region with rising life expectancy and relatively high access to health care (CEP 2002c).

Also, the educational system has suffered from the recent economic constraints in the Caspian region. While the Soviet school system used to offer free education which ensured 98% literacy in the four former republics, the educational budgets have decreased significantly since independence and many schools in the region are closed due to lack of funding. In the Russian republic of Daghestan, pre-school institutions can accommodate only 30% of the children. However, 70% of the Daghestan population still has access to schools which is slightly less than the average enrolment ratio in Russia as a whole and in each of the other four Caspian states (CEP 2002a).

In the coming decade, the economic instability is likely to remain, and one can expect low rates of capital formation and national income growth as well as high inflation and unemployment in the CEH. It is also likely that income will become more unevenly distributed among the regional population and that poverty will continue to spread. While oil production is expected to increase and provide the northern countries of the Caspian region with increased resources, economic hardship and inequality is likely to affect regional political stability for some time.

The Human Development Index (HDI) is a combined measure of life expectancy at birth, adult literacy rate, combined primary, secondary and tertiary gross school enrolment and the Gross Domestic Product (GDP) adjusted for purchasing power parity (PPP). In 2002, all five Caspian states were ranked as "medium human development countries" according to this measure (Figure 6) (UNDP 2002). The high literacy in the former Soviet states has raised their respective HDI rates and placed these countries higher in the international ranking than Iran. In a comparison of 173 states during 2002, the Russian Federation was ranked 60th, Kazakhstan 79th, Turkmenistan and Azerbaijan 87th and 88th respectively and Iran 98th.

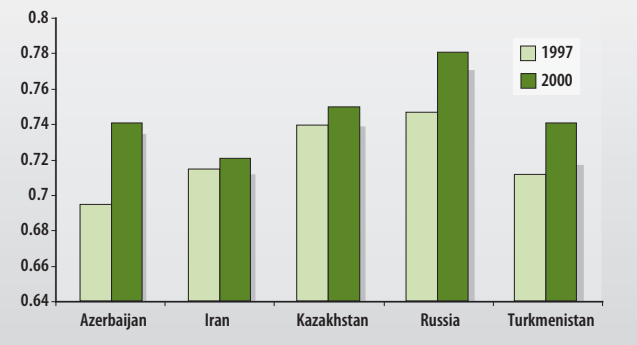

Figure 6 Human Development Index (HDI) in the Caspian littoral countries.
(Source: UNDP 2002)

Legal and institutional framework

The Caspian region has a history of despotism and colonisation and, as a consequence, democratic structures and practices are traditionally weak. Governments dominated by strong executive powers mark the Caspian littoral states. Although each country now has a democratically elected president, the five countries have reached varying stages of democratisation. Three of the littoral states (Azerbaijan, Kazakhstan and Turkmenistan) have leaders who have governed almost since the Caspian independent states were formed. For these states, the question of succession dominates current politics. Iran is governed by an Islamic democracy that is intending to bring democratic changes to the country, despite often being challenged by the established conservative faction. The Russian Federation has an elected president who maintains a strong grip on the outlying regions, including the Caspian.

While the five littoral states have reached varying stages of democratisation, government transparency and accountability tends to be low throughout the region. Since their independence, the former Soviet states in the Caspian region have primarily focused their efforts on economic growth and given less attention to the development of public participation, policies and institutions for environmental protection (CEP 2002c).

The Caspian Sea is nevertheless regulated by a number of national and multilateral laws and regulations. A number of bilateral agreements primarily concerning freedom of navigation and national fishing rights within the Caspian Sea region were formed during, or even before, Soviet times. Presently there are no regional treaties signed by all five Caspian states, and environmental management is therefore primarily dependent upon national legislation (CEP 2001). However, during the 1990s, a range of efforts has been made to increase environmental cooperation between the littoral states. The Caspian governments have adhered to a number of Multilateral Environmental Agreements (CEP 2002c), demonstrating their increased interest in, and willingness to cooperate with, the international community to introduce environmental considerations into the development process (Annex VI).

Great efforts have been made since the establishment of the new political situation in the Caspian Sea region, however, the discrepancies in views of the riparian states concerning the legal status of the Caspian, and the approaches to be used to manage the natural resources of the Caspian Sea have prevented a five-sided regional agreement. Nevertheless, all five states have certain international obligations with regard to the Caspian Sea due to their ratification of several different multilateral environmental agreements (Table 5). The most successful area pertains to the protection of fauna and flora. The Convention on Biological Diversity (CBD), which has been signed by all the Caspian states, and the Convention on International Trade in Endangered Species (CITES), should allow for a generally acceptable level of wildlife protection, including habitat conservation, and the protection of plant life. International regulation of oil exploration, navigation, the construction and operation of pipelines, marine pollution from land-based sources, and coordination of emergency responses to environmental disasters is more complicated. The legitimacy even of signed global conventions and agreements that could potentially be used as a legal basis for managing and protecting transboundary resources in the absence of regional instruments may be doubted because of the discrepancies regarding the legal status of the Caspian Sea.

International agreements signed by countries belonging to the Caspian Commonwealth of Independent States (CIS), (Russia, Azerbaijan, Kazakhstan and Turkmenistan) are recognised as a part of their respective national legal systems. The four Caspian CIS countries are still using some of the legal and regulatory mechanisms inherited from the former USSR, alongside legal and regulatory mechanisms that have been developed during the past decade. In the CIS countries the national legislation is represented by the constitutional provisions and, in some instances, by special laws. It is worth noting that the

Table 5 Participation of littoral states in multilateral environmental agreements.

	Azerbaijan	Iran	Kazakhstan	Russia	Turkmenistan
Convention on Biological Diversity	●	●	●	●	●
World Heritage Convention	●	●		●	
Convention on International Trade in Endangered Species (CITES)	●	●		●	
Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters	●		●		
Convention on EIA in a Transboundary Context	●		●		
Convention on the Transboundary Effects of Industrial Accidents			●	●	
UN Convention to Combat Desertification	●				
UNECE Convention on Transboundary Watercourses	●		●	●	
International Convention on Civil Liability for Oil Pollution Damage			●		
Ramsar Convention	●	●			
The International Oil Pollution Compensation Fund					
IMO Oil Pollution Preparedness Convention					
UN Convention on the Law of The Sea				●	

(Source: CEP 2002c)

legislation of these countries recognises the supremacy of international agreements over the national laws, and, therefore, that these impose specific responsibility upon the respective legislative and executive bodies for the decisions taken.

Azerbaijan

International cooperation is effected in conformity with the Constitution that provides for the supremacy of the international law, and also in conformity with the principles and requirements established in the law "On Environmental Protection". In particular, Azerbaijan aims to achieve overall environmental security, to avoid violation of sovereign rights of other states to their natural resources, to participate in international exchange of information, to cooperate in the elimination of negative effects of ecological disasters, and to expand the scientific and technical links in the field of ecology and nature use. The proclaimed principles demonstrate the goodwill and interest of the country in the development of the international environmental cooperation as a whole, including the Caspian Sea. In practice, the constitutional term "agreement" is interpreted quite broadly, and includes, in particular, agreements of a civil character. Examples of such agreements are those between the State Oil Company of Azerbaijan and the international oil consortiums that envisage conditions and other requirements for the exploitation of oil deposits. It may be questioned how far this approach may be extended and whether the supremacy of international law may overrule commercial agreements signed within the framework of international private law. Nonetheless, this is a choice for the country.

Iran

Iran participates in international cooperation on the basis of its constitution. It decrees that all international treaties are to be approved by the Majlis (the Islamic Consultative Assembly). The Department of the Environment is charged with developing cooperation concerning environmental issues. Although Iran has expressed a willingness to develop new cooperative agreements regarding the use of resources within the Caspian, it currently recognises the "Treaty on Friendship" signed with the Soviet Union in 1921 and the "Treaty on Commerce and Navigation" signed in 1940 as a valid basis for determining the legal regime of the Caspian Sea. The international environmental policy of the country is expressed in several declarations made by the President of Iran. In particular, in his statements delivered at an annual session of UNESCO in Paris, the President pointed to the high priority of environmental protection both for the country and for the international community. In other speeches and statements, strong emphasis was placed on searching the legal instruments and other measures to ensure sustainable development of the country and overcome the pure economic attitude towards nature. The President also stressed that the international community should develop effective cooperation and take joint efforts for achieving sustainable development globally.

Kazakhstan

The basic provision concerning international law is contained in the constitution that recognises the supremacy of international agreements. Types of agreements, procedures for their ratification and other procedural requirements were established by the Presidential Decree "On Procedures for the Conclusion, Implementation and Denunciation of the International Agreements of the Republic of Kazakhstan" in 1995.

Russia

The Constitution of the Russian Federation recognises the supremacy of the international law. In addition, several laws, including the law "On Participation in International Information Exchange", in general regulate procedures for international cooperation. The principle trends of international environmental cooperation are expressed in the Presidential decrees "On State Strategy of the Russian Federation in Environmental Protection and Achieving Sustainable Development" (1994) and "On the Concept of Achieving Sustainable Development in the Russian Federation" (1996). It is highlighted in these documents that political and legal priorities include development of international cooperation in the field of environmental protection of the Caspian Sea, e.g. biodiversity conservation, forest protection and combating desertification.

Turkmenistan

The constitution of Turkmenistan recognises the supremacy of international agreements. There are no special provisions regulating international environmental cooperation.

In 1992, the four former Soviet states launched a Commission on Aquatic Bioresources. The Commission meets every year to define national fishing quotas, to collect information and to advise the national governments on measures required to regulate fishing. At present, the Commission possesses only advisory power in the four states, and since Iran participates only as an observer, it cannot influence Iranian fishing policies (CEP 2001). In the absence of international agreements between the five states, fishing in the Caspian Sea is still regulated by a treaty signed by the Russian Federation and Iran in 1921. This agreement builds on the principle of free fishing throughout the Sea except within a 10 nautical mile coastal zone that is reserved for the national fishing fleet in respective country (CEP 2002c). National fishing regulations in most of the Caspian states build on state licensing and quota systems that both restrict fishing intensity and fishing methods along the

coastal zone (CEP 2001). Since CITES included sturgeon on the list of endangered species, the Caspian littoral countries are committed, as parties to the convention, to strengthen national legislation to better regulate sturgeon fishing and trade (CEP 2001).

In 1994, the littoral states signed the Almaty Declaration of Cooperation in the Field of Environmental Protection and agreed to jointly implement the CBD. In the declaration, the states also expressed a willingness to cooperate in order to strengthen the environmental protection of the Sea, to ensure sustainable management of its resources and to gain international support for an environmental programme dedicated to the Caspian Sea (CEP 2002c). One year later, the World Bank, in conjunction with UNEP and UNDP and funding from the GEF, created the Caspian Environment Programme (CEP) to pursue an "environmentally sustainable development and management of the Caspian environment, including living resources and water quality, so as to obtain the utmost long-term benefits for the human populations in the region, while protecting human health, ecological integrity and the region's sustainability for future generations" (Sievers 2001) (Annex V). In 1998, the five littoral states officially launched the CEP and agreed to implement its goals in cooperation with the three international bodies. The Programme structure includes a coordination unit, 10 regional thematic centres (dealing with issues such as pollution control and monitoring, coastal zone management, water level fluctuations, biodiversity, legal and economic instruments, fisheries and desertification) and a steering committee convening on a yearly basis (Sievers 2001). One of CEP's initiatives has been to form a Framework Convention on the Protection of the Environment of the Caspian Sea aimed at regulating marine pollution, seabed exploitation and fishing activities in the region. Since 1995, considerable effort has been expended negotiating and developing the content of the Convention. The multilateral agreement was signed in November, 2003 and ratifying the Convention is generally perceived as a precursor to obtaining additional funds from the GEF.

During the past decade, national environmental legislation has improved within the littoral countries. All five Caspian states have adopted national environmental quality standards in order to limit pollution and industrial waste discharges into the Caspian Sea. The littoral states have also set up a range of protected areas along the coastal zones of the Caspian Sea, and passed environmental regulations aimed at protecting the seabed during exploration and development of oil and gas deposits (CEP 2001). While the implementation, monitoring and enforcement of environmental legislation is distributed among a variety of national ministries and agencies in all five littoral states, the centralised government systems in the region have limited the executive power of regional and local bodies (CEP 2001). The economic constraints in the former Soviet states have also hampered the implementation of the environmental legislation for the Caspian Sea, and poor funding of national agencies severely restricts monitoring and enforcement (CEP 2001). Despite a fairly well developed legal framework in the Caspian region, the mechanisms to protect the environment are not yet fully effective.

Assessment

Table 6 Scoring table for the Caspian Sea region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter).
IMPACT 0 No known impact
IMPACT 1 Slight impact
IMPACT 2 Moderate impact
IMPACT 3 Severe impact

The arrow indicates the likely direction of future changes.
↗ Increased impact
→ No changes
↘ Decreased impact

Caspian Sea	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	1.3* ↗	2.0 →	2.0 →	1.8 →	**2.0**	**4**
Modification of stream flow	1					
Pollution of existing supplies	2					
Changes in the water table	1					
Pollution	1.4* ↗	2.0 →	2.0 →	2.0 →	**2.0**	**3**
Microbiological pollution	1					
Eutrophication	2					
Chemical	2					
Suspended solids	1					
Solid waste	1					
Thermal	1					
Radionuclide	1					
Spills	2					
Habitat and community modification	2.0* ↗	2.4 ↗	2.4 →	2.3 →	**2.6**	**1**
Loss of ecosystems	2					
Modification of ecosystems	2					
Unsustainable exploitation of fish	2.2* ↗	2.0 →	2.0 →	2.4 →	**2.2**	**2**
Overexploitation	3					
Excessive by-catch and discards	2					
Destructive fishing practices	2					
Decreased viability of stock	2					
Impact on biological and genetic diversity	2					
Global change	1.0* ↗	1.5 →	1.5 →	1.0 →	**1.2**	**5**
Changes in hydrological cycle	1					
Sea level change	2					
Increased UV-B radiation	1					
Changes in ocean CO_2 source/sink function	0					

* This value represents an average weighted score of the environmental issues associated to the concern. For further details see Detailed scoring tables (Annex II).

** This value represents the overall score including environmental, socio-economic and likely future impacts. For further details see Detailed scoring tables (Annex II).

*** Priority refers to the ranking of GIWA concerns.

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 6. Detailed scoring information is provided in Annex II of this report.

Freshwater shortage

The Volga drainage basin has the highest water consumption of any basin in the Caspian Sea region (CEP 1998d). In 1996, despite 80% (51.2 km^3) of the total water demands in the basin being met through the progressive use or recycling of water, 28.8 km^3 of freshwater was withdrawn from water bodies within this watershed, amounting to 31% of the total water withdrawal in Russia (CEP 1998d).

Environmental impacts

Modification of stream flow

The annual discharge of water into the Caspian Sea has declined because each of the large rivers draining along its northern coast (Volga, Ural and Terek) have been regulated by the construction of reservoirs that store and supply water for agriculture and hydropower. Between the early 1930s and the 1970s, dozens of reservoirs were built, the largest being the chain of huge man-made reservoirs known as the Volga cascade which is situated on the Volga River above Volgograd (Aubrey 1994). The storage and regulation of large volumes of water in reservoirs has led to increased losses of water through evaporation, which is exacerbated

by the widespread use of spray irrigation and the construction of small irrigation ponds (Aubrey 1994). Moreover, the regulation of stream flow has caused changes in the annual and inter-annual influx of water into the Caspian Sea. Nowadays, water is strategically released from reservoirs in late winter in order to accommodate the influx of water entering rivers with the spring snowmelt and prevent dangerous overflows from the dams (Aubrey 1994). The water released carries with it heavy sediment loads that alters the natural regimes of suspended solids influx to the Caspian Sea (Aubrey 1994).

The modification of stream flow has had considerable consequences on the biota living within these systems, particularly on anadromous species of sturgeon that spawn in the lower reaches of rivers in the region. For example, before 1957, the Atrek River stopped flowing only in exceptionally dry years. However, owing to overabstraction of water in Iran during the 1960s and 1970s, the volume of water entering the Caspian progressively declined until the 1980s and 1990s when its connection with the Sea was virtually lost (1984, 1986, 1990, 1995-1997 and 1999-2000) (CEP 1998f). As a consequence, suitable conditions allowing migration of sturgeon to spawning grounds on the 15 000 ha floodplains of Adjib and Deleyly are increasingly rare, restocking has halted, and stocks, which are subjected to increased fishing intensity, have diminished considerably (CEP 1998f). In an attempt to prevent the continued decline in sturgeon stocks, artificial spawning grounds were created during the early 1970s at Adjib and Adjiyab in the lower reaches of the Atrek River. The decline in the abundance of sturgeon was temporarily curbed, however, often during the last decade there has been no water in the lower reaches of the Atrek River, thereby preventing the migration to and spawning of sturgeon at these grounds (CEP 1998f). In addition, these artificial spawning grounds have fallen into disrepair as a result of lack of funding since 1990, despite the fact that they have contributed to the local populations of sturgeon for more than 25 years. It is now estimated that between 60 and 100 km^3 of water would be required during the critical spawning period between November and June to ensure the normal functioning of the Adjib spawning grounds (CEP 1998f).

Pollution of existing supplies

At the regional scale, moderate environmental impacts resulting from pollution of existing supplies of water occur. The waters of the Volga River are moderately polluted, while those of its major tributaries, the Oka and Kama rivers, and the Ural River are highly polluted (CEP 1998d). In addition, intensive development of the mining (Armenia), metallurgic (Georgia), chemical, power and processing industries (Azerbaijan, Armenia, Georgia) and irrigated agriculture between 1970-1990, has caused a sharp increase in the influx of sewage into the basin of the Kura River resulting in the deterioration of water quality (CEP 1998a). Because of the almost total absence of natural freshwater resources, the rate of freshwater consumption in the Turkmenistan CEH (Balkan velayat) is significantly lower than in the other velayats. In 1995, 1.1 billion m^3 of water was consumed in Balkan velayat, which constituted only 5.5% of the total water consumption of Turkmenistan. However, it is anticipated that after the completion of the Kazandjik-Kizyl-Atrek branch of the Karakum Canal, the subsequent development of new lands will cause the consumption of freshwater to increase markedly. Furthermore, because of the deficiency in potable water, the population often uses mineralised water obtained from underground lenses without preliminary treatment, making them vulnerable to contracting water-borne viral infections.

The Ural River is the main source of potable, industrial and agricultural water in Kazakhstan (CEP 1998c). Pollution of the lower reaches of the Ural River, between Uralsk and its estuary, is mainly a result of inflow of the upper middle portions of the River. Water in the middle reaches of the Ural, between the Iriklin Reservoir and Uralsk, particularly at the confluence of the Ural and Ilek rivers and in the Ilek River itself, is classified as "dirty" according to the Kazakhstan classification (Integrated Ecology Program, Atyrau, 1996). However, the influx of large quantities of water from the spring snowmelt enables the River to flush pollutants accumulated during the remainder of the year from the system. This seasonal flushing provides the Ural with some capacity to clean itself. This is confirmed by comparing data obtained during the first quarter of 1995 from the lower reaches near the borders of Atyrau Oblast, which classified the River as "clean", with data obtained from periods later in the year which classified the River as "moderate-dirty" (CEP 1998c). The general results of monitoring of the concentration of pollutants in the lower reaches of the Ural River are shown in Table 7.

Table 7 Concentrations of various pollutants in the lower reaches of the Ural River.

Pollutant	Concentration (mg/l)	Maximum Allowable Concentration (MAC[1]) (mg/l)	Exceeded concentration (x MAC[1])
Oil products	0.43	0.05	8.6
Phenols	0.001	0.001	1.0
Surfactants	0.03	0.1	0.33
Copper	0.0053	0.001	5.3
Manganese	0.019	0.01	1.9
Iron	0.056	0.5	0.112
Lead	0.02	0.03	0.67
Nickel	0.006	0.01	0.6
Molybdenum	0.003	0.25	0.112

Note: [1] Maximum Allowable Concentration (MAC) of harmful substances in the surface waters were used in the former Soviet Union for assessment of the surface water quality. Even after the disintegration of the Soviet Union, Azerbaijan, Kazakhstan, Russia and Turkmenistan still use MACs for this purpose. (Source: CEP 1998c)

The Russian Federation discharges 1 993 million m^3 of sewage into the Caspian Sea annually. The majority of this is untreated because most wastewater treatment plants in the region do not work or are inefficient resulting in untreated sewage being discharged directly into water bodies. As a consequence, the quality of water in most reservoirs is degraded and does not meet the Russian standards for drinking water which, in general, coincide with standards set by the World Health Organization (WHO).

In Azerbaijan, 169 million m^3 of raw sewage and 240 million m^3 of treated sewage is discharged into the Caspian Sea every year. Baku's wastewater accounts for 80% of the municipal discharges from Azerbaijan into the Sea. Sumgayit discharges roughly 10%, and the remaining 10% comes from the other coastal cities. The Govsany municipal wastewater treatment plant in Baku is virtually the only plant operating on the coast of Azerbaijan and it biologically treats approximately half of the city's wastewater. Elsewhere, there is either no treatment or the treatment plants have insufficient coverage or are not operational. Many of these towns and cities are located very close to the coast and the majority of wastewater probably finds its way into the Sea untreated (CEP 1998a).

Municipal wastewater discharge is the primary environmental pollution problem in the Iranian coastal zone. A population of more than 6 million inhabitants is connected to central sewage systems that, in most cases, discharge into rivers or directly to the Sea. None of the cities have installed treatment facilities. The pollution load from human activities is much higher than that from industrial activities, particularly with regard to discharge of total nitrogen and phosphorous. Industrial activities provide 31% of the organic load and the remaining 69% originates from municipal discharges (CEP 1998b).

In Kazakhstan, the wastewater from the city of Atyrau is discharged to evaporation fields and it is purported that no domestic wastewater is discharged to the Ural River or the Caspian Sea. The smaller cities in the area also discharge their wastewater to evaporation fields. Sewage from the centre of the city of Aktau is discharged to the municipal wastewater treatment plant (KOC-1). The wastewater treatment plant receives 75% of municipal wastewater (from approximately 90 000 persons) and also receives industrial wastewater. KOC-1 was constructed in 1972 with a capacity of 40 000 m^3/day. Extension work of the plant was initiated in 1982 but the work was stopped because of a lack of funds. The actual load on the plant today is estimated to be 50 000 to 60 000 m^3/day. During the winter, the treated wastewater is chlorinated and discharged into the Sea. In the summer, the wastewater is reused for irrigation. Raw municipal sewage generated from the upper part of the city of Aktau is discharged into Lake Karakol (25% of the total municipal wastewater) from where it evaporates. Construction of a second treatment plant (KOC-2) began in 1991 but was never completed due to lack of funds and remains only 30% complete. Approximately 40% of municipal wastewater discharged directly into the Caspian has been mechanically treated and in some cases has also been biologically treated. The remaining 60% is discharged directly to the Sea or river usually without the provision of long outfalls that would ensure adequate dilution. Even where treatment facilities have been provided, the treatment efficiencies are low because plants are generally old and largely not working as designed. In terms of overall load on the Sea, direct municipal discharges contribute much less than the rivers. Nonetheless, the quantity of effluent is sufficient to cause health risks close to these coastal cities and, in some cases, hazardous substances are discharged that will have long-term effects on the ecology and human health. The effluent collection systems in coastal cities are currently poorly developed and in poor condition. When these collection systems are improved and extended, municipal effluent flows will increase considerably if counteractive measures, such as proper pricing for water usage along with institutional improvements in water companies, are not instituted.

In the Mangistau Oblast, industrial and domestic sewage is disposed of in 41 facilities that are located far from the coast ensuring that there is no discharge of pollution into the Caspian Sea from this region (CEP 1998c). In Iran, pollution of existing supplies is not a problem, despite the fact that the area has many potential sources of pollution. Samples obtained during a recent investigation of pollution in waters supplying various cities in Mazandaran and in Gilan were free of any chemical pollution. Microbial pollution was found in only 20% of samples from the Mazandaran and in almost none obtained from Gilan (CEP 2002c).

The most widespread pollutants of surface waters are petroleum products, phenols, lightly oxidising organic substances, metals and nitrogen originating from various kinds of industries, agricultural production, municipal services, and from surface rain (CEP 2002c). These same substances occur in groundwater supplies but, at present, these are not as heavily contaminated (Tacis-CEP 2001). Nevertheless, despite the apparent quality of water supplies in some areas, the growing population in the Caspian Sea region and the continued degradation of traditional water sources is causing growing dependence on groundwater to supply drinking water, particularly deeper reserves that have so far escaped the influences of anthropogenic activities (CEP 2002c).

Changes in the water table

Changes in the water table vary across the region according to the influence of both water abstraction and fluctuations in the sea level

of the Caspian. In low-lying areas in the lower Kura-Araks River delta of Azerbaijan, the water table is very high and has risen by 1 to 2 m because of the sea level rise in the Caspian. Such high water table levels, in conjunction with the hot climate, have lead to salinisation of groundwater, reducing the area of land suitable for agriculture (CEP 1998a).

Socio-economic impacts

The economic impacts of Freshwater shortage on the region are moderate. Permanent freshwater shortage has resulted from the salinisation of groundwater in Azerbaijan (CEP 1998a), Iran (CEP 1998b) and Turkmenistan (CEP 1998e). Currently, the main impacts of freshwater shortage on the economy of the region are associated with the increased cost for the supply of drinking water. Although data describing these costs are rare, it could be assumed that the direct costs associated with the supply of drinking water are relatively low because labour costs in the region are low. However, it is the quality and availability of safe drinking water that causes moderate and, in some specific areas, even acute negative impacts on the economy.

In order to mitigate freshwater shortage in Turkmenistan it was decided to construct the Kazandjik-Kizyl-Atrek branch of the Karakum Canal (CEP 1998e). However, the construction of this branch diverts water away from the Aral Sea which may lead to long-term negative impacts and, if not managed properly, jeopardise the positive outcomes expected from the construction.

Inundation of some areas by rising sea levels of the Caspian has reduced the attractiveness of the coastal zone for potential users and developers. In addition, changes in the level of the water table have caused indirect losses for industries and the local population (CEP 2002c). These phenomena have further increased the risks associated with investing in the region, making long-term direct foreign investments, which are considered to be one of the major driving forces for the development of newly emerging economies, increasingly untenable. Tourism has also declined in the region recently, despite usually being a profitable sector of the economy. Although it is very difficult to quantify, expert estimation indicates that about 30% of the decline in tourism could be attributed to freshwater supply problems.

The moderate impacts on human health of freshwater shortage are linked to the deteriorating quality and limited supply of safe drinking water. In Kazakhstan an increasing number of people have to use low quality water for household purposes because river waters in the Atyrau Oblast are chemically polluted, particularly near human population centres (CEP 1998c). Only 40 of 280 inhabited localities in the oblast have piped drinking water. Although the state standards on drinking water quality are quite high, the level of compliance is known to be insufficient. The percentage of illnesses caused, directly or indirectly, by the quality and availability of drinking water varies among different sources from 30 to 70%. Such high figures should have attracted the attention of authorities. However, since the health care system in most of the countries concerned is still state-owned and governed, quantitative estimates and monetary values of the impacts of freshwater shortage on the health of the population are virtually non-existent.

The decline in tourism and agriculture in some areas has prompted some people to migrate to more prosperous areas causing moderate social and community impacts. Populations in the region are becoming increasingly centralised, particularly around the big cities. Ratios of the proportions of the population living in rural and urban areas and in the capital and other cities are very quickly approaching those typical for developing countries. This migratory process degrades traditional values and activities, causes partial loss of ethnic identity and tension between social groups competing for urban employment. The migration of people away from rural areas has been partially compensated by general population growth in the majority rural territories of the region.

Data describing the direct and indirect losses caused by the impacts of different aspects of freshwater shortage on the economic and social situation in the region are not currently available. In order to address this situation, special investigations focusing on these issues should be implemented to obtain quantitative estimates of the impacts of freshwater shortage on the region.

Conclusions and future outlook

Freshwater shortage resulting from reduced stream flow is an important problem in some areas of the Caspian Sea region, particularly in the southern part which is characterised by increased population density, profitable agriculture and considerable recreational activities. The construction of water reservoirs and the expansion of irrigation and industrial development have caused an increased loss of non-renewable freshwater supplies resulting in reduced availability of water for drinking and agricultural purposes, and a concomitant decrease in fish productivity in these river basins. While the deterioration of water quality has moderately affected the health of the human population, the present impacts of freshwater shortage on the environment are nevertheless, only slight.

In the future, it is anticipated that water withdrawal from rivers and other sources will increase as a consequence of population growth

and expanding industry. Climate change is also likely to exacerbate freshwater shortages in the region by decreasing the amount of precipitation and increasing evaporation causing further recession of the water level in wells in the southern part of the Caspian Sea region.

Pollution

The Volga River and its tributaries are responsible for 90% of the total pollution load that enters the Caspian Sea (CEP 1998d). The concentrations of pollutants, such as oil hydrocarbons, phenols, synthetic surfactants, organic matter and metals, in river mouths often significantly exceed Maximum Allowable Concentrations (MAC) by 10 times or more and remain constantly high with little variation between seasons or years (CEP 1998d). These pollutants generally originate from anthropogenic activities such as agriculture, mining, oil refining, the petrochemical and chemical industry, machinery, wood and paper manufacturing, energy production and shipping (CEP 1998d).

Point sources are responsible for the remaining pollution that enters the Caspian Sea. These sources are primarily human settlements along the coast such as Baku, Cheleken, Atyrau and Astrakhan. Fortunately, owing to the sparse distribution of these cities, point sources of pollution are few and far between.

Environmental impacts

Eutrophication

Since the early 1980s, the condition of the Caspian Sea, particularly in the Iranian Bank and the Volga River delta, has steadily deteriorated as a result of eutrophication (Salmanov 1999) originating from anthropogenic sources such that it exerts moderate impacts on the region. In the southern Caspian, along the coast of Iran, agriculture, which is mechanised and highly dependent on the application of chemical fertilisers and pesticides, is the primary source of excess nutrients, while the deforestation of a significant area of woodland has increased the nutrient loads leached into rivers discharging into the Sea. In fact, it is estimated that the natural forests of Iran have been reduced from 30 million ha to their present area of 9 million ha within one generation (CEP 1998b) in order to accommodate population increases, urban expansion and the increasing demand for farmland.

Rivers in the region discharge between 6 and 20 times more nitrogen and phosphorus into the Sea than direct discharges from municipalities and industries. The elevated concentrations of nutrients in the region cause several phytoplankton blooms per year and, as a consequence, the annual phytoplankton production of the Caspian exceeds that of both the Black and Azov Seas (Table 8) (Caspian Scientific Network 2000). The decline of phytoplankton blooms produces hypoxic conditions in some areas causing fish and zoobenthos mortality.

Table 8 Average biomass of phytoplankton within regions of the northern Caspian Sea in August 2001.

Algal group	West			East			Total for the Sea
	Shallow water zone	Deep water zone	Whole area	Shallow water zone	Deep water zone	Whole area	
Cyanobacteria (mg/m^3)	1 138	548	614	961	366	470	539
Diatoms (mg/m^3)	1 971	906	1 024	364	260	279	634
Dinoflagellates (mg/m^3)	51	124	116	20	34	32	72
Euglenales (mg/m^3)	0.8	1.5	1.4	1.0	1.1	1.1	1.3
Chlorophyta (mg/m^3)	184	263	255	797	232	325	294
Total (mg/m^3)	3 345	1 843	2 010	2 143	893	1 107	1 540

(Source: GIWA Task team 2003)

Chemical pollution

Oil related activities are the main contributors to the moderate chemical pollution of the Caspian Sea. Oil and gas exploration and production have occurred in the Caspian Sea for nearly 150 years and, currently, there are oil activities in the waters of all riparian countries except Iran. Although high levels of pollution have been attributed to these activities, the actual contribution of these activities to oil pollution in the Caspian is estimated to be less than half of that originating from natural seeps, and only 5% of the total annual inputs of oil into the Sea from all sources. The primary source of oil pollution in the Caspian are oil-related activities such as oil refining, transport, and related industries that tend to pollute rivers that discharge into the Sea (Table 9) (CEP 2002c). For example, in Kazakhstan, serious pollution of landscapes has resulted from the oil and gas fields located on the delta and left banks of the Ural River (CEP 1998c). An extensive area around the city of Atyrau was developed during the Soviet period. Drilling facilities, roads, pipelines, oil storage facilities, maintenance depots, temporary construction sites and homes for the oil and gas workers were built which degraded the semi-desert and desert vegetation. In addition, the impacts from the large newly established Tengiz oil and gas field, south of Kulsary, have been similar to those experienced around Atyrau. However, because of the close proximity of this field to the Sea, the impacts have been more intense with recent rises in sea level causing flooding of a belt of up to 40 km wide that has carried the contaminants to the Sea (Salmanov 1999).

Table 9 Pollution loads from rivers, municipalities and industry in the littoral countries.

Country	Sources	River flow (km^3/year)	BOD (tonnes/ year)	Nitrogen (tonnes/ year)	Phosphorus (tonnes/ year)	Oil (tonnes/ year)
Azerbaijan	Rivers	15.2	36 000	19 000	1 000	600
	Municipalities		38 000	13 000	3 300	9 400
	Industry		7 100	1 100	300	14 000
Sub-total		15.2	81 100	33 100	4 600	24 000
Iran	Rivers	17	49 500	12 000	1 200	400
	Municipalities		68 000	16 000	4 400	7 800
	Industry		28 200	600	210	12 500
Sub-total		17	145 700	28 600	5 810	20 700
Kazakhstan	Rivers	9.8	13 200	6 000	600	400
	Municipalities		800	500	100	200
	Industry		2 900	7 100	100	1 800
Sub-total		9.8	16 900	13 600	800	2 400
Russia	Rivers	257.4	807 900	805 000	87 500	73 100
	Municipalities		1 600	400	100	100
	Industry		1 500	100	3 970	5 400
Sub-total		257.4	3 100	500	4 070	5 500
Turkmenistan	Rivers	0	0	0	0	0
	Municipalities		1 600	400	100	100
	Industry		1 500	100	3 970	5 400
Sub-total		0	3 100	500	4 070	5 500
All countries	Rivers	299.4	906 600	842 000	90 300	74 500
	Municipalities		124 400	34 900	9 300	21 300
	Industry		44 600	9 200	4 680	42 600
Total for Caspian	**All sources**	**299.4**	**1 075 600**	**886 100**	**104 280**	**138 400**

Note: BOD = Biological Oxygen Demand. (Source: CEP 2002c)

The Bay of Saymonov in Turkmenistan is a dead part of the Caspian. Industrial effluents of an oil refinery have been discharging pollutants into this bay since 1942. The bay is separated from the Krasnovodsk Gulf by overflow control facilities, which partly impede the flow of wastewater into the Sea. However, due to increased production of the refinery, the pressure has increased. This has led to reduced bio-productivity of the Krasnovodsk Gulf and contamination of fish tissue. Furthermore, numerous oily lakes in the vicinity of onshore oil fields have caused mass mortality of birds (CEP 1998e).

It is recognised that development of the oil and gas industry has brought about a number of indirect impacts, particularly as a result of increased urban construction and land uses, increased desertification of sites because of infrastructure, and increased freshwater demand. As a consequence, the indirect environmental and socio-economic impacts of increased oil and gas exploration are potentially greater than the direct impacts associated with pollution.

In 1995, all seawaters monitored in the Caspian Sea were classified as polluted, despite the fact that concentrations of pollutants in the northern part had stabilised or even decreased (CEP 1998d). Average annual concentrations of oil hydrocarbons were 0.3 to 1.6 times greater than the Maximum Allowable Concentration (MAC), while the concentrations of phenols were 4 to 5 times higher than the MAC. Levels of ammonium and synthetic surfactants did not exceed the appropriate MAC. Concentrations of oil hydrocarbons in bottom sediments varied from 1-14 mg/g; those of copper, from 4.6-27.9 mg/g; and lead, from 0.1-4.2 mg/g.

Apart from oil and agriculture, other factors have influenced the load of chemical pollutants in Caspian waters. In Azerbaijan, for instance, the former highly developed industrial city of Sumgait has virtually closed down but pollution from historical activities still persists in this area. Natural factors, such as water level rise, have also brought buried pollutants to the surface in formerly polluted land areas (CEP 1998a).

Analysis of long-term data describing the water quality of the Kura River shows that the concentrations of dissolved oxygen are generally satisfactory and ranged between 82 and 100% of the saturation point. The biological oxygen demand (BOD_5), which is an index of the content of lightly oxidised organic matter in the water, varies between 2.0-2.5 mg O_2/l and does not exceed the sanitary norm. Also, the concentration of phosphorus ranges between 0.06-0.09 mg/l, nitrate between 0.008-0.015 mg/l and ammonium 0.08-0.14 mg/l, and do not exceed the MAC. On the other hand, the degree of mineralisation and content of sulphates exceeds the sanitary norm by 20 to 100%. In the mouth of the Kura River, high concentrations of phenol (0.015 mg/l) and copper compounds (0.0012 mg/l) that exceed the MAC by 8 to 15 times are recorded. In addition, the concentration of oil products exceeds the MAC by 5 times (0.25 mg/l) (CEP 1998a).

Falling industrial activity since the early 1990s has resulted in generally less pollution of coastal waters by industrial sewage. Nevertheless, various persistent contaminants still pose a serious threat to the fishes in and around the Caspian Sea. High concentrations of DDT metabolites, chlordane, PCBs, hexachlorocyclohexanes (HCH), and other organics, as well as some heavy metals (zinc, copper, cadmium and lead) have been measured in sturgeons (CEP 2002c).

Spills

Spills of oil and oil products during navigation and from offshore oil and gas fields as well as flooded coastal oil fields are significant sources of marine pollution (Figure 7). The areas bordering the Russian coast that are most significantly contaminated by oil are the port of Makhachkala and navigable routes and oil fields. A typical example of an accidental oil spill occurred as a result of the overfilling of cargo

Figure 7 Aerial view of the Neft Dashlari (Oily Rocks) 110 km^2 artificial island (Azerbaijan).
(Photo: Corbis)

tanks during the loading of the Volgoneft-147 tanker in the port of Astrakhan in August 1995 (CEP 1998d). This accident resulted in the spillage of about 34.5 tonnes of oil into the Volga River, which resulted in 180 000 USD in damage and the clean-up operations took 120 hours and cost 2 000 USD. In 1996, accidental discharges of oil products into the aquatic environment in the Astrakhan Oblast amounted to 270 kg, which caused 3 500 USD in damages. Most frequently, such accidents arise from the sinking of old ships that are not properly repaired, maintained or guarded.

To date, there have been no severe spills in the Caspian Sea; although a spill from the old block oil well in the Tajigali oil field occurred, however figures describing the size of the spill and the extent of the impacts were not available. Nevertheless, with the high volume of oil being shipped through the Volga-Don river system to the Black Sea, there is great potential for oil tanker accidents resulting in the release of significant quantities of oil into the marine environment. These activities are currently having a moderate impact on the ecosystems of the Caspian Sea. While major spills cause immediate and obvious environmental consequences, the presence of large oil carrying ships in the Caspian and adjoining river systems causes other problems, such as the day to day release of contaminated water from ships' holds. According to data collected during 1995 and 1996, pollution of the aquatic environment resulting from deliberate discharges of pollutants from ships has increased. The main reason is the relatively high price of effluent treatment services compared with possible fines for discharging such effluents into the watercourses (CEP 1998d).

Operational spills are occurring as a consequence of the present development of the shelf zone by international oil companies. A consequence of the release of oil into the surface waters of the Caspian Sea is that there are very few tar free beaches around the Caspian Sea. Oil and gas issues are of particular concern, partly due to extensive oil slicks observed in some portions of the Caspian Sea. In some cases, the origin of these slicks has been traced to industrial activities, but in many other cases the source is not as obvious (CEP 2002c).

Degradation of the marine environment can be caused by single large-scale pollutant discharges during accidents at industrial and treatment facilities as well as from the inoperative water treatment systems of industries, agriculture and human settlements in the coastal zone. In such cases, discharges are characterised by high concentrations of pollutants that are released over brief periods and affect a relatively small area. In recent years, Astrakhan and Makhachkala have remained

Figure 8 Kara Bogaz Gol (Turkmenistan).
(Photo: NASA).

the largest sources of accidental pollution of this type in the Caspian region. In 1995, accidental and single large-scale discharges of pollutants into water bodies of the Astrakhan Oblast occurred on 36 occasions and exceeded 42 tonnes. Approximately 13 tonnes were recovered during clean-up operations. Twenty-eight of these accidents were attributable to breaches of environmental requirements during operations of sea-going and river vessels, the fish processing industry, ship repairs or military units (CEP 1998d).

Other pollution sources

The environmental impacts of suspended solids, solid waste, thermal, microbiological and radionuclide pollution in the Caspian Sea are considered slight (CEP 2002c). Radioactivity is present locally as a result of industrial processes involving activated charcoal in the basin of Kara Bogaz Gol (Figure 8), from the radium mines near Aktau (Kazakhstan) and possibly from underground nuclear explosions in the north Caspian region (CEP 2002c). Data obtained during the International Atomic Energy Agency cruises conducted in the late 1990s show low levels of radioactivity in the sediments and waters of the Caspian Sea (CEP 2002c).

Socio-economic impacts

Pollution causes moderate impacts to the economy of the region and affects the priorities for regional development. The main economic losses are associated with declining fishing revenues, changes in fishing expenditure, decreased aquaculture developments and property devaluation. In addition, there are costs for freshwater treatment, cleaning of tar covered beaches and prophylactic health care for humans. The area is also losing much of its attractiveness to tourists. As a result, the competitiveness of the coastal economy is decreasing. It is difficult to single out one cause of economic decline because political, macro-economic and environmental factors are synergistically contributing to the present situation (CEP 2002c).

Pollution affects only a limited number of people within the CEH relative to the total population of the region (CEP 2002d) and, as a consequence, the impacts of pollution on the health of the human population in the region are moderate. Environmental pollution in the region is often blamed for diseases of the central nervous system, the digestive tract, respiratory diseases and cancer (CEP 2002a, d). Some data on health indicators by country are presented in Table 10. The most common diseases are typhoid, dysentery and tuberculosis, which are 15 times more prevalent in coastal areas than in the remaining parts of the region (CEP 2002c).

Other social impacts resulting from environmental pollution are moderate and mostly indirect. The regional tanker fleet needs to be renewed, as there is risk of transboundary pollution because of incidents. In official environmental reports of the region's countries, this factor is under consideration (CEP 1998a-e, Vladimirov et al. 2002). In addition, countries' governments cannot allocate sufficient funds to ensure adequate environmental protection, which impedes problem solving in the region (CEP 2002c).

Conclusions and future outlook

At present, the most important forms of pollution in the Caspian Sea region are chemical, nutrients causing eutrophication and oil spills, which significantly influence the economy and human health of the region and exert moderate impacts on the environment. These pollutants originate primarily from sewage, agricultural run-off and oil-related activities and are transported by rivers and discharged into the

Table 10 Population health indicators in the littoral countries.

Characteristics	Azerbaijan	Iran	Kazakhstan	Russia	Turkmenistan
Tuberculosis cases per 100 000 people (1998)	61	18	126	82	89
Malaria cases per 100 000 people (1997)	130	60	ND	ND	ND
People living with HIV/AIDS aged 15-49, % (1999)	<0.01	<0.01	0.04	0.18	0.01
Pregnant women with anemia, % (1975-1991)	36	17	27	30	ND

Note: ND = No Data. (Source: CEP 2002a)

Caspian Sea. This situation is unlikely to change in the future because of industrial development and population growth in the coastal zone (CEP 2002c). In addition, rehabilitation of the economy and agriculture is likely to cause an increase in the quantity of wastewater discharged into the Sea (CEP 2002c).

Much of the economic improvement in the future will result from oil exploration. However, despite the economic benefits that increased oil production will yield and the application of modern environmentally sound technologies for hydrocarbon exploration and production, the current extent and intensity of oil-based industries provides no basis for an optimistic prognosis concerning oil pollution in the future. In the Kazakhstan sector of the northern Caspian where prospecting and development of new oil fields is most intense, the annual production will, in the short-term, reach 50 million tonnes, based on forecasted reserves of 5 to 7 billion tonnes. In addition, the oil and gas reserves on the shelf of the northeast Caspian Sea are estimated to be as large as 10 billion tonnes (CEP 1998c).

At present, this shelf zone is being developed by a number of international oil companies. Azerbaijan has signed contracts concerning oil prospecting and extraction in Azeri, Chirag, Guneshli, Karabakh, Yalama, Lenkoran-deniz, Talysh-deniz and others oil fields that are already operating. For example, the first oil has already been extracted from the Chirag deposit. At present, four international oil consortia have been established, of which the biggest is the Azerbaijan International Operating Company (AIOC) (CEP 1998a). Drilling in the Sea is planned from the fixed platforms in Turkmenistan and in the Galkanysh region where the depth of oil wells is estimated to be 3 050 m. Also, 10 additional wells are being constructed in the Korpedje region (CEP 1998e).

Continued development of existing oil fields will increase the risks of contamination occurring in the future and, moreover, the construction of new pipelines, particularly the underwater pipeline between Aktau and Baku, and the transportation of the Tengiz oil by tankers to Baku will exacerbate the potential for significant environmental damage resulting from oil exploration and transport.

Habitat and community modification

The coastal landscapes and habitats in the Caspian region are degraded by a number of natural and human induced factors. Natural factors include fluctuations in the sea level, earthquakes, and climate change. Some of the anthropogenic causes of degradation of coastal landscapes and damage to coastal habitats are deforestation, regulation of rivers, urbanisation, industrial development, inadequate agriculture/aquaculture development, inadequate recreational development and land- and sea-based pollution.

The current Caspian transgression during the last two decades has resulted in a sharp increase in sea level by approximately 2.5 m which has displaced wetlands and other habitats located in shallow waters and along the coast. This has caused a concomitant decline in biodiversity and loss of ecosystem stability, particularly in the CIS-Caspian Lowland (Kazakhstan, Russia), lowland deltas in Azerbaijan and offshore shoals. A number of species, such as the rare Nut lotus (*Nelumbo nucifera*), which has almost disappeared in the eastern part of the Volga delta, have lost their environment, although, in the long-term, these habitats are likely to re-establish themselves along the new coast. In addition, the advance of the Sea has caused the progressive salinisation of soils and a shift in the surge zone in the coastal area. Moreover, the impacts associated with the inundation of coastal areas by rising sea levels have been exacerbated by the contamination of marine and wetland habitats with pesticides, herbicides and oil products that were previously contained within coastal or inland areas.

The impacts of sea level rise have not all been negative. Despite the temporal loss of biodiversity, the inundation of coastal areas has also provided new habitats. The rise in sea level has in some areas favourably influenced restoration of shallow spawning grounds (e.g. carp), nesting locations for birds (e.g. flamingos and swans), diversity of flora and productivity and quality of feeding grounds.

Environmental impacts

Major anthropogenic causes of habitat destruction in the Caspian region include construction of hydropower dams, oil exploration, domestic and industrial sewage, and eutrophication. The construction of dams on the Volga, Kura and Atrek rivers for hydropower, which

Table 11 Loss of spawning grounds for sturgeon due to stream flow regulation.

River	Area of spawning grounds before river regulation (ha)	Area of remaining spawning grounds (ha)
Kura	ND	160
Terek	ND	130
Sulak	ND	200
Ural	1 700	1 100
Volga	3 390	372

Note : ND = No Data. (Source: CEP 2002c)

started in the 1930s, caused a decline in water flow and alterations of the natural water regimes and concomitant changes in environmental conditions and structure of habitats in their deltas. In particular, a large part of the natural spawning grounds of sturgeons in the Volga River and semi-anadromous fish in the Atrek River (e.g. zander, carp and Caspian roach) have been lost resulting in declines of fish stocks in all littoral states (Table 11) (CEP 2002c). However, in order to offset the decline in stocks of these species resulting from decreases in natural recruitment, several hatcheries have been constructed, with more being planned in the future. Indeed, the number of fry released from hatcheries is one of the main factors that determine how quotas for catches of valuable fish species are allocated.

Conflicts arise because the regulation of rivers affects the size of stocks of commercial fish species in the entire region but only those countries that have constructed dams benefit from the electricity and water for irrigation that these reservoirs provide. Under these circumstances, nations that do not benefit from the construction of these dams do not have any incentives to restore natural spawning grounds. Moreover, one of the main principles outlined in the "Agreement on the preservation and use of Caspian bio-resources" states that the "distribution of aquatic bio-resources depending on the input of Parties into their reproduction and preservation as well as bio-productivity of coastal waters" is not fully implemented within the region. As a consequence, the preservation of other natural habitats of sturgeons, such as feeding and wintering grounds, is not encouraged.

In Azerbaijan, the oil industry has long been by far the greatest culprit in destroying landscapes in the coastal zone, especially on the Apsheron Peninsula and the area south of Baku. Oil fields developed prior to the achievement of independence cover 20 000 ha of the Peninsula, of which more than 8 000 ha are severely contaminated by oil and 2 000 ha are occupied by artificial oil-water lakes and pits. These areas are classified as severely degraded semi-desert landscapes. In addition, wastes from the oil industry have contaminated 165 natural lakes (CEP 1998a and f, CEP 2002c).

The existence of persistent bio-accumulative toxic compounds in the environment, which have generally originated from the oil industry, jeopardises offshore habitats and wetlands of Azerbaijan, Russia and the northeastern coast of Kazakhstan. Eutrophication, on the other hand, threatens enclosed water bodies of wetlands (gulfs, lagoons and delta lakes) in the deltas of the Volga and the Kura rivers.

In the Caspian Sea region, anthropogenic activities have caused a considerable decline in the resource and functional value of many habitats. As a consequence, rehabilitation and reconstruction of degraded habitats is a regional priority. Although a thorough inventory of the habitats of the Caspian Sea region has not been conducted, sufficient data were available to prioritise the following areas (CEP 1998f):

Marine habitats:

- The contaminated oil areas in the Azerbaijan sector;
- The contaminated areas of the transitional zone along the northeastern coast of Kazakhstan between the Emba delta and the Tub-Karagan Peninsula where oil wells have been inundated by rising sea levels;
- The oil fields in shallow waters of Turkmenistan (Komsomolskoye, Koturdele oil fields);
- The introduction of alien species, such as Mnemiopsis leidyi, into the Caspian Sea, particularly the southern regions.

Coastal habitats:

- The relic gyrcanic forests on the coasts of Iran and Azerbaijan;
- The areas damaged by the oil fields along the eastern coast of Kazakhstan (Teren-Uzyak, Western Prorva, Karajanbas) and Turkmenistan;
- Desertified areas throughout the Caspian Sea region, particularly in Russia and Kazakhstan.

Marshy areas:

- The spawning area and migration routes of sturgeons in navigable channels and riverbeds of the Volga, Ural, Kura River deltas;
- Divichi estuary and the Apsheron-Gobustan area that are valuable habitats for waterfowl, shore birds and rare species of flora;
- The spawning areas in the lower Atrek River;
- The contaminated areas of Saymonov Bay and the Turkmenbashy Gulf (Turkmenistan).

Loss and modification of habitats by country

In Azerbaijan, the abundance and viability of animals and plants in coastal habitats, particularly trout (*Salmo trutta caspius*), South Caspian Danubian bream (*Abramis brama orientalis*), Marine zander (*Stizostedion lucioperca*) and the Caspian lamprey (*Caspiomyzon wagneri*), have sharply declined as a consequence of intensified oil activities. Additionally, the migration and wintering of waterfowl and shore birds have been affected by desiccated wetlands and changes in crops. The wetlands of protected areas in the Salyan and Lenkoran districts and hunting reserves in the Samur-Devechi and Neftchala districts are under threat of extinction (CEP 1998f).

In Kazakhstan, fluctuations in discharge of the Ural River (from 6 to 12 km^3 per year) and an increase in the volume of water entering the Caspian Sea during the past few years have led to siltation of its delta. This process has severely hampered passage of sturgeons to their spawning grounds. Coastal habitats located within the territory of oil fields developed during the Soviet period (Tazhigaly, Teren-Uzyak, Eastern and Western Prorva, Karazhambas and Noviy Uzen) have been lost due to oil production (CEP 1998f).

In Russia, the main factor causing the degradation of habitats is pollution from industrial discharges, agro-chemicals and oil products. The most vulnerable habitat is the Volga Delta, particularly in the lower reaches of its fore delta. During the sea level rise, about 150 000 ha along the coast was flooded, and the surge that occurred in March 1995 (1.7 m) caused considerable damage (CEP 1998f).

There are few cases of degradation of habitats in Turkmenistan. There has been a progressive fall in the water levels of the Atrek River during the last 40 years as a result of withdrawal of water in the Iranian part of the River (CEP 1998f). This is directly responsible for the reduction of spawning grounds in the lower reaches of the Atrek where semi-anadromous fishes such as Caspian roach (*Rutilus rutilus caspicus*) and common carp (*Cyprinus carpio*) reproduce.

In Iran, the impacts of extensive salinisation of soils have been exacerbated by livestock farming. The most important critical habitats of the southern regions of the Caspian Sea are situated in two main areas: the Anzali Complex, which is located in a coastal lagoon; and Gorgan Bay, which is a coastal bay (CEP 1998f). Deforestation of the coastal zone is also an important problem in northern Iran and a main factor in the destruction of coastal habitats.

Loss of biodiversity

Concerns over loss of biodiversity in the Caspian Sea at genetic, species and habitat levels are widespread in the region. Loss of biodiversity is occurring as result of many factors including overfishing, poor water and sediment quality, damming of rivers, loss of habitat and the introduction of alien species (Aladin 2001). With clear threats to some of the economically important fish species (including sturgeon), general concern over loss of biodiversity is increasing. Documentation of the loss of biodiversity in the Caspian region is generally sparse. First, basin-wide assessments of biodiversity at repeated intervals are not available because of the large expenses associated with this kind of monitoring. Red books of the four northern Caspian countries list rare and endangered species but lack a general context of their impact on overall diversity. Sturgeons, for instance, reflect only a few of more than hundred species of fish in the Caspian Sea, and therefore, their loss may not represent a major decline in the overall biodiversity. Country reports on biodiversity and coastal habitats provide largely incomplete lists that do not permit quantitative assessment of the loss of biodiversity in the Caspian Sea. There is clearly an information gap for this issue. The damage to biodiversity is evident, but quantitative evidence is sparse (CEP 2002c).

Socio-economic impacts

The economic impacts of habitat and community modification are moderate. The main feature of degraded habitats is the decreased capacity to meet the basic needs, such as food and fuel, of the population in the region. The elevated sea level has affected the quality of agricultural land and increased the expenses for harvesting. Agricultural production has steadily declined as a result of desertification and failed to provide for the needs of the progressively increasing population in the region. In Kazakhstan, agricultural outputs decreased by 21% between 1993 and 1994 and by half between 1993 and 1995. More recently though, agricultural production has improved. In 1998-1999, the relative growth in this sector was 29% but the situation in the region continues to be precarious.

Rises in sea level and the subsequent surges have not only affected the agricultural sector but also inundated communications and production facilities in some areas. Inundation further increases production costs, fertiliser use, unemployment and requires implementation of land protection measures in local communities.

In addition, the aesthetic and recreational value of the coastal territory has decreased for both local inhabitants and tourists. The number of international and national tourists visiting the region has declined since the disintegration of the former Soviet Union (CEP 2002c).

Modification of habitats has moderately influenced the health of the population in the region. The incidences of tuberculosis and typhus in the Caspian region of Russia are 15 times greater than the national average. The prevalence of infectious diseases in the Caspian region exceeds that recorded in more favourable territories. Territories of the northern and eastern lowlands directly affected by sea level rise, climate and soil changes or areas dependent on resources from the Sea have suffered most. The modification of habitats might contribute to increased child and infant mortality, birth pathologies and reduced life expectancy through the general stress imposed on the population by the inappropriate natural conditions. In Azerbaijan, child mortality is 34% higher in coastal areas compared with mid-country areas where effects of habitat modification of the Caspian Sea are less pronounced.

However, habitat and community modification is not the only reason for deteriorating health conditions. It should be mentioned that pollution is probably more responsible than habitat modification. Significant socio-economic factors caused by the formation of national economic systems and the legacy of the economic complexes of the Soviet Union also contribute to the current situation (CEP 2002c). The disintegration of the Soviet Union caused loss of production and working places through the collapse of economic relationships between the industries that were the interactive units within the now defunct all-union economic complexes.

Other social and community impacts are moderate but less serious than impacts on economy and health. In general, these concerns include increased charges for preservation of biodiversity and protection of endemic species, support for sustainable utilisation of habitats, increased costs for preservation of cultural heritage and the loss of educational and scientific values of the coastal territories. In the Russian coastal area, about 200 houses in Makhachkala, Derbent and Lagan have been destroyed and 800 families displaced as a result of salinisation caused by poor irrigation techniques (CEP 2002c).

Conclusions and future outlook

Ecosystems in the Caspian Sea region have been modified by the construction of hydropower dams, oil exploration, domestic and industrial sewage and eutrophication. The changes to regional ecosystems have influenced the regional economy, particularly through the impacts on fish stocks.

In the future, the situation is expected to worsen if measures are not taken to address existing problems. Further decline and commercial extinction of endangered fish species such as sturgeon, trout and Caspian inconnu (salmon) will be observed during the coming decades as more of their spawning grounds are lost. Benthic communities in the shelf area and the pelagic ecosystem are expected to suffer further damages with the increase of human activities, particularly oil exploration. Based on experiences from the Black Sea, it is anticipated that the pelagic habitat will be adversely affected by the impacts of the introduced comb-jellyfish *Mnemiopsis leidyi*. Decreased biological diversity, desertification and increased pollution are some of the conditions that the coastal areas around the Caspian Sea will face in the future. With the expansion of oil and gas activities and growth of populations in the region, it is likely that urbanisation will increase as well as landfilling, and industrial development. The combined socio-economic pressures accompanying these stresses will result in increased land encroachment and possibly more contamination and, in turn, more degradation of landscapes and habitats.

IMPACT Unsustainable exploitation of fish and other living resources

There are four primary groups of commercial fish in the Caspian Sea:

- Fishes of the Sea: kilka (*Clupeonella cultriventris caspia*), shad (*Alosa kessleri kessleri* and *Alosa saposchnikowii*), and gobies such as (*Benthophilus stellatus*).
- Fishes of the rivers: perch (*Perca* spp.), Tench (*Tinca tinca*), Rudd (*Scardinius erythrophthalmus*), and Sterlet (*Acipenser ruthenus*).
- Anadromous fishes: lamprey (*Lampetra* sp.), Trout (*Salmo trutta caspius*), Caspian roach (*Rutilus rutilus caspicus*), and all sturgeons (Acipenseridae) except Sterlet (*Acipenser ruthenus*).
- Semi-migratory fishes: Breams (*Abramis brama orientalis*), Carp (*Cyprinus carpio*) and Zander (*Stizostedion lucioperca*).

Sturgeons are abundant, having originated from freshwater forms and acclimatised to higher salinity so that they are now distributed throughout the entire Caspian. The traditional Caspian sturgeon fishery is well known because of the high economic value of the caviar. However, in recent years, landings have decreased significantly, despite the introduction of a quota system and a temporary ban on pelagic fishing.

The impacts of unsustainable exploitation of fish and other living resources are moderate in the region. Overexploitation is the main issue since many stocks are heavily fished both legally and illegally. Decreased viability and changes in genetic structure are of moderate concern while by-catch and destructive fishing practices cause slight impact.

Environmental impacts

Overexploitation

Overexploitation of aquatic organisms is severely affecting the regional environment. Overfishing, in conjunction with pollution, river regulation, the introduction of alien species, loss of habitats and poaching, have reduced the stocks of some commercially important fish and nearly eliminated some of them from catches.

The Caspian Basin sustains an important fisheries sector. In the past, more than 400 000 tonnes of fish, particularly valuable species such as sturgeon and Caspian roach, were caught annually. This situation remained unchanged until the early 1950s but, since then, sprat fishing has significantly intensified in the middle and southern Caspian in order to compensate for poor catches of more valuable fish species. Between 1960 and 1980, the total volume of fish caught was largely maintained by the annual extraction of between 300 000 to 400 000 tonnes of sprat (Table 12, Figure 9).

Table 12 Average annual fish catch in the Caspian Sea.

Fish	Commonwealth of Independent States							Iran	
	1910-1930	1932-1959	1960-1970	1971-1978	1979-1980	1991-1995	1996-1998	1927-1998	1996-1998
Sturgeons (1 000 tonnes/year)	13.8	12.8	15.3	22.1	21.2	6.4	1.8	1.3	1.5
Bony fish (excluding kilka) (1 000 tonnes/year)	382	349	107	86.4	60.5	72.1	72.5	6.2	16.6
Kilka (sprat) (1 000 tonnes/year)	ND	37.3	308	357	283	149	133	2.0	63.3
Total (1 000 tonnes/year)	395.8	399.1	430.3	465.5	364.7	227.5	207.3	9.5	81.4

Note: ND = No Data. (Source: CEP 2002c)

The official sturgeon catch from the Caspian CIS countries has dropped from an average of 13 800 tonnes per year between 1910-1930 to 1 800 tonnes per year between 1996-1998, peaking in the 1970s at about 22 000 tonnes per year. Official catch statistics are unable to account for illegal poaching which makes it very difficult to estimate the actual catch. For example, the quota of Turkmenistan for offshore sturgeon catches was 3 tonnes in 2001 (for research purposes), but according to approximate calculations, the real amount of sturgeon meat sold at markets only in Ashghabad was of the order of 300 tonnes.

During the 1970s and 1980s, there was a ban on offshore fishing for sturgeon and salmon but, since the cancellation of the ban, poaching has been uncontrollable, particularly during the 1990s as a result of declining living conditions and a high rate of unemployment (CEP 2002c). Data of Caspian Scientific Research Institute of Fisheries (CaspNIRKh) show that illegal fishing throughout the Caspian region exceeds the quotas for catches by a factor of 10 to 13. Rapacious overfishing of sturgeons in estuaries during spawning run inflicts significant damage to populations and their resource potential.

Decreased viability of stock

Decreased viability of stock through pollution and disease is causing moderate impact on the Caspian ecosystem, particularly on populations of the Caspian seal (*Phoca* (*Pusa*) *caspica*). The Caspian seal, which is endemic to the Caspian Sea, is the only mammal within the aquatic fauna of the region. The main threats to the seal are oil exploration, pollution and viral outbreaks. Since April 2000, thousands of Caspian seals have died primarily as a result of an epidemic of canine distemper virus (CDV), although other complex factors are said to have contributed to the mortality. Estimates of the present population of Caspian seal span a factor of 10, between 30 000 and 400 000 individuals compared with historical data (19th century) describing 1 million seals (CEP 2002c).

Impacts on biological and genetic diversity

Impacts on the biological and genetic diversity of the region are moderate. The flora and fauna of the Caspian Sea include species introduced from the Arctic, Atlantic and Mediterranean complexes. Although many of these introductions occurred in the distant past, between 1930 and 1970, intentional and unintentional introduction of a number of species has occurred. Fourteen species of commercial fishes; the flounders, three salmon species, eel, mullets, mosquito fish, anchovy, and mackerel have been introduced deliberately, while two other species of fish (pipefish - *Syngnathus* and silverside - Atherinidae) and several other species such as invertebrates like the polychaete worm (*Nereis diversicolor*), bivalve (*Abra ovata*) and shrimp (*Palaemon elegans*) have accidentally been introduced.

Three new alien species of jelly plankton have been found in the Caspian during the last 50 years, two jellyfish *Blackfordia virginica* and *Aurelia aurita* and one comb-jellyfish *Mnemiopsis leidyi*. At present, the two jellyfish both occur in the Black and Azov Seas and have most likely invaded the Caspian from these Seas by travelling through the extensive shipping networks that connect these systems. Both species of jellyfish are planktivores but it seems that they are not as voracious as *Mnemiopsis* and their impact on the pelagic ecosystem has been low (CEP 2002c). *Mnemiopsis*, on the other hand, is a voracious planktivore that invaded the Black Sea during the 1980s causing considerable disruption to the marine ecosystem as a result of competition for food between *Mnemiopsis* and fish, leading to the decline in fish stocks in this system.

Mnemiopsis, which originate from the northwest Atlantic and invaded the Black and Azov Seas and subsequently the Caspian Sea, has the capacity to reduce its metabolic rate when food supplies are inadequate, allowing it to survive long periods in ballast water. The probability of transportation of *Mnemiopsis* from the Black Sea into the Caspian in ballast waters of ships was acknowledged several years ago and preventive measures, namely the replacement of ballast water in the freshwater part of the Volga-Don navigation system, were recommended. Even so, *Mnemiopsis* was found along the coast of Kazakhstan and then Turkmenistan in late 1999. Since then, it has rapidly migrated southwards where the salinity and temperature of the Sea are favourable. At present, *Mnemiopsis* occurs throughout the Caspian, except in the extreme north and northeast, where the salinity is too low (CEP 2002c). The current abundance of *Mnemiopsis*

Figure 9 Fishermen catch sturgeon with nets near the town of Atyrau (Kazakhstan).
(Photo: Corbis)

in the Caspian is about twice as high as the maximum ever recorded in the Black Sea. The greatest potential impacts from the introduction of this species would be exerted on the sprat fishery primarily because of competition for food between these two species and predation of *Mnemiopsis* on the planktonic sprat larvae. In addition, because sprat is the main component of the diet of Caspian seals, declines in sprat stocks are likely to cause further declines in the population of this endemic mammal.

Socio-economic impacts

The substitution of high value fish for lower priced fish in the catches, changed species composition, decreased catch efficiency and low investments, indicate that fishing in the Caspian Sea is becoming unsustainable. However, the unsustainable exploitation of fish stocks has not, to date, caused changes in the formal economic structure of the region. Nevertheless, in the early 1990s in Baku, the street price of caviar was pushed to its lowest levels ever by the illegal poaching of sturgeons. The combined impact of unsustainable exploitation on the economic sector was considered moderate. It is difficult to discern the impacts of overexploitation despite the decline of fish exports and small domestic market during the last 10 years.

Health impacts are also moderate and are determined by the overall economic situation in the region. Reduced fish catches are affecting health in the sense that it contributes to reductions in living standards (CEP 2002c).

Other social impacts are moderate and largely attributable to rising unemployment. Because of the decline in fishing the level of unemployment in the region has increased. For example, in Kazakhstan, unemployment has risen from 1.1% in 1994 to 3.9% in 1999. Unemployment is associated with the 50% decline in fish processing

industries during the last 10 to 12 years. Currently, it is difficult to accurately assess the social impacts of overexploitation because it is obscured by the general economic recession. Because of poverty and high unemployment fish poaching is becoming common (CEP 2002c).

Conclusions and future outlook

Unsustainable exploitation of fish and other living aquatic resources, particularly in river mouths, has a significant negative impact on the ecology of the marine environment and the economy of the region. The sharp decline of sturgeon stocks have necessitated stock enhancement. In the future, overexploitation is likely to continue because of lack of enforcement, despite international conventions and agreements. Bottom trawling, catching of under-sized fish and fishing in the river mouths will increase and continue to degrade the marine ecosystem. Increased chemical pollution, eutrophication, microbiological pollution, and oil spills will also adversely affect fish stocks. With increasing maritime transport, ballast water will continue to introduce alien species into the Caspian which will further affect local fauna and flora.

Global change

Natural fluctuations in sea level have been occurring in this region throughout history right up until present times. However, at present, there is no reliable information that connects fluctuations in the sea level of the Caspian with global change.

Environmental impacts

Changes in hydrological cycle

The changes in the regional hydrological cycle are slight and mainly related to human activities and global climate change. These are observed in the more extreme magnitude of fluctuations between high and low water in the rivers, as well as in the dynamics of the surface level variation of the water bodies. The river spates in spring and the dry periods in summer are more intensive and longer. Also, because winters are becoming warmer, significantly less ice cover is observed. The seasonal fluctuations, as well as the wind-induced surges, have had a significant impact on the fluctuations in the level of the Caspian Sea. The wind-induced surges are maximal in the northern Caspian, while in the middle and southern parts they are smaller. Wind induced surges of 1.5 to 3 m high have been observed in the Caspian Sea within the past few decades. In the northern Caspian, the wind-induced surges may even penetrate up to 20-30 km inland and remain in the shore depressions up to 15-20 days (CEP 2002c).

Sea level change

The impacts of sea level change are moderate. Sea level fluctuation is primarily due to: climatic changes; regional precipitation and evaporation from the Sea; wind stresses/surges; changes in atmospheric transport patterns; as well as human activities, such as construction of dams on the major rivers. The rise in sea level of the Caspian (2.5 m) has had both positive and negative impacts on the biotic life in the region. While some habitats have been lost, others have been created, facilitating among other things, spawning of anadromous fishes (CEP 1998f).

Increased UV-B radiation

There is a slight impact of increased UV-B radiation and changes in the carbon storage capacity of the water bodies. There has been an increase in UV-B radiation but at the same time there is no evidence of this affecting the sea ecosystem.

Socio-economic impacts

There is moderate impact on the economic sector because of elevated sea level mainly connected to changing agricultural efficiency, fishing and nature protection. Even for the socio-economic sector, sea level rise has brought about some positive implications, particularly by reducing industrial pollution of the shallow waters and the need to dredge harbours. Wind-induced surges causing a temporary increase in sea level have resulted in inundation of vast areas of the coast causing some economic losses to the Caspian littoral states (CEP 2002c).

Impacts caused by global change on the health of the population in the region and to society are slight and the effects indirect.

Conclusions and future outlook

No improvement of the situation is anticipated in the future but instead impacts will continue to increase. An anthropogenic threat of global warming due to the greenhouse effect is a distinctive feature of the 21st century. In accordance with the calculations by Budyko (1988) and Klige and Myagkov (1992), global warming should lead to a drop in sea levels of the Caspian as a result of greater rates of evaporation relative to freshwater inflow. The occurrence of global warming would result in cyclones bringing considerably more rainfall into the catchment of the Caspian Sea which would increase the volumes of water discharged from rivers into the Sea. At the same time, an increase of global temperatures would lead to a higher rate of evaporation from the surface of the Caspian, not only compensating, but even exceeding, the amounts of water gained through increased precipitation. If these calculations prove correct, then the Caspian will experience a recession of levels in the near future which will, in turn, affect the state of its biotopes and its biodiversity.

Priority concerns

The Caspian Sea Basin plays an important role on the Eurasia continent both in terms of environmental sustainability and socio-economic development. The environmental situation in the region is far from sustainable and deterioration of environmental conditions may have significant negative impact on the economy of Europe and Asia.

Having assessed the complex environmental and societal impacts of each concern within the Caspian Sea Basin and considering the Caspian Economic Hinterland as a discrete system with transboundary water-related problems, the results of the assessment have produced the following ranking of concerns in descending order of importance:

1. Habitat and community modification
2. Unsustainable exploitation of fish and other living resources
3. Pollution
4. Freshwater shortage
5. Global change

As a result of the analysis, and considering the trends of the problems for the region, a Causal chain and Policy option analysis of Habitat and community modification was recommended in order to develop mechanisms by which the impacts of this concern can be mitigated in the future.

Besides the formal results of the assessment presented in Annex II, there are other arguments to justify this conclusion. It was stated during the assessment of each concern that Habitat and community modification has significant linkages with other GIWA concerns and issues such as modification of stream flow, pollution, overfishing and the introduction of alien species that are responsible for the degradation of habitats and changes to community structure and species composition. It was concluded that by focusing the Causal chain and Policy option analysis on Habitat and community modification, these associated concerns and issues would indirectly benefit from the resulting policy options.

This conclusion corresponds with the outcome of the Transboundary Diagnostic Analysis (TDA) for the Caspian Economic Hinterland carried out within the framework of the Caspian Environment Programme (CEP) (CEP 2002b-d). Table 13 shows that the issues identified by the TDA as the highest priorities, namely the decline in certain fisheries, biodiversity and threats from invasive species, (CEP 2002c) are similar to those included within the GIWA concern Habitat and community modification. Although the GIWA addresses these issues from a broader global perspective, the similarities between the GIWA and the TDA becomes more evident at the level of policy options.

Table 13 Stakeholder group prioritisation of major perceived problems and issues according to Caspian Sea Transboundary Diagnosic Analysis.
(High priority, Medium priority, Low priority)

Stakeholders	Major perceived problems and issues							
	Decline in certain fisheries	Degradation of coastal landscape	Decline in biodiversity	Decline in overall environmental quality	Decline in human health	Damage to coastal infrastructure and amenities	Potential damage from oil and gas activities	Threats from invasive species
Environmental ministries								
Agriculture and fishing ministries								
Energy ministries								
Regional and municipal governments								
Multinational corporations								
Industry								
Scientific community								
NGOs								
Public healthcare providers								
Fishermen								
Coastal zone residents								

(Source: CEP 2002c)

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.

Introduction

Habitat and community modification was ranked as the concern of highest priority for the Caspian Sea. As a consequence, the causal chain analysis will focus on immediate causes, sector activities and root causes contributing to the severity of impacts caused by this concern. The spatial scale of the analysis is the region under assessment i.e. the Caspian Sea and its coastal zone. Eight immediate causes were identified for this geographical area; pollution, poaching, invasive species, regulation of stream flow, deforestation, coastal erosion/ dredging, land use and eutrophication.

Methodology

The methodology describes the process of selecting the most important immediate causes of Habitat and community modification in the Caspian Sea. Eight immediate causes are described in short in order to provide a background to the prioritisation. By estimating the current situation and the trends for the next 10 years, 12 experts from the five littoral states ranked the immediate causes on a scale from 0-100. The individual ranking by the experts acknowledged that each Caspian country had its own priority regarding the relative importance of each of the different immediate causes. However, there was a general consensus that the negative impacts of most immediate causes are likely to accelerate in the future.

The scores indicate the degree of severity of each immediate cause and were ranked by the experts during the second regional workshop in Baku (Annex III). The first figure presented for each immediate cause refers only to the Caspian Sea and the second to the surrounding freshwater basins.

Pollution 70/75

Pollution exerts negative impacts on habitats both in the freshwater basins and in the brackish Caspian Sea. Pollution has led to changes in benthic and pelagic habitats, water chemistry and sediment composition. The main sources of pollution are oil spills, industry, agriculture and urban wastewaters. The two main hotspots for oil pollution are the marine areas around Baku and Apsheron Peninsula on the west coast and along the Caspian east coast. The situation has been aggravated by sea level rise that has inundated old oil wells. Industrial pollution is considerable but has decreased during the last 10 years due to the economic situation in the region. River inflow is the main source of industrial pollution contributing 80% of the total load. One of the most heavily polluted rivers is the Terek, which exhibits

high concentrations of mercury, lead and chromium. Agrakhana Bay in the mouth of the Terek was previously one of the richest waters in the Caspian Sea with high numbers of shads. Now, it is practically dead, containing essentially nothing but microorganisms. Agricultural activities are the third major source of pollution and are prominent in the Ural, Volga and Kura river basins and in many small rivers on the southern coast. The highest concentrations of pesticides are found in sediments along the Iranian coast.

Poaching 75/70

Poaching has a significant impact on fish populations in both the Caspian Sea and the associated river basins. Changes in population structure and relative abundance of predatory fish have caused changes in the trophic web and subsequently altered the pelagic habitat. Poaching of sturgeon has forced the fishing sector to rely on large-scale releases of hatched juveniles. Fishing has contributed to the current situation which is characterised by general declines in abundance. Both fishing and restocking activities have contributed to changes in species composition from Great (or Beluga) sturgeon (*Huso huso*) and Russian sturgeon (*Acipenser gueldenstaedti*) to Persian sturgeon (*Acipenser persicus).*

Introduction of invasive species 80/25

There have been substantial intentional introductions of fish species in rivers, deltas, artificial reservoirs and in the Sea. Most of these introduced species have remained at naturally low numbers. Accidental introductions of invertebrates and algae have, on the other hand, caused more concern. The latest newcomer, the planktivorous comb-jellyfish, *Mnemiopsis leidyi*, has caused a sharp decline in the abundance of zooplankton in areas where it is found in high densities. This has, in turn, implications for other planktivores such as the economically valuable sprat fishes. The main route of entry for invasive species is the Volga-Don Canal, in ballast water or as fouling organisms.

Regulation of stream flow 55/95

All major Caspian rivers have been dammed, generally for energy production. On the Volga River more than 10 dams have been constructed. As a result, plankton, benthos and fish communities in both rivers and the Caspian have changed. In building the dams, large terrestrial areas have been inundated causing loss of riparian vegetation and river habitats. The primary production of the Caspian Sea has increased as a consequence of changed patterns of river discharge and increased organic loads. The changed conditions have caused environmental stress and made it easier for alien species to establish themselves. The dams have also blocked migration routes and destroyed spawning grounds for anadromous fish.

Deforestation 20/20

Deforestation is a cause of concern only in the southern Caspian region since large stretches of coast are historically devoid of woods in the eastern and northern parts. Deforestation occurs in the Lenkoran region in Azerbaijan and on the Caspian coast of Iran. Deforestation has led to changes in stream flow and increased erosion and turbidity.

Coastal erosion and dredging 30/35

The keeping and transport of livestock have caused coastal erosion in the northern part of the Caspian region, particularly in Kazakhstan and Kalmykia. Pasture is common here, but numbers of grazing animals are low due to freshwater shortage. The lack of proper roads enhances the erosion. Many local people drive on the open terrain causing harm to the already sparse vegetation. In order to facilitate navigation, the Volga and Ural river deltas have been subject to dredging. Dredging has aided the upstream migration of fish but the increased turbidity disturbs other organisms.

Land use 15/35

Land use related activities are of most relevance in Iran and less so in the other littoral countries. The major activity in Iran is agriculture, which occupies half of the territory, while industry occupies one third and human settlements one quarter. The current land use practices have eradicated most natural habitats. In the other littoral countries, there is currently low industrial and agricultural development, slow urbanisation and, as a result, land encroachment rates are low. However, there is a history of vast areas under direct use for agriculture, settlements and industry.

Eutrophication 20/40

Even though eutrophication is limited in the Caspian Sea, it is currently a problem in the big reservoirs in the Caspian drainage basin. Agricultural run-off, sewage, oil exploration and aquaculture are the main sources of nutrients and the Volga delta and the southern coast are the two locations most heavily impacted. However, it is justified to raise concerns regarding the future since there are many factors that are likely to lead to nutrient enrichment of Caspian waters.

Conclusion

The scores assigned to each immediate cause of Habitat and community modification in the Caspian Sea indicate that they have varying degrees of importance. According to the expert ranking, the three most significant immediate causes in the Caspian Sea are; invasive species, pollution and poaching. In the freshwater basin, modification of stream flow, pollution and poaching were prioritised. Together these four immediate causes were selected for further analysis (Table 14).

Table 14 Absolute and relative importance of each immediate cause contributing to Habitat and community modification in the Caspian Sea region.

Immediate cause	Caspian Sea		River basins	
Pollution	70	19%	75	20%
Poaching	70	19%	75	20%
Invasive species	80	23%	25	6%
Flow modification	55	15%	95	24%
Deforestation	20	6%	20	5%
Erosion/dredging	30	8%	35	8%
Land use	15	4%	35	9%
Eutrophication	20	6%	40	8%

Note: Absolute figures scored from 0-100. (Source: GIWA Task team 2003)

Root causes

Pollution

Pollution is one of the primary immediate causes of Habitat and community modification in the Caspian Sea. Pesticides are considered the most deleterious pollutants and "hot spots" can be found in the dense agricultural areas of river deltas and along the coast of Iran. Oil pollution is currently a localised problem but could become a significant threat in the future due to the expanding oil exploration activities in the region. The following paragraphs explore the main sector activities and root causes responsible for pollution in the coastal waters of the Caspian Sea and its freshwater deltas.

Agriculture

The generally high unemployment rates in the Caspian Economic Hinterland (CEH), as well as the population growth in the coastal provinces of Azerbaijan, Iran and Turkmenistan, have resulted in an increase in small-scale farming along the coastline of the Caspian Sea and in its freshwater deltas (Figure 10). Since most parts of the arable land in the region are already subject to agriculture, new farms have become dependent upon irrigation and pesticides to ensure adequate production. Pesticides are also used in the northern part of the region to shorten production cycles and to enable harvesting earlier in spring, when regional market prices for agricultural products are higher than during the rest of the year. While the use of harmful chemicals, such as DDT, was prohibited by the Soviet regime already in 1970, local authorities in the region currently fail to control both the market supply and consumption. Today, environmentally harmful pesticides are both cheap and readily available on local markets throughout the CEH, whereas modern and less damaging alternatives are relatively expensive and therefore seldom seen as an alternative among poor farmers. Public knowledge about the ecological consequences of pesticides is also generally low in the region.

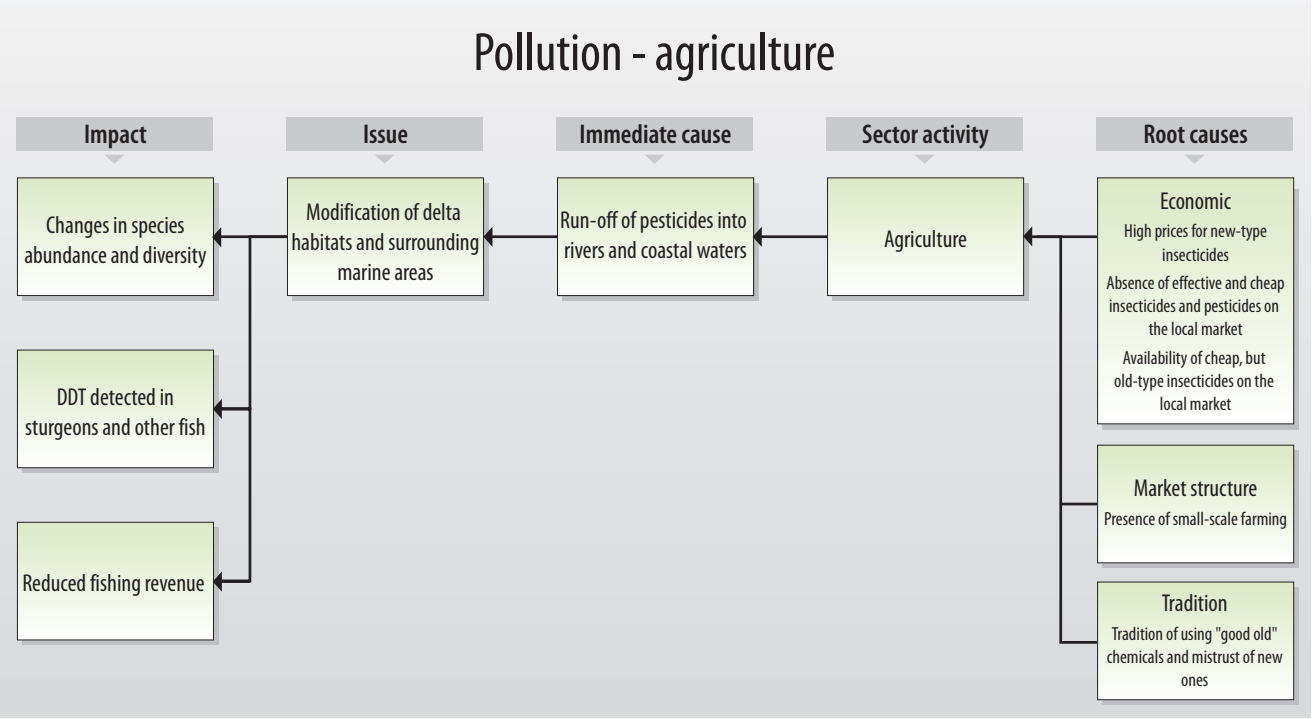

Figure 10 Causal chain diagram illustrating the causal links for agricultural pollution.

The frequent use of chemicals in small-scale agriculture has resulted in substantial run-off of these pollutants into the Caspian freshwater basins and the coastal waters. After the mass invasion of locusts (grasshoppers) in the Atyrau region in Kazakhstan in 1999, DDT concentrations in the delta increased significantly and traces of DDT could be found in tissues of many gobies and sturgeons. As a result of this event, the number of gobies was drastically reduced in the Ural delta. Traces of pesticides have also been found in coastal sediments, particularly along the Iranian coastline (Watanabe et al. 1999). The highly mechanised agriculture and abundant use of pesticides and fertilisers in the coastal provinces of Iran have resulted in a considerable run-off into rivers and coastal waters (CEP 2002c).

While farmlands constitute the major source for chemical run-off, regular spring flooding of chemical stores also contribute to water pollution. Since small-scale farmers in the region seldom protect their stores from flooding, chemicals have on several occasions been dissolved and discharged into rivers. While these events are not officially recorded by any of the Caspian authorities, expert data suggest that they are not uncommon in the region. Two particularly severe events occurred in the Ural River during spring 2000 and 2001, resulting in a considerable amount of dead sturgeons, carps and zanders.

Industry

Industrial discharges contribute substantially to the pollution in the Caspian Sea (Figure 11). Even though purification technology is readily available, most old industries in the CEH have so far lacked the necessary financial resources to introduce wastewater treatment systems, and effluents are therefore often directly discharged into the Caspian Sea. The four former Soviet states still use environmental quality standards developed during Soviet times to control water pollution. These build on standards for maximum allowable discharges of pollutants from point sources and maximum allowable concentrations of pollutants in water bodies (CEP 2001). While the sufficiency of these standards is debated, it is clear that the level of compliance and enforcement is inadequate in most of the Caspian states. This problem is directly linked to the economic difficulties in the region as well as the limited resources given to local authorities. In the Atyrau district for instance, the Department of Environmental Control only has three officers and five inspectors with authority to control and sample water pollution. These officials do not have access to modern equipment and must perform their analyses in old and inefficient laboratories.

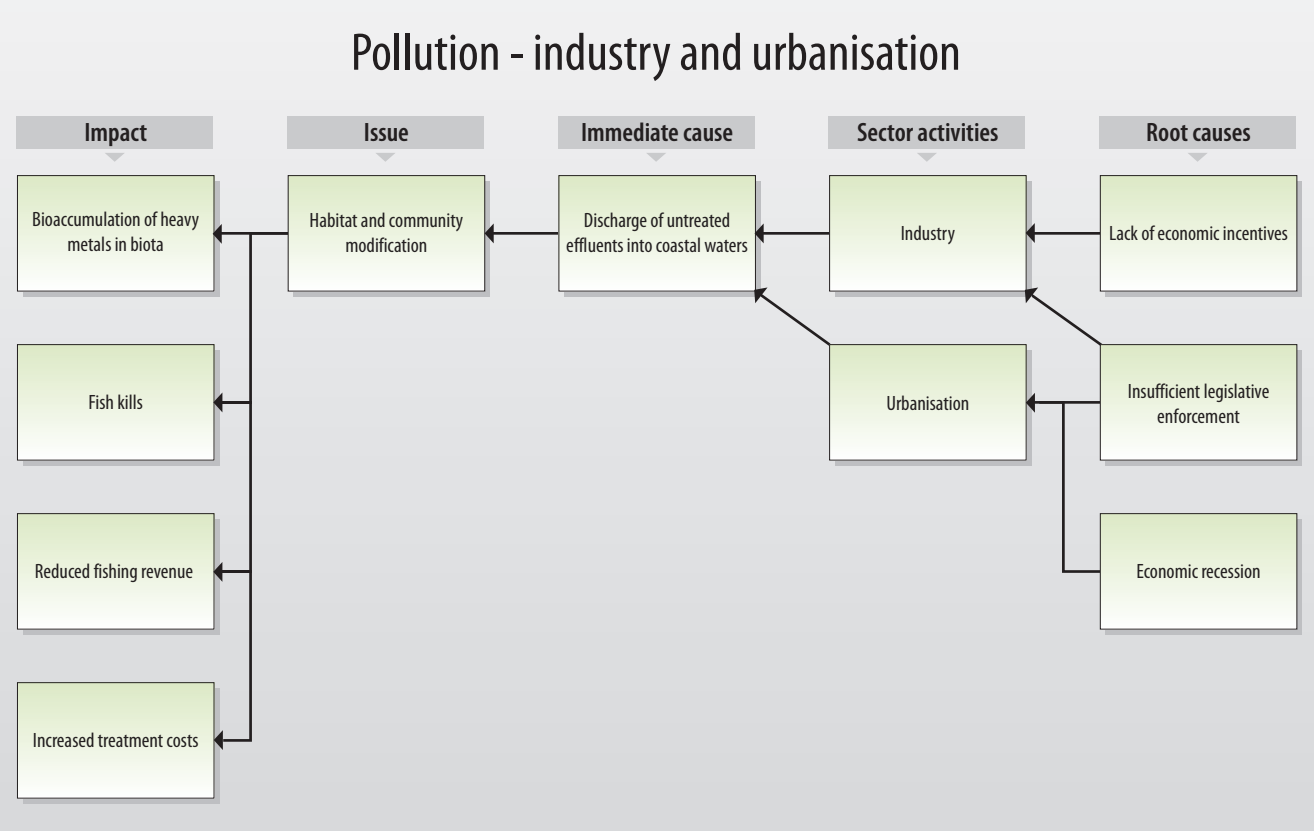

Figure 11 Causal chain diagram illustrating the causal links for industry and urban pollution.

The failure to comply with existing legislation is also due to the lack of economic incentives to improve environmental performance. While most Caspian states have introduced economic penalties for industries that exceed their pollution limits, most enterprises today find it more economically viable to pay the fines than to treat their wastewater. Since many industries in the region have closed down in recent years, the level of discharges into the Caspian Sea has automatically dropped. Therefore, industrial pollution is not currently the main cause of habitat modification in the Caspian Sea, except in some areas with high industrial activity and poor wastewater treatment systems such as in the Terek Delta.

Urbanisation

The causes of urban water pollution are similar to those of industrial discharges. Most of the urban areas around the Caspian Sea rely on old Soviet wastewater treatment systems that are not adjusted to the modern levels of water consumption and therefore are in desperate need of reconstruction. In Sumgait city in Azerbaijan, for instance, the entire wastewater system has collapsed and effluents are discharged into the Sea without any purification. Since the reconstruction requires large investments, the city has been unable to comply with the urban pollution limits enacted by the government. In other cities around the Caspian Sea, the situation is not quite as acute, but the high urbanisation rates in the CEH have lead to increased volumes of wastewater in most cities and old wastewater treatment systems are hence put under pressure.

Oil industry

To date, the Caspian Sea has not experienced any large-scale oil spill, but the increasing regional oil extraction and transport is a matter of great concern (Figure 12). Many parts of the Caspian Sea are so far unaffected by oil pollution. This is true for the northern, mid- and southeastern parts of the Caspian Sea as well as for the Iranian coastline. However, around the Apsheron Peninsula in Azerbaijan, oil pollution is an acute problem and the primary immediate cause of habitat and community modification. The waters outside Turkmenbashi and Cheleken in Turkmenistan and Ataraya in Kazakhstan are also severely affected by oil pollution (CEP 2002c).

While it is difficult to control accidental spills, improved technologies and trained staff could reduce the risks of future large-scale disasters and the sporadic smaller spills. Currently, there is a great need to modernise

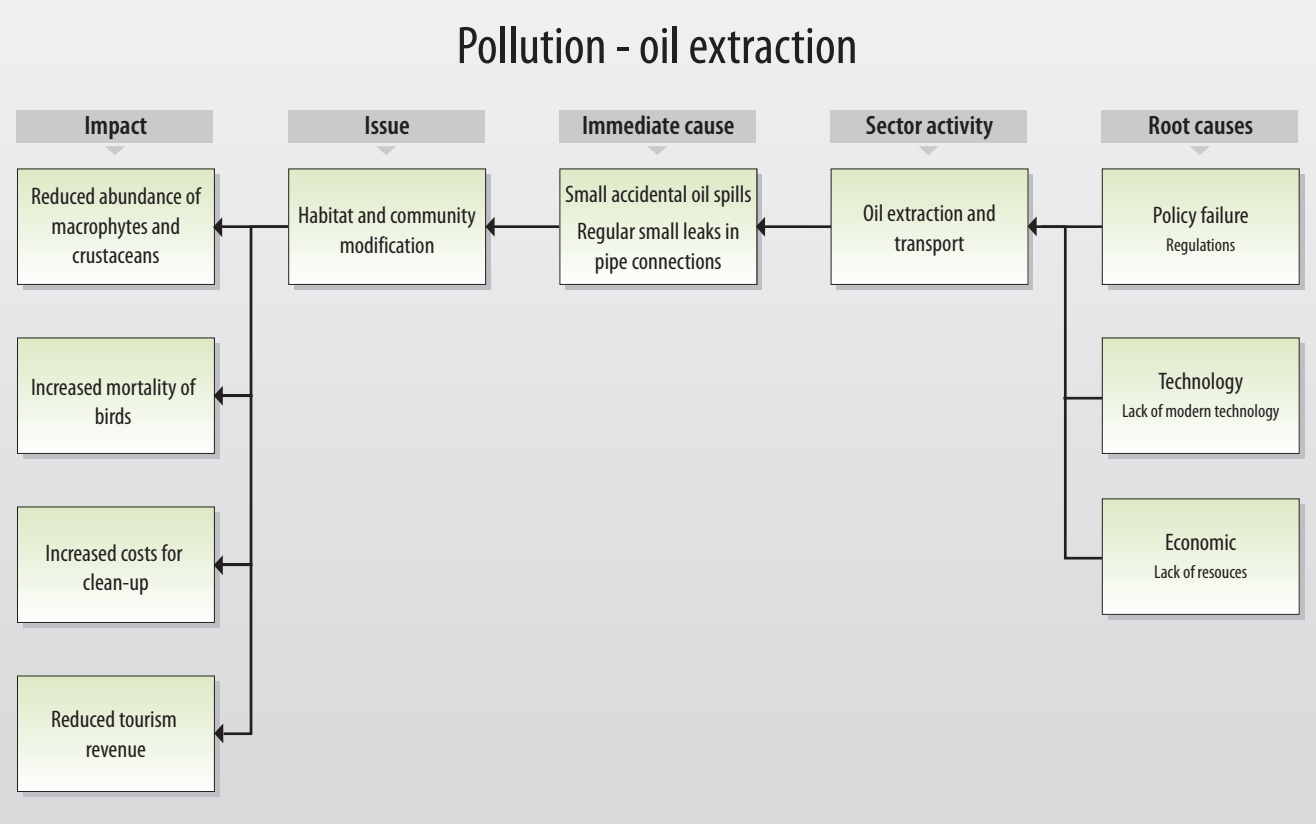

Figure 12 Causal chain diagram illustrating the causal links for oil extraction.

the technology and infrastructure used for the older and often leaking oil wells in the region. For instance, the numerous pipelines along the seabed outside Baku have been leaking since Soviet times. These ongoing small spills have similar impacts as other types of pollution, such as changes in the content of water and sediments, diseases and a decrease in the number of aquatic organisms ranging from micro-organisms to higher plants and animals. Even though they are local, small spills may also have transboundary impacts by affecting critical habitats (spawning, nursing and feeding grounds) of transboundary bioresources (sturgeon, shad, sprat and seals).

Since it is fairly easy to identify the source of smaller oil spills and leakages, oil pollution could be controlled by local or national authorities. However, in Azerbaijan, national oil companies were granted oil deposits by the former Soviet Union and do not have to comply with the pollution limits established by the "Law On Subsoils" from 1998 (CEP 2001). Also, international oil consortia are placed above national legislation and are instead subject to the restrictions established in their contract with the State Oil Company (CEP 2001). In Kazakhstan, it is practically only one international company - the consortium OKIOC - that has the right to develop oil deposits along the Kazakh coast. In 1993, the national government in Kazakhstan adopted a decree that allows the development of oil deposits within the Northern Protected Area. This is a reserve in the northern part of the Caspian Sea established with the purpose of protecting fish resources and creating optimum habitat conditions and natural spawning grounds for sturgeon and other valuable fish species. Also, the Russian government has adopted a decree that permits the oil company Lukoil to explore the Northern Protected Area. Even though the Kazakh decree requires that underground mineral resources users identify ecologically sensitive areas, conduct environmental impact assessments, forecast the ecological consequences of oil extraction and prepare an emergency plan, the compliance with these regulations is debated (CEP 2001).

Poaching and unsustainable harvest practices

Fish has always been a significant part of the diet of people living in the Caspian Economic Hinterland and fishing in the nearby river is an important part of the local lifestyle. The high unemployment rates in most Caspian states have increased the intensity of small-scale fishing for subsistence (Figure 13). Since the black market price for one sturgeon buys food for an entire family for one month, illegal fishing is also increasing in the region. However, the impact of small-scale poaching

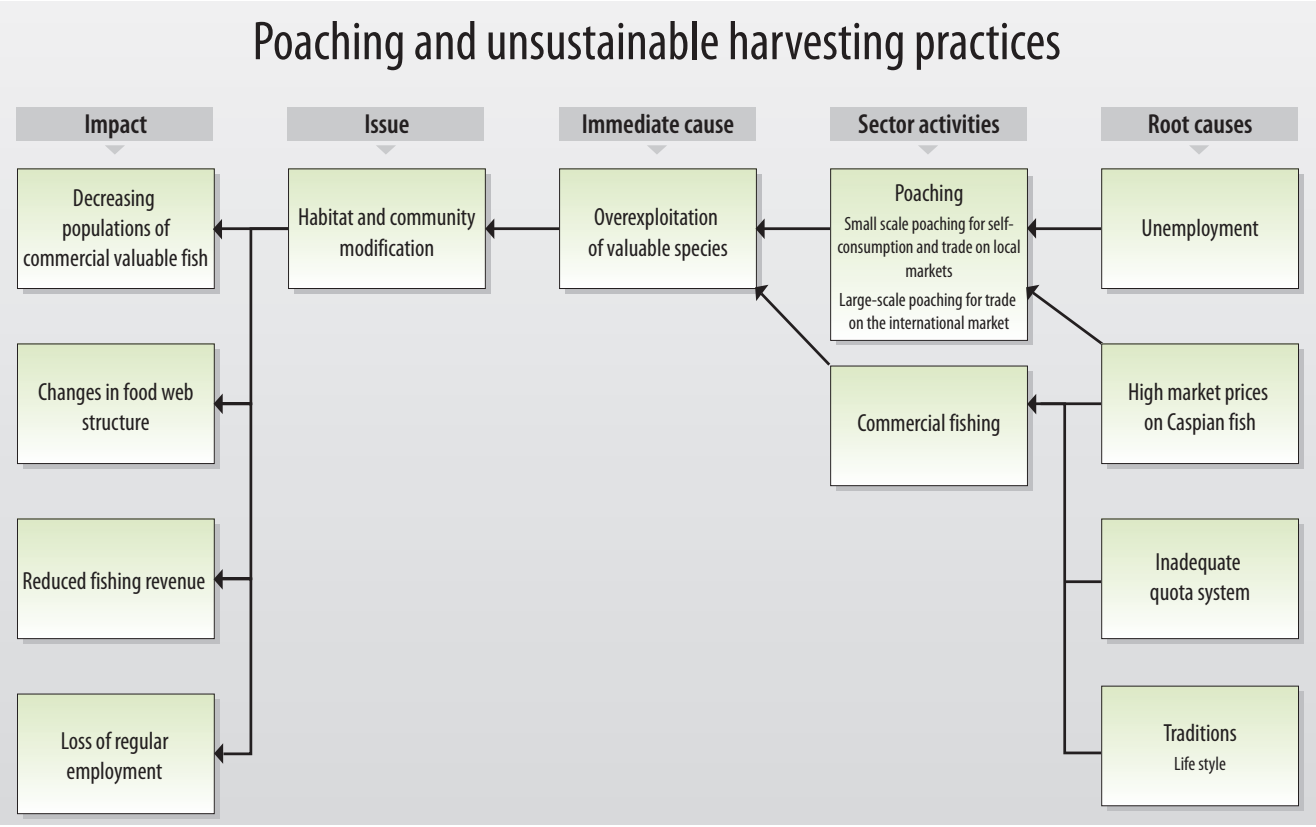

Figure 13 Causal chain diagram illustrating the causal links for poaching and unsustainable harvesting practices.

is limited compared to commercial fishing. The fishing industry is, at present, focused on the most valuable and easily accessible species in the Caspian Sea and ecosystem effects of harvesting are therefore highly disproportionate. Drastic decreases in one species, such as the Great sturgeon (Beluga), have altered the population structures and food web in the Caspian Sea. The negative impacts of commercial fishing are exacerbated by the ongoing "semi-governmental poaching". Since black caviar from the Great sturgeon costs more than 7 500 euro per kg on the international market, illegal organisations, in cooperation with some of the littoral governments, are currently selling unknown amounts of sturgeon abroad.

Fishing is primarily regulated at the national level in the Caspian region. Today, each of the five littoral states has introduced state permits or licences for fishing in specific aquatic areas, and the catches are generally regulated by national quotas (CEP 2001). The quotas in the four former Soviet States are established on the basis of advice provided by the regional Commission on Aquatic Bioresources, which was established in 1992. Each year, the Commission's scientific experts estimate the total fish stock in the Caspian Sea and, on the basis of their estimations, recommend quotas for catches in the coming year. While these scientific recommendations guide the political negotiations between the littoral states, the final allocation of national quotas is in the end a political process that does not always follow the Commission's advice.

The effectiveness of the current quota system is debated. First of all, the system is affected by an old Soviet tradition to exceed quotas. In Soviet times, regional fishing organisations were given quotas by the state as part of the annual organisational plan. If the organisations managed to catch more fish than planned, they were rewarded with a prize, and to exceed quotas was therefore highly beneficial. Today, the reward system is no longer in place, but the tradition survives in many parts of the Caspian region. However, national quotas have not been exceeded by more than 5-10% in recent years. More problematic is the large scientific uncertainty surrounding the ecological processes in the Caspian Sea and the limited appreciation of maximum sustainable yields. The regional scientific expertise is currently underfunded and has, to date, not had the financial or technical resources to conduct a thorough assessment of the living resources in the Caspian Sea. Regional scientists are also exposed to pressure from the littoral governments and the regional fishing industry to adjust the scientific recommendations according to political and economic factors rather than ecological realities.

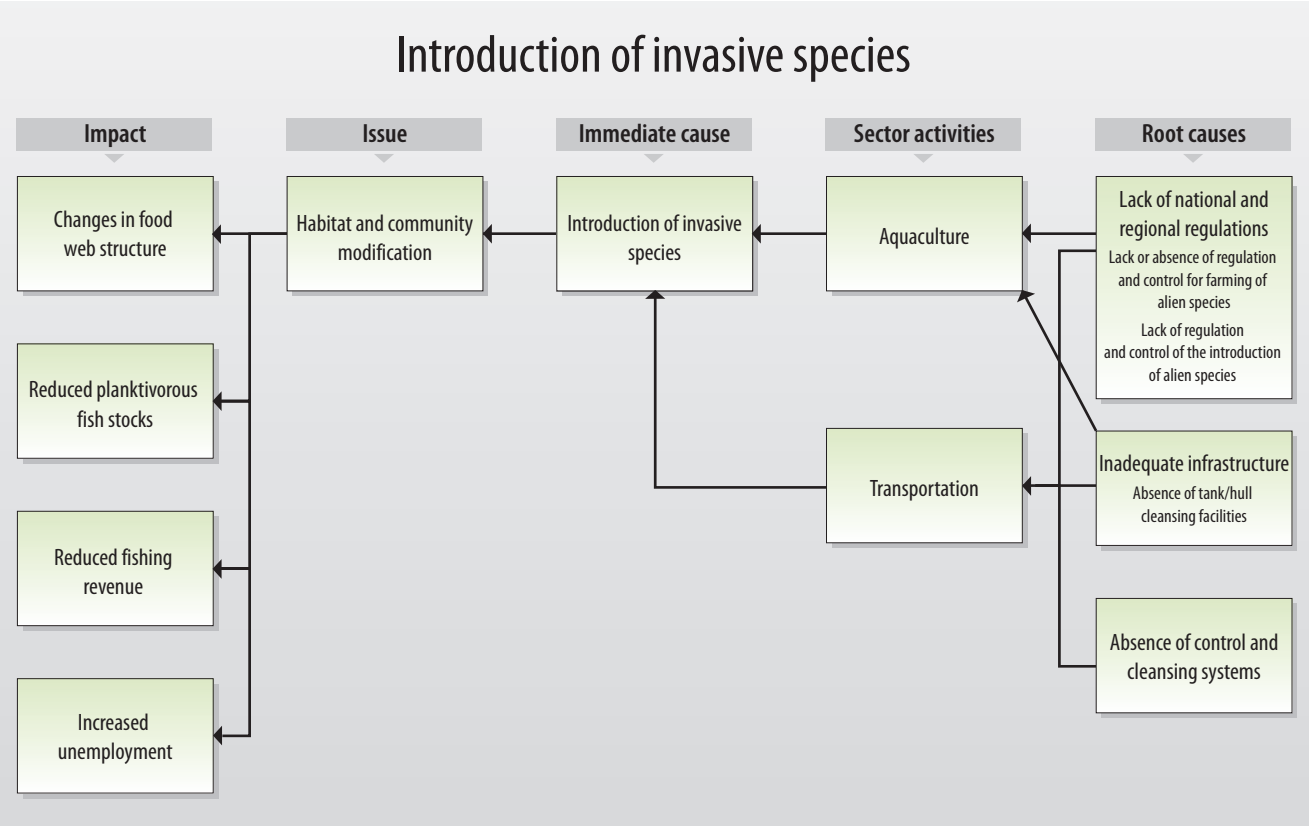

Figure 14 Causal chain diagram illustrating the causal links for the introduction of invasive species.

Introduction of invasive species

Species introduction has a long history in the Caspian region and was initially conducted for commercial purposes. During the period between 1930 and 1975, a range of commercially valuable species was introduced into the Caspian region (Figure 14). During the 1930s the Grey mullet (*Liza auratus*), the Leaping Grey mullet (*Liza saliens*) and the polychaete *Nereis diversicolor* were introduced into the Sea. In the 1960s and 1970s, the Grass carp (*Ctenopharyngodon idella*), the Silver carp (*Hypophtalmichthys molitrix*) and the Spotted silver carp (*Hypophtalmichthys nobilis*) were brought into several river systems in the region, while the Chum salmon (*Oncorhynchus keta*), the Pink salmon (*O. gorbusha*) and the Coho salmon (*O. kisutch*) were introduced into the Caspian Sea (Kazancheev 1981, Mitrofanov 1999, Ivanov 2000). This deliberate species introduction resulted in the elimination of several native species (e.g molluscs such as *Mytilaster* sp. and *Abra* sp.) and also changed some benthic (*Nereis* sp.), plankton (*Rizosolenia* sp.) and fish communities. However, many of the commercial species did not survive in the Caspian waters, and those that found suitable living conditions in the Sea are today part of the modern Caspian ecosystem and no longer pose a threat to natural habitats.

In contrast to the deliberate introduction of species during the 20th century, the existence of invasive species in the Caspian Sea is today primarily accidental. Most of the invasive species pass through the artificial shipways from the Black Sea via the Don and Volga rivers. Since these canals cannot be closed and do not have any system for controlling or preventing migration, small mobile species such as eel and planktonic freshwater organisms are migrating into the Caspian Sea. Alien species are also accidentally introduced into the Sea via ballast water and as fouling organisms on the hulls of ships. While many of these invaders have only limited impact on Caspian ecosystems, others can radically change food webs and hence have the potential to affect many native habitats. The comb-jellyfish, *Mnemiopsis leidyi,* is an example of a recent invader that has managed to alter the habitats of planktivorous species and predators in all areas where it has appeared in large numbers.

Aquaculture is another source of invasive species in the Caspian Sea. Many alien species are today subject to farming (including sturgeon hybrids and paddle fish) and a range of alien feeding organisms is also used in this process. While most hatcheries in the Sea require re-construction in order to prevent accidental penetration of species into open water, aquaculture is today poorly regulated by the littoral states. Regional regulation to control invasive species in the Caspian Sea is in general missing, and the scientific understanding of the consequences is highly inadequate. In the absence of adequate national and regional legislation as well as a shared perception of the risks of invasive species, few investments are currently made to better control the migration of invasive species via shipways or to develop a regional control system for decontamination of ballast tanks and hulls of visiting ships.

Regulation of stream flow by the construction of hydroelectric dams

Regulation of the many rivers flowing into the Caspian Sea has both chronic and acute impacts on the biodiversity of the Sea. Changes in hydrological regimes and reduced spring run-off result in both decreased depth of river delta waterways and reduction in delta vegetation (e.g. reeds, cat-tail and bushes). As spring flows are reduced, the upstream migration of fish for spawning is impeded and essential nursery areas are inaccessible. The construction of dams also floods and destroys spawning sites immediately upstream and, even if special fish ways and lifts are constructed, sturgeon and salmon often fail to reach potential spawning grounds further upstream. Spawning grounds for migratory species are also lost when delta vegetation is reduced. Together, these factors have caused a drastic reduction in the Caspian salmon and sturgeon populations. The only remaining natural spawning grounds for sturgeon are located along the Ural River and in the few Iranian rivers that are not affected by the extraction of sand and gravel from the riverbed.

In addition to these long-term and chronic impacts on the biodiversity of the Caspian Sea, hydroelectric plants also have acute effects. In order to prevent dangerous overflowing of dams, many reservoirs in the region have in recent years chosen to release water prior to the spring thaw. These early releases carry heavy sediment loads and alter the flux of biogeochemically active substances in the Caspian Sea (Aubrey 1994). This large and early nutrient input into the still frozen sea, alters both the location and timing of the entire north Caspian phytoplankton-based food web and inhibits spring spawning migrations by damaging bottom and coastal ecosystems. During periods of low flow in the summer and winter, the water levels are on the other hand kept high in the reservoirs for the production of hydroelectricity. While this regulation of stream flow reduces river influx into the Caspian Sea, shallow branches of rivers and flood plains downstream tend to dry up.

There is an additional conflict between energy and ecological interests in the regimes of water flow discharge regulation, i.e. intra-daily distribution of water flow. From the energy production point of view, discharges of water through the dams should be timed so as to provide for the increased (peak) energy demands that occur during two-three hours in the morning and evening while from the environmental point of view this discharge should be distributed evenly throughout the day. At the present time, the operational guidelines for the regulation of

stream flows through the existing hydropower plants do not meet this environmental demand. The lack of national environmental legislation controlling the regulation of stream flow by hydropower plants is one of the underlying reasons of habitat and community modification in the Caspian Sea and river deltas. National and regional expert advice on environmentally sound control for the regulation of stream flow is also inadequate.

Conclusion

The causal chain analysis of Habitat and community modification in the Caspian Sea and its coastal zone has identified a number of recurring drivers or root causes (Figure 15). It seems that many of the immediate causes are primarily affected by insufficient enforcement of national legislation, absence of regional regulations, inadequate expert advice and both the overall economic situation in the region, and low levels of public participation and environmental awareness/transparency. Some of the root causes such as regional poverty and the economic recession are difficult to change in the immediate future and are, to a large extent, dependent upon international and national factors. Other root causes are more specific to the Caspian Economic Hinterland and are hence within reach of local and regional governance.

This study identified four primary immediate causes of habitat and community modification in the Caspian Sea and its coastal zone: pollution as a result of oil spills and agricultural discharges; poaching and unsustainable fishing practices; introduction of invasive species; and regulation of stream flow by dams on rivers discharging into the Caspian Sea. The following root causes were identified as the most pressing for each immediate cause:

- Pollution: Old technology and infrastructure for oil extraction and insufficient control of harmful pesticides;
- Poaching and unsustainable fishing practices: Inadequate expert advice on quotas and insufficient enforcement of existing legislation;
- Introduction of invasive species: Absence of cleansing facilities to treat ship ballast water and hulls; and
- Regulation of stream flow: Insufficient control of water discharges by dams.

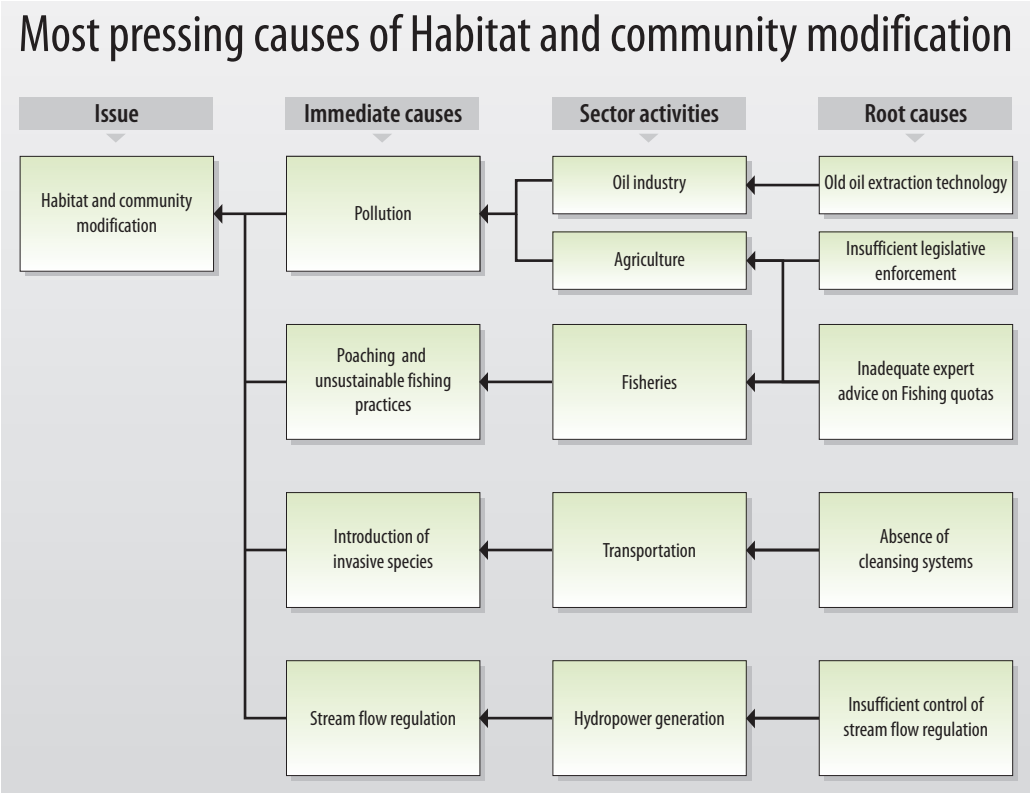

Figure 15 A summary illustrating the main causal links for Habitat and community modification in the Caspian Sea and its coastal zones.

Policy options

This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

Problem definition

The primary immediate causes of Habitat and community modification in the Caspian Sea and its coastal areas include: pollution from oil spills; heavy metals and environmentally harmful pesticides such as DDT; poaching and unsustainable harvesting practices; introduction of alien species; and regulation of stream flow by the construction of dams on the Volga, Kura and Sefid-Rud rivers. A number of root causes were identified as particularly urgent for the Caspian Economic Hinterland (CEH) and therefore prioritised in this policy options analysis. These root causes include: insufficient control of harmful pesticides; old technology and infrastructure for oil extraction; inadequate expert advice on fishing quotas; absence of regional decontaminating facilities for ballast tanks and hulls; insufficient controls for regulating stream flow by dams; and excessive extraction of freshwater from rivers. Possible policy interventions were explored for each of the prioritised root causes.

Policy options

Harmful pesticides

The use of environmentally harmful pesticides in small-scale farming along the Caspian coastline and river deltas has been identified as a serious threat to the aquatic biodiversity in the region. In order to reduce the discharge of toxic and bioaccumulative substances into coastal waters, legislative enforcement must be strengthened. As pointed out in the Causal chain analysis, the sale and use of DDT has been legally prohibited in the former Soviet states for three decades but the supply is still abundant throughout the CEH. To better enforce the ban on DDT, regional control functions need to be strengthened and local officials must be given the necessary resources to control local market supply and sale. The feasibility and effectiveness of improved legislative enforcement are expected to be high since forbidden chemicals are easy enough to identify and confiscate. Responsibility for improved enforcement should be given to local and municipal authorities.

A recommended parallel measure is to provide local farmers with economically viable alternatives to DDT. This could be done by reducing import taxes on modern and less environmentally harmful pesticides. Today modern pesticides are generally more expensive than DDT on the local markets in the CEH, and can therefore not compete with traditional products. Tax reductions could lower the prices on modern pesticides substantially, but it is unlikely that prices can drop enough to compete with the very cheap chemicals currently in use. The short-term effectiveness of a state driven substitution of obsolete pesticides is hence expected to be fairly low. This measure is however still recommended as a long-term policy for all Caspian states.

Since the public awareness of the ecological consequences of DDT use is generally low in the region, educational efforts would complement the two top-down measures suggested above. Special training, lectures

and educational TV programmes need to be developed and offered both to authorities and local communities in the region. A better public understanding of the ecological vulnerability of the Caspian waters can, in the long run, increase local engagement in the regional environment. Educational policies are hence to be recommended on a broad scale in all five littoral countries.

Infrastructure for oil extraction

Old technical equipment used in the extraction and transport of oil is the most important root cause of oil pollution in the Caspian waters. Much of the small but regular leakage from oil wells and pipelines could be effectively reduced if the infrastructure in use is reconstructed or replaced. However, since local authorities in most Caspian states fail to control pollution from point sources and the legal consequences of exceeding pollution limits are generally very limited, the regional oil industry has few economic incentives to modernise its equipment. Improved local control of oil wells and pipelines and more effective taxes or fines on oil pollution are hence central strategies to enforce the "polluter pays principle" in the region.

A parallel strategy would be to stimulate the introduction of "green technologies" and hence support the modernisation of the Caspian oil industry. While the former measure is important, the general effectiveness is expected to be limited since pollution taxes or fines most likely will be lower than costly reconstructions. It is also unlikely that the introduction of "green technologies" would generate immediate effects, but the long-term benefits are expected to be significant.

Expert advice and fishing quotas

Inadequate expert advice has been identified as the primary root cause of overfishing in the Caspian Sea. As suggested in the Causal chain analysis, the regional Commission on Aquatic Bioresources provides the scientific advice for the establishment of annual fishing quotas in the Sea. Since the scientists involved in this process are put under pressure by the littoral governments and the fishing industry, the recommended quotas are often influenced by political and economic considerations. Therefore, it is important to make the Commission politically independent if more ecologically sustainable quotas are to be imposed. A second, and perhaps even more important policy measure is to stimulate research in the Caspian Sea in order to improve the scientific understanding of the decreasing fish stocks. Currently a range of factors such as overfishing, climatic and hydrological changes and local population fluctuations are suggested as possible causes, but their relative importance is still highly uncertain.

However, improved scientific advice is not the only key to effective fishing quotas in the Caspian Sea. Reduced fishing levels in the Sea also require that quotas are respected. This problem refers mostly to the dire economic situation of the small-scale fishermen. The Tacis project, which is a partnership between the EU and the Newly Independent States, has clearly acknowledged this and will address poaching and unsustainable fishing practices by enhancing/improving community livelihoods. Today, small and large-scale poaching is a significant problem that must be better controlled by all littoral states. While local controlling institutions need to be reorganised and strengthened by better equipment and trained staff in order to enforce fishing quotas, the effectiveness of control measures is expected to be relatively low. This is due to the widespread corruption in the region and the high domestic and international market prices on sturgeon that make illegal trade a highly lucrative business.

Decontamination of ship hulls and tanks

As identified in the Causal chain analysis, alien invasive species have been accidentally introduced into Caspian waters via ballast water of visiting ships and as hull fouling. Since all sea transport from outside the Caspian Sea is channelled through the Volga River, a facility for hull cleansing and control of ballast water is currently under construction in the strategically located port of Astrakhan. The Russian Ministries of Ecology and Transport are responsible for the construction in cooperation with the local authorities in the Astrakhan Oblast. While this initiative is expected to effectively reduce the number of alien species in the Caspian Sea, the project is currently in need of additional funding.

A regional organisation devoted to the control of alien invasive species is another longer-term measure that could reduce the habitat and community modification in the Caspian waters. Such an organisation could strengthen the institutional framework necessary to control the currently unregulated aquaculture in the Sea, and support the control facility in Astrakhan port. However, strengthened local control in the five littoral states is expected to be more effective than cooperative efforts.

A more specific measure aimed to control the negative effects generated by the recent invader, the comb-jellyfish *Mnemiopsis leidyi*, is the deliberate introduction of another comb-jellyfish, *Beroe ovata*, which feeds on *Mnemiopsis*. Since the consequences of this measure are not fully understood, scientific studies are currently being undertaken in Russia, Iran and Azerbaijan. However, these studies are also under-funded and hence need support from the international community.

Regulation of stream flow

There are three main groups of stakeholders affected by the construction of dams on the Caspian rivers. These include the power industry, farmers in need of irrigation, and fishermen. Since the interests of these three groups do not coincide, the regulation of stream flow in dammed rivers requires careful management. As suggested in the Causal chain analysis, the construction of large dams, particularly the Volgograd Dam on the Volga River and the Mingechaur Dam on the Kura River, has resulted in a 90% loss of spawning grounds for mature sturgeon and blocked important migratory pathways. To safeguard the sturgeon's continued existence in the Caspian Sea, the remaining spawning grounds need to be protected. Economic instruments such as fines and compensations could be introduced at the national and local level in order to internalise the external costs of damaged bioresources. Water prices that better reflect the ecological consequences of stream flow regulation are likely to stimulate a more sustainable water use in the region. Local and national authorities would be responsible for the implementation of these measures.

Finally, national regulations on dam construction and operation need to be substantially improved and better enforced in all five littoral states, in order to provide for the environmentally sound regulation of stream flows within rivers entering the Caspian Sea.

Recommended policy options

The policy options recommended to reduce habitat and community modification in the Caspian Sea can be grouped under four main headings: Control functions, Infrastructure, Economic instruments and Science and education.

1. Control functions:
- Strengthen local control of prohibited chemicals;
- Strengthen local control of oil wells and oil pipelines; and
- Strengthen local control of poaching.

As suggested by this study, improved local control of chemical use, oil extraction and transport as well as poaching are central in order to reduce habitat and community modification in the Caspian waters. National and local authorities tend to share the cost and responsibility for legal enforcement in the former Soviet states. While strengthened local control is important, the effectiveness is impeded by the ongoing corruption among state officials in these countries.

2. Infrastructure:
- Modernisation of regional oil industry; and
- Facility for ballast water control and hull decontamination.

Modernisation of the equipment used by the regional oil industry and the control of transport vessels in the Astrakhan port are important but expensive measures. As a consequence, it is important to enact the "polluter pays principle" and hence make oil companies share the implementation costs. When implemented, these measures can be very effective since they are expected to drastically reduce oil pollution and the number of alien invasive species in the Caspian Sea.

3. Economic instruments:
- Tax reductions on less harmful pesticides;
- Point taxes and fines on oil pollution;
- State stimulation of "green technologies"; and
- Fines on damaging stream flow regulation.

A range of economic instruments can be used to stimulate more sustainable production and consumption patterns in the region and hence reduce the ongoing Habitat and community modification. While national and local authorities in the littoral states are responsible for developing suitable instruments, international advice will be important in this process.

4. Science and education:
- Environmental training for the public;
- Expert independence from authorities and fishing industry;
- Scientific research on Caspian fish populations;
- Increased public participation; and
- Institutional strengthening of key managerial institutions.

Raising public awareness of the Caspian environment and investment in further research are important long-term measures for reducing Habitat and community modification in the region. While educational and research efforts will not generate direct effects, they may, in time, lead to a more sustainable management of the aquatic resources in the region.

A detailed assessment of performance of the suggested indicators and level of implementation of the suggested policy options are given in Annex IV.

Comparison with existing international programmes

Possible policy measures for the environmental protection of the Caspian Sea and its coastal areas have been explored prior to the GIWA assessment by the Caspian Environment Programme and in the GEF sponsored Transboundary Diagnostic Analysis. CEP Strategic Action Plan highlights four areas of concern, namely: fisheries development, biodiversity protection, pollution monitoring and control, and sustainable development of coastal areas and has further identified five Environmental Quality Objectives (EQO):

1. Conservation and sustainable use of commercial fisheries resources
2. Conservation of biodiversity
3. Improvement of the water quality of the Caspian Sea
4. Sustainable development of the coastal zones
5. Strengthening of stakeholder participation in Caspian environmental stewardship

TDA policy options are comprehensively described in the TDA reports and provide a good basis for environmental management in the Caspian Economic Hinterland. Many of the policy recommendations in this report coincide with these previous studies. These include:

- To reduce the oil pollution from offshore activities in the Caspian Sea;
- To ensure safe transportation of hydrocarbons and other raw materials;
- To achieve sustainable use of aquatic resources with emphasis on fisheries;
- To establish a control system for the import and export of alien species into and from the Caspian Sea;
- To prevent adverse human activities in sensitive areas (including deltas, reed beds, macrophyte habitats);
- To upgrade/renovate existing treatment plants for mechanical and biological treatment (but compatible with future upgrade to nutrient technology, if studies so suggest);
- To develop training and re-skilling programmes taking into account similar efforts being implemented by other organisations and programmes; and
- To agree to a list of banned agro-chemicals and a programme to destroy stored banned products.

At the same time, the present study emphasises the importance of using already existing legal, institutional and public awareness resources under the local, national and international governance in order to enable a rehabilitation of the habitats and communities in the Caspian Sea.

Conclusions and recommendations

The catchment area of the Caspian Sea is 3.1 million km^2, entirely or partially covering eight countries: Russia, Azerbaijan, Iran, Kazakhstan, Turkmenistan, Georgia, Turkey and Armenia. These include the five littoral states: Russia, Azerbaijan, Iran, Kazakhstan and Turkmenistan as the main part of the drainage basin. The scaling procedure was implemented in order to define the most significant part of the Caspian Sea region and the most significant transboundary waters in terms of productivity and biodiversity. As a result, water-bodies of the Caspian Economic Hinterland (CEH) were recognised as having highest transboundary significance, productivity and biodiversity. The CEH has been defined as the geographical area including the Caspian Sea itself, freshwaters of the coastal areas, and all land between the Sea and the first administrative line in the territory of each state. Only those parts of the Volga downstream of Volgograd and those parts of the Kura downstream of the Mingechevir Dams were included in the assessment. In addition, the same administrative units that defined the CEH were used to define the geographical extent of this assessment. These were: Gilan, Mazandaran and Golestan in Iran; Balkan in Turkmenistan; Atyrau and Mangistau in Kazakhstan; Astrakhan, Daghestan and Kalmykia in Russia; and Guba-Khachmaz, Absheron, Central Aran and Lenkoran in Azerbaijan.

Having studied the complex environmental and societal impacts of each GIWA concern, using the geographical area defined by the CEH as the foundation of the assessment, the concerns were ranked in descending order of importance:

1. Habitat and community modification
2. Unsustainable exploitation of fish and other living resources
3. Pollution
4. Freshwater shortage
5. Global change

Having analysed the results of the assessment of GIWA concerns and issues, and taking into account the trends of the problems for the region, Habitat and community modification was identified as the priority concern and selected for Causal chain analysis.

During the Causal chain analysis, immediate causes were identified and ranked for the whole Caspian region. Twelve experts from all five riparian countries scored the importance of each immediate cause on a scale between 0-100, taking into consideration the present situation and possible changes during the next 10 years. All experts agreed that the situation in the future could be worse. Analysis of the experts' estimation showed that each country had its own priorities among the immediate causes. Usually causes are the same for the Sea and freshwater basin.

The most important immediate causes were identified as the following:

- Pollution as a result of oil spills and agricultural discharges;
- Introduction of alien invasive species like the comb-jellyfish *Mnemiopsis*;
- Poaching of valuable species and unsustainable harvesting practices in the fishery; and
- Regulation of stream flow by dams on the rivers discharging into the Caspian Sea.

The most important sector activities were defined as the following:

- Agriculture (run-off of fertilisers and pesticides and construction of irrigation systems);
- Fisheries (overfishing and introduction of commercially valuable species, feeding organisms and accidental introduction);
- Industry;
- Transport; and
- Energy production.

It is obvious that not all the root causes identified could be eliminated in the near future, such as poverty, population growth and economic growth. These global root causes should be targeted as part of a larger national development programme. However there are several root causes that warrant special attention in socio-cultural, knowledge, legal and technological areas.

For the four most important immediate causes, several root causes were identified:

- Access to technology (bad equipment especially old oil wells and pipelines);
- Availability of cheap, but obsolete insecticides and absence on the local market of environmentally acceptable alternatives;
- Absence of cleaning and decontaminating facilities for ships (tanks/hulls);
- Poor expert advice on quotas, inadequacy of laws and administrative regulation and equipment;
- Poor environmental control of the regulations of stream flow by dams; and
- Excessive extraction of freshwater from incoming rivers.

Analysis of the main root causes showed that for different sectors of activities the same root causes were often found. The policy options recommended to reduce Habitat and community modification can be grouped into a few clusters.

1. Establishing and strengthening regulations to control environmentally damaging activities in the region:
- Establishing and/or strengthening the control of the sale of prohibited chemicals on the local market;
- Strengthening the control of leaks from active and blocked oil wells and oil pipelines;
- Reorganising and strengthening organisations responsible for regulation of fishing activities in the region.

For this cluster, national and local authorities are responsible and money needs to come from national and local budgets. It is a traditional way to solve the problems in all post-Soviet countries. This action can be very effective, but the effectiveness decreases due to corruption and venality at the officer level.

2. Creation or refurbishment of facilities:
- Refurbishment of old oil wells and pipelines;
- Renovation of old water purification systems;
- Creation of special sanitary facilities for decontamination of vessels' tanks and hulls; and
- Improve equipment for fish migration protection related to operations of dams.

All these actions need additional investment and could be very expensive. From this point of view, the responsibilities and budgets should be divided between local authorities and when relevant, oil companies.

3. Socio-economic actions:
- Provide the local market with cheap, effective and environmentally acceptable chemicals; and
- Develop a system of incentives for using "green technologies".

Both policy options can contain a package of different smaller actions that refer to improvement in the legislation and regulation systems. National and local authorities are responsible, but for many smaller actions advices and/or financial help from specific international organisations are needed.

4. Science and education:
- Conduct special ecological training courses, lectures and videos;
- Ensure autonomy and independence of experts from authorities and the fishery industry;
- Build the capacity of staff responsible for the operations of dams with expert training and scientific investigation of fishing and operation of dams.

Development and subsequent implementation of policies is very important, but the effectiveness and efficiency can be very low at the beginning and will increase in future. Education processes, scientific studies, and high expert qualification cannot improve the situation in the region by themselves, but only indirectly. In time, decisions on environmental management and sustainable use of natural resources will improve.

The policy options and their background are planned to be presented to the scientific international community, local, regional and international decision-makers, funding bodies and the public.

Carrying out the above recommendations would contribute to mitigating the identified environmental problems of the Caspian Sea region.

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Annexes

Annex I
List of contributing authors and organisations

Name	Institutional affiliation	Country	Field of work
Prof. Felix Stolberg (regional coordinator)	Kharkov Academy of Municipal Economy	Ukraine	Environmental engineering
Dr. Olena Borysova (deputy regional coordinator)	Kharkov Academy of Municipal Economy	Ukraine	Environmental policy
Dr. Igor Mitrofanov (local focal point since October 2002)	Institute of Biology, Kazakhstan Academy of Science, Alma-Aty	Kazakhstan	Marine biology
Dr. Rowshan Mahmudov (local focal point until October 2002)	Caspian Centre for Pollution Control, Caspian Sea Environmental Protection, Baku	Azerbaijan	Environmental chemistry
Dr. Serik Akhmetov	Head of the division for water usage and regulation of the Committee for Water Resources of the Ministry of Agriculture, Astana	Kazakhstan	Environmental officer
Dr. Peyman Araghi (deputy local focal point)	Biology Department, Iranian National Centre for Oceanography, Tehran	Iran	Marine biology
Dr. Valeriy Barannik	Kharkov Academy of Municipal Economy	Ukraine	Water modelling
Prof. Mikhail Bolgov	Head of the Caspian Sea Laboratory, Institute of Water Problems, Russian Academy of Science	Russia	Marine water science
Dr. Latifa Husejnova	Senior expert, Department of Ecological Expertise, Ministry of Environment of Azerbaijan	Azerbaijan	Environmental Impact Assessment
Dr. Hamid Jafar-zadeh	Caspian Sea Environmental Program, Baku-Tehran	Iran	Environmental economics
Dr. Evgeniy Khlobystov	Council of the Study of the Production Forces, National Academy of Science, Kiev	Ukraine	Environmental economics
Prof. Martin Khublarian	Institute of Water Problems, Russian Academy of Science, Moscow	Russia	Water science
Dr. Aleksander Korshenko	Head of Marine Pollution Monitoring Laboratory, State Oceanographic Institute, Moscow	Russia	Environmental monitoring
Dr. Valeriy Lysenko	Department of Geo-Research, Institute of Ecology and Sustainable Development, Alma-Aty	Kazakhstan	Geology and geography
Dr. Irina Patoka	Senior researcher, Ukrainian National Acvadey of Science	Ukraine	Social geography
Dr. Djumamurad Saparmuradov	National Contact person for Biodiversity, Ministry of Nature protection of Turkmenistan	Turkmenistan	Biodiversity
Prof. Victor Sapozhnikov	Marine Ecology Laboratory Russian Federal Research Institute of Fisheries and Oceanography, Moscow	Russia	Fisheries
Mr. Olexiy Varivoda	MSc Student, Kharkov National University, Department of Geography	Ukraine	Geographic computer design
Dr. Vladimir Vladimirov	Caspian Sea Environmental Program, Baku	Azerbaijan	Scientific liaison and information management
Mr. Namiq Zeynalov	Expert, Department of Ecological Expertise, Ministry of Environment of Azerbaijan	Azerbaijan	Environmental Impact Assessment

Annex II
Detailed scoring tables

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	1	N/a*	Freshwater shortage	1.33
2. Pollution of existing supplies	2	N/a		
3. Changes in the water table	1	N/a		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	33.3
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	33.3
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33.4
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	28.5
Degree of severity	Minimum – Severe 0 1 2 3	2	28.5
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	43
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	40
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	20
Weight average score for Other social and community impacts		**1.8**	

**not applied*

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	1	N/a	Pollution	1.37
5. Eutrophication	2	N/a		
6. Chemical	2	N/a		
7. Suspended solids	1	N/a		
8. Solid wastes	1	N/a		
9. Thermal	1	N/a		
10. Radionuclide	1	N/a		
11. Spills	2	N/a		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	33.3
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	33.3
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33.4
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	20
Degree of severity	Minimum – Severe 0 1 2 3	2	40
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	40
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	33.3
Degree of severity	Minimum – Severe 0 1 2 3	2	33.3
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33.4
Weight average score for Other social and community impacts		**2.0**	

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	2	N/a	Habitat and community modification	2.0
13.Modification of ecosystems or ecotones, including community structure and/or species composition	2	N/a		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	28.5
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	28.5
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	43
Weight average score for Economic impacts		**2.43**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	28.5
Degree of severity	Minimum – Severe 0 1 2 3	2	28.5
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	43
Weight average score for Health impacts		**2.43**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	16.7
Degree of severity	Minimum – Severe 0 1 2 3	2	33.3
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	50.0
Weight average score for Other social and community impacts		**2.33**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	N/a	Unsustainable exploitation of fish	2.2
15. Excessive by-catch and discards	2	N/a		
16. Destructive fishing practices	2	N/a		
17. Decreased viability of stock through pollution and disease	2	N/a		
18. Impact on biological and genetic diversity	2	N/a		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	33.3
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	33.3
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33.4
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	33.3
Degree of severity	Minimum – Severe 0 1 2 3	2	33.3
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33.4
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	28.5
Degree of severity	Minimum – Severe 0 1 2 3	2	28.5
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	43.0
Weight average score for Other social and community impacts		**2.43**	

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	1	N/a	Global change	1.0
20. Sea level change	2	N/a		
21. Increased UV-B radiation as a result of ozone depletion	1	N/a		
22. Changes in ocean CO_2 source/sink function	0	N/a		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	1	25
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	1	25
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	2	50
Weight average score for Economic impacts		**1.5**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	1	25
Degree of severity	Minimum Severe 0 1 2 3	1	25
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	2	50
Weight average score for Health impacts		**1.5**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	1	33.3
Degree of severity	Minimum Severe 0 1 2 3	1	33.3
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	1	33.4
Weight average score for Other social and community impacts		**1.0**	

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall Score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.33	2.3	2.0	2.3	2.0	2.3	1.8	2.2	**1.99**
Pollution	1.37	2.0	2.0	2.3	2.0	2.3	2.0	2.3	**2.03**
Habitat and community modification	2.0	3.0	2.43	3.0	2.43	2.8	2.33	2.7	**2.59**
Unsustainable exploitation of fish and other living resources	2.2	2.5	2.0	2.1	2.0	2.1	2.43	2.5	**2.23**
Global change	1.0	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.24**

Annex III
Causal chain analysis – detailed evaluation tables

1. Environmental impacts

Habitat and community modification. Experts evaluation (all countries)

Organisms used as impact indicator s		Environmental impacts								
		1. Modification of natural productivity or population size	2. Modification of biodiversity	3. Changes in ecosystem stability	4. Changes in community structure	5. Increase in susceptibility to disease	6. Changes in migratory species and in migratory system	7. Modification in natural storm barrier and reduced protection from erosion	8. Increased vulnerability to opportunistic invaders	Total
Fish (all species)	i	18	15	18	17	14	18	8	15	123
	ii	21	23	21	15	18	15	10	24	147
Caspian seal	i	11	11	13	9	18	9	3	8	82
	ii	18	13	16	14	21	11	3	14	110
Birds (terrestrial, waterfowl, shorebirds)	i	9	6	10	8	12	8	7	5	65
	ii	13	11	15	12	13	11	7	8	90
Mammals (terrestrial, wetland)	i	12	6	11	7	9	4	6	4	59
	ii	12	11	14	10	15	7	11	4	84
Zooplankton	i	18	14	19	14	6	9	9	15	104
	ii	19	15	18	16	6	11	8	17	110
Zoobenthos (macro-, micro-)	i	12	12	13	11	7	6	6	10	77
	ii	12	13	14	10	8	5	7	11	80
Total	i	80	64	73	66	66	54	39	57	
	ii	95	86	98	77	81	60	46	78	

Notes: i) current, ii) future

Expert evaluations suggest several conclusions:

1. *The most vulnerable are fishes and zooplankton (seals are important, but come only second);*
2. *Birds and terrestrial mammals are of less concern;*
3. *Modification of natural storm barriers and reduced protection from erosion is of less concern for biota. This kind of impact could be left out in the further analysis;*
4. *All experts predict worsening of the situation in the future;*
5. *Modification of ecosystem productivity and change in ecosystem stability are the most important. This result can reflect the scientific backgrounds of experts (most of them are scientists: biologists, ecologists, chemists).*

2. Socio-economic impacts

Habitat and community modification

Countries	Basin	Socio-economic impacts (1. Reduced capacity to meet human needs, 2. Loss of income, 3. Loss of employment, 4. Loss of aesthetic and recreation value, 5. Loss of cultural heritage, 6. Increased risk from natural disaster, 7. Costs of controlling invasive species, 8. Other)						
		Economic impacts (Weight average score 2.4 of max 3.0 - according to scoping results)		Health impacts (Weight average score 2.4 of max 3.0 - according to scoping results)		Social and community impacts (Weight average score 2.3 of max 3.0 - according to scoping results)		Economic damage by habitat modification (estimation) (million USD)
Azerbaijan	Sea	2	80%	1	100%	1	30%	
	Freshwater	3	100%	2	80%	2	60%	
Iran	Sea	1+2+3+4+6	100%	1+2+3+4	100%	1+2+3+4+7	100%	800
	Freshwater	1+2+3+4+6	100%	1+2+3+4	100%	1+2+3+4+7	100%	10 000
Kazakhstan	Sea	1+2+4+6+7	80%	1	60%	1+2+3	80%	5 000
	Freshwater	2	80%	1+7	60%	7	50%	3 000
Russia	Sea	2	80%	1	80%	All equal		500-3 000
	Freshwater	2+3	100%	1+4	80%	All equal		3 000-5 000
Turkmenistan	Sea	1+2+3	60%	1+2+3	60%	1+2+3	60%	55
	Freshwater	1+2+3	60%	1+2+3	60%	1+2+3	60%	150

3. Immediate causes

Habitat and community modification

Assessed area	Basin	Immediate causes									
		1. Unsustainable harvesting practices in fisheries	2. Chemical pollution including accidents	3. Stream flow regulation by hydro-technical constructions on rivers	5. Change of sea level as natural phenomena	6. Introduction of invasive species	7. Oil production and transport	8. Coastal erosion, sludging, dredging of water bodies	9. Land use	10. Eutrophi-cation	11. Poaching
Azerbaijan	Sea	5	10	5	15	20	5	15	0	0	25
	Freshwater	5	10	5	20	10	5	15	0	5	25
Iran	Sea	10	25	10	10	25	10	5	5	5	0
	Freshwater	10	25	10	10	0	0	10	20	15	0
Kazakhstan	Sea	10	15	10	15	10	10	0	5	0	25
	Freshwater	10	15	15	10	0	5	5	10	5	25
Russia	Sea	10	10	25	5	10	15	0	0	10	15
	Freshwater	10	15	30	5	5	15	0	0	10	10
Turkmenistan	Sea	10	15	5	10	15	15	10	5	5	10
	Freshwater	10	5	35	20	10	5	5	5	5	10
Total	Sea	45	70	55	55	80	55	30	15	20	70
	Freshwater	45	75	95	65	25	30	35	35	40	75

Each country has its own priority concerning the immediate causes of the environmental problem. Usually causes are the same for the Sea (A) and freshwater basin(B).

Invasive species is the most important cause for the whole sea with two sub-dominants (chemical pollution and poaching). In the freshwater basin there is another dominant cause – stream flow regulation with the same sub-dominants (chemical pollution and poaching). Land use and eutrophication are of low importance both in the Sea and the freshwater basins, while species introduction is not a major issue in the freshwater basins.

4. Sector activities

Habitat and community modification

Sector activities	Immediate causes							
	1. Unsustainable harvest practices in fisheries	2. Pollution including accidents	3. Stream flow regulation by hydro-technical constructions on rivers	4. Introduction of invasive species	5. Deforestation	6. Coastal erosion, sludging, dredging of water bodies	7. Land use	8. Eutrophication
1. Agriculture		Run-off of pesticides 20%	Construction of irrigation systems 20%		Deforestation to create agricultural land 75%	Overgrazing of the costal zone 25%	Agricultural fields 50%	Run-off of fertilisers 40%
2. Fishery	Overfishing 90%			Introduction of commercial and feeding species 33%		Dredging in river deltas 60%		
3. Industry		Discharges and air pollution 25%	Construction of reservoirs for industrial water supply 10%				Direct construction of plants, waste deposits etc. 30%	Thermal discharge 5%
4. Urbanisation		Run-off of surfactants and other 10%	Supply of drinking water 20%	Accidental introduction of pets into nature 2%	Deforestation to supply household heating 20%		Growth of towns and settlements 25%	Run-off of nutrients 30%
5. Oil extraction		Oil spills 40%						Influx of organic matter 10%
6. Transport		Direct input from vessels 5%	Special construction of dams 5%	Accidental introduction with ballast waters etc. 60%	Deforestation during road construction 5%	Inappropriate technology in road construction in the coastal zone 15%	Road construction 5%	
7. Energy production			Hydropower stations 45%					Thermal discharge 10%
8. Aquaculture	Take out of mature fishes for artificial spawning 10%			Accidental introduction with ballast waters etc. 5%				Run-off of nutrients 5%

"Kara-Bogaz-Gol hydrotechnical reconstruction" and "Change of sea level as natural phenomena" were taken out of the table as they have no connection with specific sectors of activity. Poaching is included in Fishery activity.

5. Root causes

Habitat and community modification

Sector activities	Root causes																		
	1. Demographic			2. Technological				3. Economic									4. Socio-cultural	
	1.2 Population growth	1.3 Urbanisation trends	1.4 Migration	2.1 Access to technology	2.2 Technological trends	2.3 Inadequate knowledge of technological and technical response function	2.4 Inappropriate expert advise on technology	3.1 Prices (inputs, outputs, consumption goods)	3.2 Incomes	3.3 Income distribution	3.4 Poverty	3.5 Economic growth	3.6 Economic structure	3.7 Market structure	3.8 Taxes and subsides	3.9 Inadequate valuation of environmental goods and services	4.1 Traditions	4.4 Lifestyle
Agriculture	25				65			30	20	30	50			5			30	
Fisheries	15				30		40	60	60	30	50			80	80	10	70	100
Industry				NS	5				5			75	100			40		
Urbanisation	25	35																
Oil extraction						100												
Transport	20		100	NS						40								
Energy production	15	65					60		15			25				50		
Aquaculture								10						15	20			

Sector activities	Root causes																		
	5. Legal		6. Knowledge							7. Governance (including Policy failures)						8. Political		9. Natural phenomena
	5.1 Laws (especially property rights)	5.2 Regulations	6.1 Information	6.2 Training	6.3 Education	6.4 Inadequate scientific understanding	6.5 Inadequate or unreliable information	6.6 Ineffective information interpretation	6.7 Inadequate access to technical and scientific information	7.3 Bureaucratic competence (including adequate budgets)	7.4 Deficiencies in stakeholder participation	7.5 Lack of coordination among the different levels of government	7.6 Corruption	7.7 Inadequate integration of environmental considerations into public policy	7.8 Inadequate coordination of national policies	8.1 Power structure (relative capacity of affected groups to oppose/promote policy)	8.2 Conflicts	9.1 Sea level changes
Agriculture			20	10	20				30								5	15
Fisheries	70	50	10	10	10	50	100	100	20	70		25	50	5		20	5	10
Industry		30	10	10	10								25	10			10	5
Urbanisation			10	10	10												5	5
Oil extraction	30		10	20	10					30	20	15	25	35	50	50	30	35
Transport			10	10	10										50	30	25	10
Energy production		20	20	10	10	50			50		80	30		50			5	5
Aquaculture			10	20	20							30					15	15

Annex IV
Policy options – detailed performance tables

1. Recommended involvement of the Caspian states on a local, national and international level

○ = not involved ● = local ● = national ● = international

Type	Policy options	Azerbaijan	Iran	Kazakhstan	Russian Federation	Turkmenistan
Legislative/Regulatory	Develop systems to stimulate the use of "green technologies"	●	●	●	●	●
	Fill the local market with cheap, effective and acceptable chemicals	●	●	●	●	●
	Expert independence from authorities and fishery industry	●	●	●	●	●
	Use of economic instruments such as penalties, compensations etc.	●	●	●	●	●
	Correct estimation of water prices (include attendant services and actions)	●	●	●	●	●
	Improvement and enforcement of regulation on dam construction/operation	●	●	●	●	●
Investment	Investments in refurbishment of old oil wells and oil pipelines	●	○	●	●	○
	Investments in refurbishment of old water purification systems	●	●	●	●	●
	Special investments in the equipment of control organisations	●	●	●	●	●
	Special investments to build purification facilities	●	●	●	●	●
Institutional strengthening	Create and/or strengthen control systems of forbidden chemicals	●	●	●	●	●
	Strengthened control of small leaks from active and blocked oil wells and oil pipelines	●	●	●	●	●
	Change and strengthening of control organisations	●	●	●	●	●
	Develop special systems of biological control in the artificial shipways	●	●	●	●	●
	Strengthening organisations controlling the introduction of alien species	●	●	●	●	●
Education	Special training courses, lectures, videos, etc.	●	●	●	●	●

2. Main root causes and policy options for Habitat and community modification by – Pollution

Root causes	Policy options	Priority	Possible outcomes and efficiency (low-medium-high)	Who could be responsible	Existing base for implementation	Preliminary cost (USD)
Agriculture						
Population growth	Population growth accompanied with economic growth of the region could be a positive factor and do not need any policy option to prevent it					
Economic growth in the region	Economic growth is a positive factor and do not need any policy option to prevent it					
Existing prices for agricultural products	Fill the market with cheap vegetables all year round by developing hot house gardening especially in the northen Caspian region	5 recommended	Stable vegetable market all the year without periodical price changes Efficiency - medium	Small business and Local authorities	Small market gardening	200 000 - 300 000
	Import of cheap vegetables from other regions, for example from southern Caspian countries to the north	6	Semi-stable vegetable market with small periodical price changs Efficiency - medium	Small business and Local authorities	Sea transport	Tax privileges
Poverty	There are several National programmes, so it is not GIWA responsibility					
Lack of incentives to promote "green technology"	Develop systems to stimulate "green technologies", for example reduction of discharge and air pollution, gardening without pesticides, etc.	2 recommended	Development of environment friendly "green technologies" in the region Efficiency - low	National and Local authorities		100 000
Availability of cheap, but old-type insecticides on the local market.	Create and/or strengthen systems at the municipal level controlling sale of forbidden chemicals	1 recommended	All forbidden chemicals (such as DDT) can be removed from the local market and become unavailable for further usage Efficiency - high	Local authorities	"Ecological police"	
Absence of effective and cheap insecticides and pesticides on the local market	Supply the local market with cheap, effective and acceptable chemicals	2 recommended	New acceptable chemicals will substitute old and dangerous ones Efficiency - medium	National authorities and International organisations		Tax privileges
Lack of control of pesticide usage in small-scale gardening and farming	Strengthening the control on sale and use of pesticides in farming and gardening (including sale on the market and black market)	4	Absence of illegal sale of pesticides, fertilisers , etc. Efficiency - low	Local authorities, Control organisations		
Technology and budget problems with creation of special water purification systems for run-off from small-scale farming	Investigate the possibilities of creating such systems					
Oil industry						
Technology and budget problems with refurbishment of old oil wells and pipelines	Investments in refurbishment of old oil wells and old oil pipelines	1 recommended	Absence of regular small leaks	Oil companies		?
	Strengthen control of small leaks from active and blocked oil wells and oil pipelines	2 recommended	Absence of regular small leaks	Local authorities	Existence of "ecological police"	
Technology and budget problems with refurbishment of old water purification systems	Investments in refurbishment of old water purification systems	1 recommended	Improved purification of discharges Efficiency - high	Local authorities		1 000 000
Education						
Lack of information, education and training in the negative effects of different pollutants on the Caspian ecosystem and human health	Special training courses, lectures, videos, etc.	3 recommended on a broader scale	Better understanding and education of local people, salesmen, producers and decision makers Efficiency - potentially very high, but low at the begining	Local authorities, Universities, NGOs, etc.		100 000 - 200 000 annually

3. Main root causes and policy options for Habitat and community modification by – Overfishing and poaching

Root causes	Policy options	Priority	Possible outcomes and efficiency (low-medium-high)	Who could be responsible	Existing base for implementation	Preliminary cost (USD)
Tradition of continuous and non-selective fishing coupled to the lifestyle of local people	Increase fines for exceeding fishing quotas	8	Incomes and taxes on illegal fishing need to be comparable Efficiency - medium	National authorities, Ministries of Environment	Exist, but needs to be improved	
	Control by all official local fishermen	5	Permanent control in multiple places along the rivers Efficiency - medium	National and Local authorities, Ministries of Environment		
	Privileges for fishermen obeying the regulations i.e. fishing periods, species restrictions, quotas etc.	6	Preference of local fishermen to fish legal Efficiency - medium	National and Local authorities, Ministries of Environment		
Poverty and unemployment of local people	There are several National programmes, so it is not GIWA responsibility					
Market structure and high prices for valuable fish products	No policy options					
Tradition of exceeding quotas	Increase fines for exceeding fishing quotas	9	Fishlandings in accordance with quotas Efficiency - low (at present fishing above quotas is rare)	Ministries of Environment	Exist, but needs to be improved	
Inefficient fishery control due to corruption	Change and strengthening of control organisations	1 recommended	Better and more efficient staff Efficiency - medium	National authorities		From national budget
Inefficient fishery control due to lack of staff						
Inefficient fishery control due to lack of equipment	Special investments to provide controlling organisations with equipment	2 recommended	Properly equipped control organisations Efficiency - medium	National authorities, Ministries of Environment		1 000 000
Inadequate expert advice on quotas as a result of pressure from authorities	Expert independence from authorities and fishery industry	3 recommended	More realistic quotas Efficiency - high	Regional and International organisations, National authorities		500 000 annually
Inadequate expert advice on quotas as a result of lack of scientific equipment and funds	Special grants for the evaluation of quotas	7	More realistic quotas Efficiency - low	National authorities, International organisations		
Inadequate expert advice on quotas as a result of lacking experience and qualification	Expert training	4 recommended	More realistic quotas Efficiency - high	Academy of Sciences, Regional and International organisations		200 000 annually

4. Main root causes and policy options for Habitat and community modification – Introduction of invasive species

Root causes	**Policy options**	**Priority**	**Possible outcomes and efficiency (low-medium-high)**	**Who could be responsible**	**Existing base for implementation**	**Preliminary cost** (USD)
Absence of tank/hull decontamination facilities (lack of investments)	Special investment to the creation of purification facilities	1 recommended	Prevention of accidental species introduction with ballast water	Local authorities, Ministries of Environment	Under construction in the Volga delta	
Absence of special systems preventing penetration via existing shipways - absence of technological advice	Develop special systems of biological control in the artificial shipways	3 recommended	Prevention of self-introduction	Academy of Sciences, National authorities		1 000 000
Absence of systems for domestic pet care	Create special service for pet care	5	No pet introduction Efficiency - low	Local authorities, NGOs		
Lack or absence of regulation and control for introduction and farming of alien species	Strengthen organisations that control alien species introduction	2 recommended	Prevention of accidental introduction of aquaculture species	National authorities	Existing organisations and services (different in different countries)	100 000
Inadequate expert advice on species introduction	Expert training	4	Better expert advice	Academy of Sciences, International organisations		

5. Main root causes and policy options for Habitat and community modification by – Dam Constructions

Root cause	Policy option	Priority	Possible outcomes and efficiency (low-medium-high)	Who could be responsible	Existing base for implementation	Preliminary cost (USD)
Conflicts of interest among user groups	Shifting responsibilities to central authorities	6	medium-high	National Parliaments		5 000
	The use of economic instruments such as penalties and compensations etc.	1 recommended	high	Local and National authorities	Special instructions and recommendations	10 000
Lack of system approach	Identify decision makers and increase their competence	4	medium	International and Regional organisations, Local authorities		50 000
	Develop the scientific base through research/training	10	medium	Scientific organisations	A lot of data for analysis	1 000 000
Lack of public awareness	Training/ dissemination of information	9	low, medium, or high (depend on country)	Local authorities, Mass media	Experience of NGOs	500 000
	"Green movement" lobbying	11	low-medium	International organisations, Mass media, NGOs	"Green" NGOs	100 000
Inadequate scientific understanding of catchment area influence	Improve monitoring systems (include biological parameters)	5	medium-high	Local authorities, Scientific organisations, Environmental Ministries	Experience of monitoring in some scientific organisations	200 000
	Carry out integral research	7	medium	Environmental Ministries, Scientific organisations	Experience and high qualified experts	500 000
Weak management (operation) of dams due to lack of hydrological data	Improve monitoring of hydrological data	8	medium	Scientific organisations, Hydromet system	Experience in monitoring in some scientific organisations	1 000 000
Low prices for water supply for energy production and municipal usage	Correct estimation of water prices (include attendant services and actions)	2 recommended	medium-high	National Governments and Parliaments, Local authorities, Scientific organisations	Scientific experience	100 000
Insufficiency and inefficiency of regulation on dam safety	Improvement and enforcement of regulations on dam construction/operation	3 recommended	medium-high	National and Local authorities		

Annex V
List of important water-related programmes and assessments in the region

Caspian Environmental Programme (CEP)

The Caspian Environment Programme (CEP) is developed by the Governments of the five Caspian countries to solve common ecological problems with participation of international organisations (GEF, UNDP, UNEP, World Bank, Tacis). Within the framework of this Programme countries carry out the activities at national and regional levels. The purpose of CEP is to maintain sustainable development and rational management of the Caspian region environment.

The priority of actions within the framework of CEP is aimed at:

- Ensuring economic activity and sustainable living conditions for the human population under conditions of the Caspian sea level fluctuations;
- Ensuring ecological safety in the region and preservation of the environment for sustainable human development;
- Pollution liquidation and improvement of environmental quality and biodiversity conservation;
- Improvement and restoration of the Caspian sea ecosystems and biodiversity conservation.

Caspian Sea Environmental Pollution Programme

The purpose of this project is to look at the benefits of environmental management strategies in pollution prevention such as waste minimisation and clean technologies. This minimises the environmental problems due to waste generation and eliminates the cost of treatment and disposal of the waste. The benefits of the environmental management programme along the Caspian Sea will ensure clean water and a better environment. There are many research programmes investigating future waste minimisation in the Caspian Sea region.

The important ones are given as follows:

- The first plan is to identify the point sources of pollution along the Caspian coastline. This includes the pollution from all industries, commercial operations and cities around the Caspian Sea;
- The second task is to try to identify the non-point pollution sources and to characterise them as point sources of pollution;
- The third plan is the determination of the contribution of each point source pollutant including domestic, industrial and non-point sources along the Caspian coastline and to prepare dispersion maps of sources of pollution;
- The forth plan is to investigate the effect of these pollutants on the aquatic life of the Caspian Sea;
- The last plan is to measure the amount of oil pollution in the Caspian Sea.

International Research and Exchange Board (IREX) Black Sea and Caspian Sea collaborative research programme

IREX is an international non-profit organisation dedicated to the advancement of knowledge. Central to its mission is the empowering of individuals and institutions to participate meaningfully in civil society. IREX administers programmes between the United States and the countries of Eastern Europe, the New Independent States (NIS), Asia, and the Near East.

IREX:

- Contributes to the development of students, scholars, policymakers, business leaders, journalists, and other professionals;
- Strengthens independent media, academic, public, and non-governmental institutions;
- Makes the knowledge and skills developed through its programmes available to universities, foundations, policymakers, and the corporate sector.

The last decade has unleashed major forces of change in the Black and Caspian Sea region. On the most rudimentary level, interactions of various types, including trade and travel, have proliferated in this region. Large regional projects, including political ones such as GUUAM (Georgia, Ukraine, Uzbekistan, Azerbaijan and Moldova) and the Black Sea Economic Cooperation Zone, and economic ones such as oil and gas pipelines, mean that regional developments will continue to bear consequences for each country in the region while developments at the national level will have regional effects. However, region-wide basic and comparative data, as well as regional analysis of ongoing trends, are lacking.

In September 2000, IREX convened a regional conference in Odessa, Ukraine, to assess the regional dynamics at work, as well as the state of existing knowledge and skills, and to analyse these trends. The participants of the Odessa Conference called attention to the pressing need to carry out collaborative research if understanding of the region and its dynamics are to improve. It is in response to this demand that IREX has decided to launch its collaborative research programme for the Black and Caspian Sea region. This collaborative research programme is made possible by a generous grant from The Starr Foundation.

Seeking Civil Society: Environmental NGOs and the Caspian

This activity addresses regional environmental issues and how partnerships among non-governmental organisations can influence government policies. It will also attempt to understand how environmental NGOs could contribute to the strengthening of civil society and human capital in the areas they serve, seeking ways to link partnerships with other local and international environmental NGOs, and crossing over geographic boundaries. Furthermore, this forum will highlight the newly emerged region's need to end its isolation by assembling the human capital to negotiate environmental policies.

The ISAR's Caspian Program

ISAR's Caspian Program has been working with NGOs in the Caspian region since October 1998 to protect the unique ecosystem of the Caspian Sea. The goal and principles of the Program were developed at ISAR's April 1999 conference, "Strengthening Partnerships Among NGOs Working on Environmental Problems of the Caspian Basin" (Baku, Azerbaijan), which was attended by more than 50 environmental NGO representatives.

To attain this goal, the following programme priorities have been established:

- Creating and developing systems of independent public environmental monitoring in the Caspian Basin. The Program supports efforts by local NGOs to conduct independent environmental monitoring through the entire Caspian Basin. ISAR also supports the inclusion of NGOs in the monitoring efforts of state and international organisations.
- Supporting NGO efforts to preserve, rehabilitate and rationally use the ecosystem of the Caspian Basin. The Program supports greater involvement of NGOs in evaluating the status of protected territories and biodiversity in the Caspian Basin, as well as protecting and rehabilitating them.
- Seeking and advancing alternative paths of economic development for the region. The Program supports the efforts of NGOs and other organisations to broaden the use of renewable natural resources in the region as economic alternatives to oil and gas extraction. These efforts may include: "clean" energy and programmes for energy conservation; ecotourism and other forms of environmentally friendly recreation; the development of marine resources and aquaculture; and the development of sustainable agriculture.

The Ecotoxicology Project (ECOTOX)

The Ecotoxicology Project (ECOTOX) carries out investigation into Toxic Contaminant Accumulation and Related Pathology in the Caspian sturgeon, seal and bony fish. The five Caspian countries participating in the project are Azerbaijan, Iran, Kazakhstan, Russian Federation and Turkmenistan.

The Project was started within the Caspian Region in September 1999. An Inception Workshop was held in October 1999 in Baku, Azerbaijan. The contractor of the project is PADECO, a Japanese company. The project itself is sponsored by the World Bank.

The ECOTOX Project is divided into three "teams": the seal team, the sturgeon team and the bony fish team. Each team consists of National Experts in respective fields, nominated by the National Focal Points of the countries.

Caspian Transboundary Diagnostic Analysis

A Transboundary Diagnostic Analysis (TDA) is a scientific and technical assessment, through which the water-related environmental issues and problems of a region are identified and quantified, their causes analysed and their impacts, both environmental and economic, assessed. The analysis involves an identification of causes and impacts at national, regional, and global levels and the socio-economic, political and institutional context within which they occur. The identification of the causes would specify sources, locations, and sectors.

The purpose of conducting a TDA is to scale the relative importance of sources and causes, both immediate and root, of transboundary waters problems, and to identify potential preventive and remedial actions. The TDA was completed in 2002 and provided the technical basis for the Strategic Action Programme (SAP) in the area of International Waters of the GEF.

Annex VI
List of agreements and specific laws that affect water use in the region

- EU Water Initiative, Johannesburg, 2002.
- EU Water Framework Directive 2000/60/EC of October 23, 2000.
- Agreement between Kazakhstan and Russia on co-operation in the use of Caspian resources and on oil transport via Novorossijsk (9.10.2000).
- Agreement between Azerbaijan and Russia on co-operation in the use of Caspian resources and on oil transport along the northern pipeline via Novorossijsk (9.01.2001).
- Agreement between Azerbaijan and Kazakhstan on co-operation in the use of Caspian resources and on oil transport through Georgia (1997).
- Agreement between Azerbaijan and Turkmenistan on gas transport (1998) through Georgia.
- Agreement between Azerbaijan, Turkey, and Georgia on oil transport (1999) and gas transport (2001) along a western pipeline.
- Treaty of Friendship between the Soviet Union and Persia, signed February 26, 1921, pertaining to freedom of navigation.
- Agreement between Persia and the Soviet Union of October 1, 1927, relating to fisheries in the southern parts of the Caspian Sea. This agreement, originally having a 25-year duration, was never renewed.
- Convention between Iran and the Soviet Union on Establishment, Commerce, and Navigation, signed in Tehran on October 27, 1931, reaffirming the principle of freedom of navigation and exclusive fishing rights up to 10 nautical miles from shore. This treaty was confirmed on March 25, 1940.
- Treaty of Commerce and Navigation signed by Iran and the Soviet Union on 25 March 1940.
- Agreement between Iran and the Soviet Union concerning Settlement of Frontier and Financial, establishing the demarcation between Iran and the Soviet Union, signed on December 2, 1954.
- Treaty between Soviet Union and Iran on May 14, 1957, giving rights to fish in frontier waters up to the frontier line.
- Almaty Declaration of December 21, 1991 between the four CIS countries stating that the new states would continue fulfill international obligations of the Soviet Union.
- Tehran Communique of October 1992, which committed the states to cooperation in environmental management of the Caspian Sea.
- Astrakhan Communique of 1993, which reinforced the need to cooperate on environmental matters.
- Almaty Declaration of Cooperation in the Field of Environmental Protection (May 1994).

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Caspian Sea. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and

policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF".*

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference*".

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

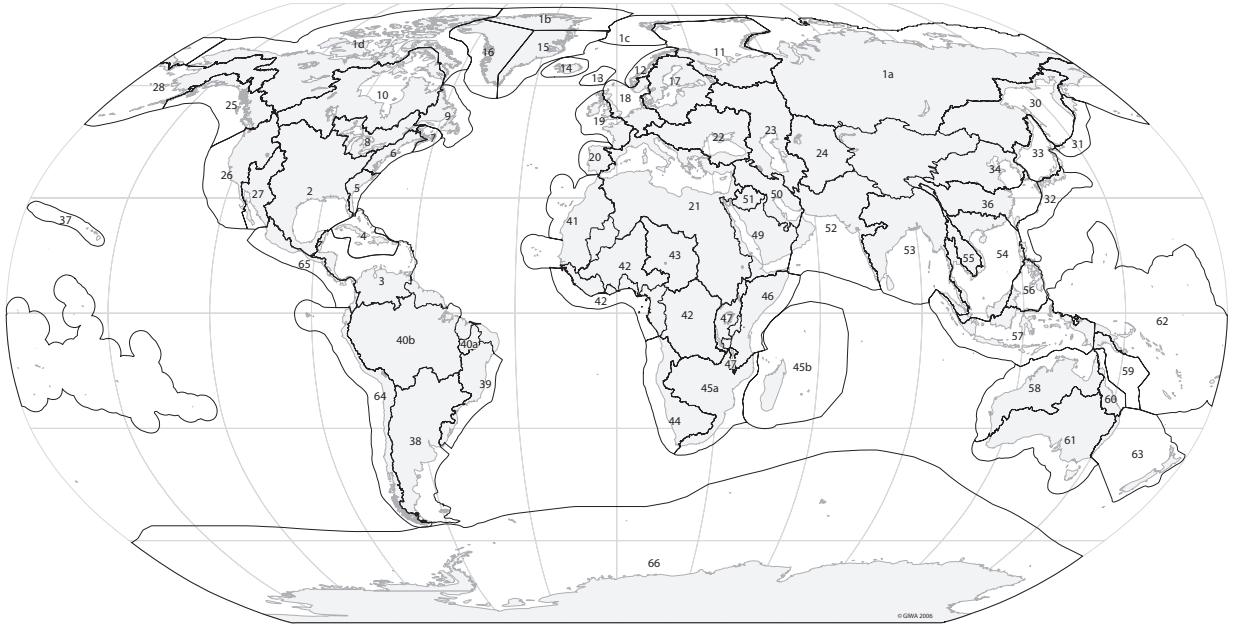
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1a Russian Arctic (4 LMEs)
1b Arctic Greenland (LME)
1c Arctic European/Atlantic
1d Arctic North American
2 Gulf of Mexico (LME)
3 Caribbean Sea (LME)
4 Caribbean Islands (LME)
5 Southeast Shelf (LME)
6 Northeast Shelf (LME)
7 Scotian Shelf (LME)
8 Gulf of St Lawrence
9 Newfoundland Shelf (LME)
10 Baffin Bay, Labrador Sea, Canadian Archipelago
11 Barents Sea (LME)
12 Norwegian Sea (LME)
13 Faroe plateau
14 Iceland Shelf (LME)
15 East Greenland Shelf (LME)
16 West Greenland Shelf (LME)
17 Baltic Sea (LME)
18 North Sea (LME)
19 Celtic-Biscay Shelf (LME)
20 Iberian Coastal Sea (LME)
21 North Africa and Nile River Basin (LME)
22 Black Sea (LME)
23 Caspian Sea
24 Aral Sea
25 Gulf of Alaska (LME)
26 California Current (LME)
27 Gulf of California (LME)
28 Bering Sea (LME)
30 Sea of Okhotsk (LME)
31 Oyashio Current (LME)
32 Kuroshio Current (LME)
33 Sea of Japan (LME)
34 Yellow Sea (LME)
36 East China Sea (LME)
37 Hawaiian Archipelago (LME)
38 Patagonian Shelf (LME)
39 Brazil Current (LME)
40a Northeast Brazil Shelf (2 LMEs)
40b Amazon
41 Canary Current (LME)
42 Guinea Current (LME)
43 Lake Chad
44 Benguela Current (LME)
45a Agulhas Current (LME)
45b Indian Ocean Islands
46 Somali Coastal Current (LME)
47 East African Rift Valley Lakes
49 Red Sea and Gulf of Aden (LME)
50 Euphrates and Tigris River Basin
51 Jordan
52 Arabian Sea (LME)
53 Bay of Bengal
54 South China Sea (2 LMEs)
55 Mekong River
56 Sulu-Celebes Sea (LME)
57 Indonesian Seas (LME)
58 North Australian Shelf (LME)
59 Coral Sea Basin
60 Great Barrier Reef (LME)
61 Great Australian Bight
62 Pacific Islands
63 Tasman Sea
64 Humboldt Current (LME)
65 Eastern Equatorial Pacific (LME)
66 Antarctic (LME)

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as

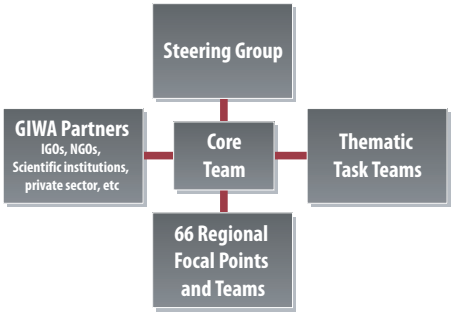


Figure 2 The organisation of the GIWA project.

universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

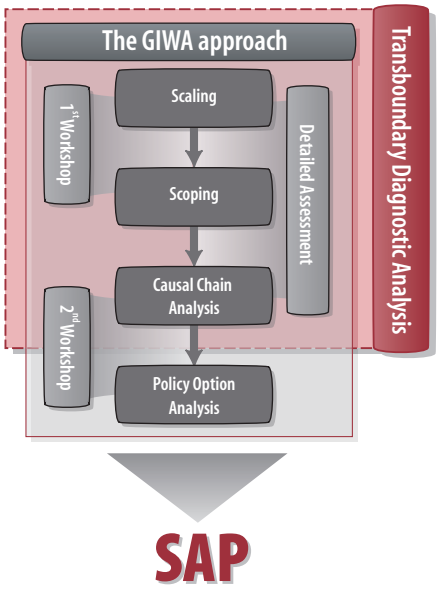

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the

results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.*" The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern.
In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small — Very large 0 1 2 3	2	50
Degree of severity	Minimum — Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

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Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/ suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of the world's transboundary waters that recognises the inextricable links between the freshwater and the coastal marine environments and integrates environmental and socio-economic information to determine the impacts of a broad range of influences on the world's aquatic environment.

Broad Transboundary Approach

GIWA recognises that many water bodies and resources, and the human impacts on them, are not confined to a single country.

Regional Assessment – Global Perspective

GIWA provides a global perspective of the world's transboundary waters by assessing regions that encompass major drainage basins and adjacent Large Marine Ecosystems. The GIWA Assessment incorporates information and multidisciplinary expertise from all countries sharing the transboundary water resources of each region.

Global Comparability

In each region, the assessment focuses on five major concerns comprising 22 specific water-related issues.

Integration of Information and Ecosystems

GIWA recognises the inextricable links between the freshwater and the coastal marine environments and assesses them together as an integrated unit. GIWA recognises that the integration of socio-economic and environmental information and expertise is essential in order to obtain an holistic understanding of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

GIWA identifies the priority concerns of each region, determines their societal root causes and discusses options to mitigate the future impact of those concerns.

This Report

This report presents the Caspian Sea – the largest land-locked water body on earth, bordered by five countries and influenced by three more in the catchment area. The assessment of the current situation and historical trends identified that Habitat and community modification exerts the greatest impact on the ecosystem of the Caspian Sea. Policy options to address the driving forces is presented and discussed in the context of current practices in the region.