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 on the methodology, please refer to the GIWA methodology chapter.

Freshwater shortage in the Orange-Vaal River Basin

The Orange-Vaal is the largest transboundary river system in the Benguela Current region. Its catchment covers some 1 million km^2 (Department of Water Affairs and Forestry 2005), almost 10 times as large as the second-largest system in the region, the Cunene River, which covers an area of 106 500 km^2 (Pallett 1997). The Orange-Vaal system stretches over four countries within the region, namely South Africa, Lesotho, Botswana and Namibia, with the Orange River itself forming part of the political border between South Africa and Namibia. Water from this system is the primary supply for more than half of the population of the Benguela Current region. The scarcity and unequal distribution of freshwater resources is considered one of the fundamental factors posing a threat to the economic and social development of the southern African region. The situation is particularly acute in the Orange-Senqu River Basin as it supplies water to the industrial heartland of South Africa, while having to provide livelihoods for people downstream in the arid western part of the drainage basin.

The headwaters of this system arise in the Drakensberg Mountain range in the east of South Africa and in Lesotho (Figure 10). In these eastern parts of the region, rainfall is high (2 000 mm), and exceeds the annual evaporation (1 200 mm). The drainage basin is highly populated and urbanised, with 48% of the population of South Africa living in the catchment and relying on its water. Most of South Africa's heavy industry and mining activities are also situated within the catchment, with more than half of South Africa's wealth being supported by water supplied from the Vaal River (Department of Water Affairs and Forestry 2005). Much of the catchment is heavily modified by impoundments and water transfer schemes both removing and augmenting the natural water supply (see Assessment, Freshwater shortage).

By contrast, at its western extreme, the Orange River flows through hyper-arid areas where the annual evaporation of 3 000 mm greatly exceeds the limited rainfall of 50 mm (Davies & Day 1998). This leads to a mean annual precipitation and to mean annual run-off conversion rate of less than 10% for the drainage basin as a whole and a rate approaching 1% in some of the drier lower reaches. Population density in these areas is correspondingly far lower than in the upper reaches. Agriculture is the major economic activity, with livestock being kept in the drier areas, and grapes and vegetables being farmed in a narrow riparian strip supported by intensive irrigation drawn from the River. The river estuary is a Ramsar site.

Figure 10 Drakensberg mountains at the border between South Africa and Lesotho.
(Photo: M. Karlsson)

Immediate causes

Modification of stream flow is the key issue surrounding the concern of Freshwater shortage in the transboundary Orange-Vaal system within the Benguela Current region. Annual flow data indicate a reduction in flow of at least 50% since 1935 (Department of Environmental Affairs and Tourism 2000). The two principal immediate causes of modification of stream flow are the construction of dams and impoundments, and the overabstraction of water from this system (Figure 11). These two causes are so closely linked, and have such similar root causes that they are treated together for the purposes of the root cause and policy options analyses.

Sectors

Dams have been constructed primarily to supply water to developing urban areas, to mining and industry, and to agriculture (Department of Environmental Affairs and Tourism 2000). Irrigation is by far the largest sectoral user of water from the Orange River, using 54% (Table 15). Data indicate, that in South Africa as a whole, the storage capacity of large and small dams together had already exceeded the maximum usable mean annual run-off in 1990 (Department of Environmental Affairs and Tourism 2000). Overabstraction of water is connected to inappropriate agriculture practices, wasteful use of water, and inappropriate water rights.

Table 15 Water demand from the Orange River by sectors.

Sector	Demand (%)
Irrigation	54
River losses	32
Environmental demands	10
Urban/industrial	2
Consumptive canal losses	2

(Source: Department of Water Affairs and Forestry 2005)

Root causes

Political

Political decisions that promoted development by prioritising industrial use of water, inappropriate irrigated agriculture, and also a low level of political will to implement existing legislation have contributed to problems of freshwater shortage in the region. Decisions to maintain the trend of development, particularly surrounding the highly industrialised Gauteng Province in the catchment of the Orange-Vaal system, made necessary the construction of dams to supply water not only to the industries, but also to the ever-increasing population in the catchment (Department of Environmental Affairs and Tourism 2000). Mining and industry in the catchment of the Orange-Vaal system were encouraged in order to generate employment, bring about economic growth and generate foreign earnings. Water was supplied to industry and mining preferentially (Department of Environmental Affairs and Tourism 2000), with these sectors being favoured as users of water above the environment or even the local inhabitants.

Some political decisions, including schemes to protect the northern borders of South Africa by actively encouraging settlement and farming in these marginal areas, and promoting inappropriate irrigated agriculture, also contributed to cause freshwater problems. Political causes also include the development of irrigation schemes for the thinly-disguised purpose of vote-gaining, and the creation of sheltered employment.

Governance

Failures in governance are primarily related to a lack of coordination between different interests and to conflicts between government departments at the policy level. This has frequently left the South African Department of Water Affairs and Forestry in the position of having to supply "extra" water to new industrial, mining or agricultural developments in the drainage basin, without due consideration of the water resource available in the area. Water management in the Orange-Vaal drainage system is highly fragmented, and there

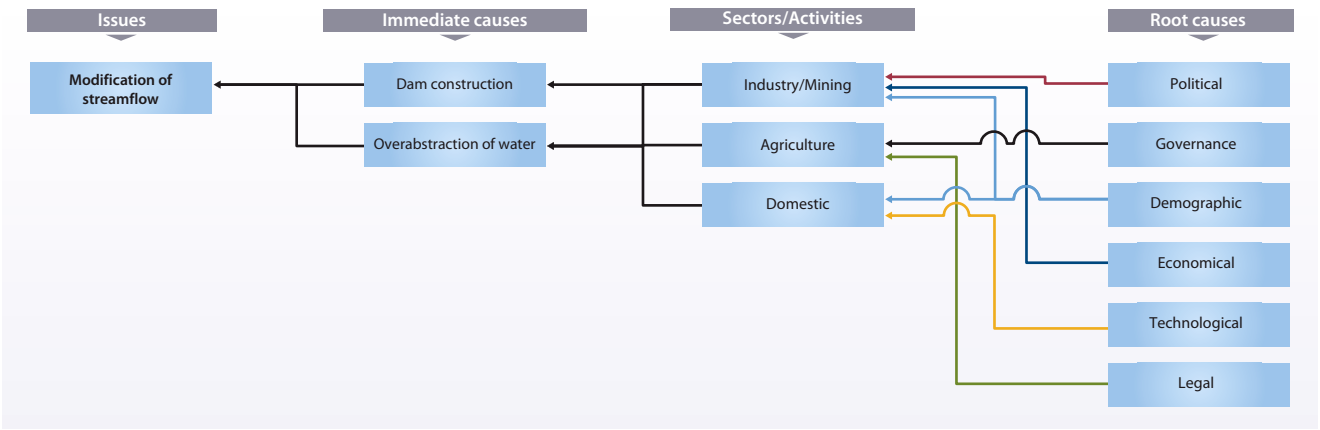

Figure 11 Causal chain diagram illustrating the causal links for freshwater shortage in the Orange-Vaal River Basin.

is no basin-wide planning to support an efficient management of water supplies. South Africa's National Water Act (36 of 1998) does, however, attempt to address several of these problems, although poor implementation and enforcement remain serious constraints to the effectiveness of this legislation. Additionally, in 2000 the four basin states of the Orange River formed the Orange Senqu River Commission (ORASECOM), tasked to serve as a technical advisor to the countries on the use, development and conservation of the River. As an organisation, ORASECOM has a legal personality and is founded on the principles of the Revised SADC Protocol on Shared Watercourses as well as the UN Convention on the Non-navigational Uses of International Watercourses. These principles commit signatories to manage shared waters in a "fair and equitable" way and "not to cause significant harm" to downstream riparian states. Although the Commission is newly-formed it is starting to make progress towards its goal to promote the equitable and sustainable development of the resources of the Orange River.

Many of the decisions to supply water preferentially to mining and industry are historical, born from the political and economic desire for South Africa to achieve self-sufficiency at almost any cost during the economic sanctions of the Apartheid era. In a region where the water supply is generally low and highly variable, until recently surprisingly little effort has been put into managing the demand for water, rather than managing the supply thereof. This is not true only in South Africa, but also in Namibia (International Rivers Network 2004).

Demographic

The political decisions to promote development have resulted in an influx of people to the highly industrialised areas of Pretoria and Johannesburg in the form of both migrant labourers and hopeful immigrants from rural areas seeking jobs. This, together with population growth, has resulted in the catchment of the Orange-Vaal becoming heavily populated, with a concomitant enormous demand for freshwater. The response to this has been attempts to capture as much water as possible, hence the construction of dams and impoundments.

Economic

The dependency of a large and growing urban population on food from rural areas has made the economic incentives associated with water-thirsty commercial agriculture highly attractive. The enormous economic incentives associated with export agriculture, which is often highly inappropriate in relation to local water supplies, have led to a high demand for water for agriculture. Economic causes are also connected to the preferential tariffs given to agriculture, industry and mining (Department of Environmental Affairs and Tourism 2000), to try to achieve the self-sufficiency desired by South Africa. In the past, water has not been considered as an economic good in South Africa, and was available free to agriculture while other users paid only low tariffs (Department of Environmental Affairs and Tourism 2000). This has resulted in a low value being placed on water.

Technological

Improved technology, and in particular irrigation technology, has played an immense part in the development of commercial farming, and in particular in the expansion of inappropriate agriculture, and hence the high demand for water for agricultural purposes. Agriculture is considered to be an inefficient user of water in this system (Department of Environmental Affairs and Tourism 2000). There is the potential for an increase in irrigated agriculture demand, with studies such as the Lower Orange River Management Study (LORMS)

projecting an increase in irrigated water use in the common border area of the Orange River between South Africa and Namibia of over 100% by 2025 (Department of Water Affairs and Forestry 2004). Much of these lower reaches of the River have to contend with low quality water, with a high salt content, a problem compounded by the high rates of evaporation in the area.

Deficiencies in the maintenance and upgrading of water supply equipment result in much water being wasted due to avoidable leakages from water reticulation systems such as irrigation canals, storage dams and pipelines, making it a wasteful and inefficient use of water.

Legal

The prevailing water rights in the Orange-Vaal system stem from South Africa's colonial history, with landowners also holding ownership over water on their property. This riparian-rights system of almost private ownership of water resources has allowed the wholesale building of farm dams and concomitant overabstraction of water for agricultural purposes. Until the shift to democracy in 1994, this system of water rights was defended by the South African government in order to protect a limited number of individuals. Under the South African National Water Act all prior rights to water are to be revoked, with water being brought under the curatorship of the state to manage in a sustainable and equitable fashion. However, this shift towards a system which takes into account the needs of the riverine ecosystem will need to be consolidated with the need for regional economic development of the catchment as a whole.

The fragmentation of water policy leads to a fragmentation of water management, which ultimately results in the wasteful or inefficient use of water in the region. The traditional approach of managing water supply rather than water demand has also resulted in wasteful or inefficient use of water by providing as much water as users request, rather than attempting to encourage an increase in the value added to each unit of water consumed. Such an approach gives users the impression that there is an inexhaustible supply of water, and consequently no need for water demand management measures. Placing inappropriately low tariffs on water results in a lack of understanding on the part of users of the value of the resource. Water is thus perceived by users to be a cheap and abundant resource and is consequently used inappropriately and wastefully.

Unsustainable exploitation of inshore finfish in the Benguela Current

The inshore finfish fishery in the Benguela Current region is a multi-species transboundary fishery which is active in all three coastal countries. It is a multi-user and multi-stakeholder fishery, with participation ranging from full-time commercial to part-time semi-commercial, recreational (including tourism) and subsistence users. Stocks of individual species are shared between the three countries, and between the different user groups. In the South African and Namibian portions of the Benguela Current region the commercial, semi-commercial and recreational sectors form the majority of users with the subsistence sector being very small, while in Angola the subsistence sector is a significant user. A variety of capture methods are employed, including boat-based angling and handlining, shore-based angling, beach seine and gill netting, and spearfishing, as well as illegal methods such as the use of explosives (Figure 12).

Figure 12 Beach seines used by traditional fishermen, False Bay, South Africa.
(Photo: C. Griffiths)

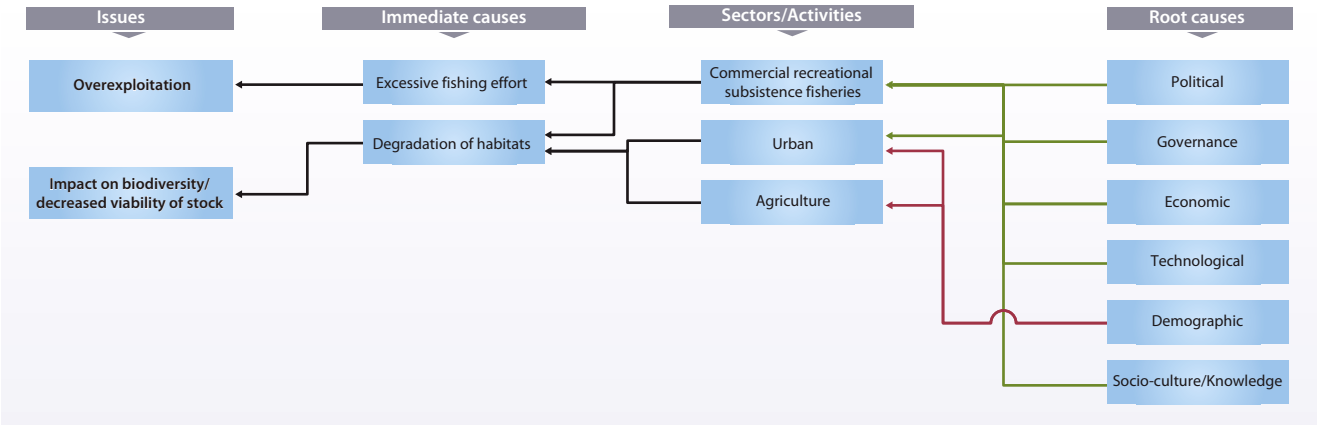

Figure 13 Causal chain diagram illustrating the causal links for unsustainable exploitation of inshore finfish in the Benguela Current.

The majority of the species involved are endemic to southern Africa, and occur only in association with particular habitat types in relatively shallow water close inshore. Some species are long-distance migrants while others may be highly range-restricted and remain resident within a few kilometres of shore for their entire lives. Most are slow-growing species which mature fairly late so that only very large individuals are reproductively mature, and many undergo sex changes as they mature. A host of management measures are currently in place in attempts to manage the fish stocks in a sustainable manner. Nevertheless, there is overwhelming evidence of major catch declines to the extent that numerous stocks are considered to be in a critical condition. This, together with the complex, multi-faceted nature of this fishery makes it an ideal case study for further analysis. Root cause analysis for four other Benguela fishery resources (Hakes, Horse mackerels, Sardine and Anchovy, and Deep-sea red crab) are provided in Hampton et al. (1998).

This case study was chosen in preference to other fisheries in the region because of its highly complex multi-species nature, with many participants falling into a number of "sectors", and with an attendant complex array of causes behind the unsustainable exploitation of these marine living resources. It was also chosen as a case study in preference to some of the more commercially important pelagic, demersal or crustacean fisheries in the region as the majority of the latter fisheries are already receiving much attention in the region through the Benguela Current Large Marine Ecosystem Programme (BCLME) and its attendant projects, and from the governments of the three coastal countries concerned.

Issues

Unsustainable exploitation of inshore finfish in the region was connected mainly to the issues of overexploitation and degradation of habitats (Figure 13).

Overexploitation

Overexploitation has been implicated as the key factor in the reduction and collapse of many inshore fish stocks in the southern African region (Griffiths 1999, Griffiths et al. 1999, Mann 2000). Most species targeted by the linefisheries in this region are rated as overexploited or collapsed (Griffiths 1999, Griffiths et al. 1999, Mann 2000, Holtzhausen et al. 2001, Sauer et al. 2003), as are the principal target species of inshore net fisheries (Hutchings et al. 2000, Hutchings & Lamberth 2002). CPUE for pelagic nomads targeted by the South African linefishery has declined to less than 60% of historical catches (Griffiths 1999), while CPUE of over half of the 25 more vulnerable linefish species for which data are available has declined to less than 5% of the historical CPUE (Griffiths 1999). In Namibian waters, commercial linefishing reached its peak in the 1980s, but has suffered from declining catches since (O'Toole & Boyer 1998). The GIWA Experts estimate that 80 to 90% of the overexploitation problem can be attributed to an excess of fishing effort, with the remaining 10 to 20% being attributed to a deterioration in environmental quality.

Degradation of habitats

Degradation of habitats in the region, notably estuaries and mangroves, has a negative impact on inshore finfish in the Benguela Current region. Estuaries and mangroves are important habitats for many of the species targeted by inshore finfish fisheries. These habitats provide productive feeding grounds, safe refuge from predators and sheltered environments on an otherwise highly exposed coastline. Many species are either partially or fully dependent on these habitats for the successful completion of their life cycles, either as spawning grounds, nursery areas for juveniles, or feeding grounds. Many human influences have negative effects on the integrity of the functioning of these habitats, including alteration of flow, siltation, development,

removal of mangroves, pollution, etc. Such degradation may result in direct destruction of the habitat, as in the case of the removal of mangroves, or may manifest itself in more subtle ways such as through reduction of the environmental signal which guides juvenile fish spawned at sea or returning breeding individuals into these essential habitats. While the dependence of particular species on these habitat types is relatively well known, very little is known of the impacts of degradation of these habitats on populations of these species (with the obvious exception of species which are entirely dependent on estuaries for their survival, and whose distribution is restricted to only one or two estuaries). The high degree of dependence of inshore finfish species on estuaries and mangroves, together with the relative scarcity of these habitat types in the region and evidence of their destruction and/or degradation suggest that the degradation of these habitats is likely to be an important contributing factor to the decline, or the lack of renewal, of these fishes.

Immediate causes

Overexploitation

One of the primary causes of overexploitation of inshore finfish in the region is excessive fishing effort. Commercial fishing effort on stocks of these resources is considered to have reached "dangerous" levels (Griffiths 1999). Effort in the recreational shore fishery on the South African coast was estimated recently at 3.2 million angler days per year, resulting in a total catch of 4.5 million fish per year or almost 3 million kg per year (Brouwer et al. 1997). The total number of shore anglers was estimated at 412 000 in 1995 (McGrath et al. 1997). Estimates of the numbers of gill nets used in coastal areas indicate that in some parts of the Benguela Current region, the density of nets is up to 20 per km of coastline (Lamberth et al. 1997). Recreational fisheries, including both ski-boat fishing and shore angling, attract large numbers of participants on the coasts of both Namibia and South Africa. During the summer months, for example, several thousand fishers partake in recreational angling on the coast of Namibia (O'Toole & Boyer 1998). During the 1996/1997 season, 65% of the total catch of Kob (*Argyrosomus* spp.) were taken by recreational shore anglers, and catch statistics indicate heavy fishing pressure on some species (O'Toole & Boyer 1998). For these participants, however, catch is not the sole incentive for participating, and a good days outing can be had even if very few fish are caught. Recreational participants are therefore still prepared to fish even at extremely low levels of CPUE.

Fishers who rely only in part on the linefishery for their income may include both part-time commercials, and artisanal or subsistence fishers. Such participants are also willing to fish at low levels of CPUE. Artisanal fishers on the Angolan coast subsidise their income through alternative activities such as agriculture and commerce (Delgado & Kingombo 1998), and are therefore not solely reliant on income generated through the fishery.

Many fishers participate in a number of different fisheries and only target inshore finfish opportunistically, taking advantage of occasions when CPUE for these species is elevated due to the presence of spawning aggregations, etc. Such fishing results in relatively large catches with a high CPUE, creating a false perception that the fish stocks are in a good condition, and further incentive for fishers to continue with this practice.

New entrants enter the fishery annually hoping to make a profit. These participants are prepared to utilise maximal effort in order to try to recoup their investment in the fishery and make a living. Most entrants soon realise, however, that they will not be able to do so, and sell their permits, boats and gear, to the next batch of hopefuls. This results in a constant turnover of enthusiastic new entrants, all of whom are hoping to recoup their investments in the fishery, and who are therefore prepared to fish at very low levels of CPUE. In South Africa, one third of all commercial linefish permits changed hands during each of the 10 years between 1996 and 1997 (Sauer et al. 2003).

The lack of a strong profit incentive makes these fisheries particularly vulnerable to excessive effort, and allows fishing to continue at very low levels of CPUE which would be unprofitable in full-scale commercial fisheries. Despite the obvious evidence of declining stocks of inshore finfish and decreasing CPUE, the numbers of participants in these fisheries not only remains high, but increases continuously.

Degradation of habitats

Many factors, including pollution, siltation, development, alteration of flow regimes, and removal of mangroves, among others, result in degradation of marine habitats, and of estuarine and mangrove habitats in particular (see Assessment, Habitat and community modification). Agriculture is an important contributor to the degradation of estuarine areas. Quite apart from the obvious effects that damming and water abstraction for irrigation have on flow and flooding in the estuaries downstream, agriculture adversely affects estuarine health in a number of other ways. Run-off of fertilisers and animal wastes lead to increased nutrient loads, thus decreasing water quality. The planting of crops right up to the edge of the river bank removes stabilising riparian vegetation, encourages erosion and leads to increased siltation of the estuary (this is further exacerbated if flooding intensity is reduced to a level which is no longer sufficient to remove the excess sediment).

Estuaries provide relatively safe, sheltered harbours on a coastline which is otherwise highly exposed, and are obvious nodes for development. Development which encroaches on the estuary or associated floodplains directly destroys previously productive environment. Furthermore, alteration of the dynamics of the estuary mouth through stabilisation and hardening in order to support mouth developments alters the environmental cues used by adult and juvenile fish seeking to enter the estuary to complete their life cycles, and alters the physical and chemical nature of the estuary. In some extreme cases, development below the natural flood-line of an estuary leads to artificial breaching of the estuary mouth to prevent flooding. In temporarily closed estuaries this alters the natural regime of the opening of the estuary mouth, creating a mismatch in timing between the opening of the mouth and time when juvenile fish are seeking to enter the estuary.

Destructive fishing methods such as the use of small-mesh nets and explosives, which occurs on the Angolan coast, are also important contributors to deterioration in environmental quality which affects the biodiversity and viability of the stocks. The use of explosives is not only devastating to the fish in the area surrounding their deployment, but also causes physical damage to the habitat. Vast tracts of underwater habitat such as reefs which support the food organisms of inshore finfish are easily destroyed forever. Although there is an awareness that this practice is ongoing in Angolan waters, there have been no studies to date which quantify the extent of use of explosives or the magnitude of damage already caused by this practice.

The use of small-mesh nets has a more subtle effect on the quality of the habitat. Such small-mesh nets are non-selective with regard to species. The removal of large quantities of small fishes from the system undoubtedly has an impact on populations of these species, and on the ecosystem as a whole. These ecosystem effects of fishing are, however, extremely difficult to identify and quantify, and no such characterisation has been performed in the region as yet.

Root causes

Political

Political encouragement of subsistence and small-scale commercial fisheries leads directly to an increase in the number of participants in the fishery. In addition to the "natural" increase in the numbers of participants in the inshore finfish fisheries, government policies aimed at poverty alleviation in coastal areas have encouraged the proliferation of subsistence and small-scale commercial fisheries in the region. The artisanal fishery in Angola, for example, is essentially an inshore fishery, with fishers making use of both rudimentary wooden canoes, and more sophisticated boats. The majority of the fleet is not motorised, relying instead on rowing and sail power (Delgado & Kingombo 1998), thus restricting fishing operations to the inshore zone. In 1992 the Ministry of Fisheries created the Fund for Development of Fisheries (FADEPA) to allow fishermen access to cheap credit for the purchase of motorised boats. Between 1991 and 1995, the total number of subsistence fishers on the Angolan coast increased by 55% from 15 114 to 23 364 fishers (Delgado & Kingombo 1998). The FADEPA also offers low-interest loans to encourage and assist potential subsistence fishers to enter the fishery and to purchase fishing gear (Delgado & Kingombo 1998). While nobly aimed at assisting to alleviate poverty in coastal areas, such programmes are not necessarily consistent with sustainability of the resources on which they are based. The vast numbers of participants in these fisheries (412 000 participants in South Africa) (McGrath et al. 1997) results in a reluctance on the part of governments to introduce further restrictions on catches and to tighten regulation of these fisheries, both of which may be perceived as controversial and discriminatory by the fishers.

Governance

The vast number of participants, which span a number of different "sectors" from subsistence to recreational to commercial, and target a wide range of species with very different life histories, make the inshore finfish fishery highly complex to regulate. It is not surprising, therefore, that difficulties are experienced in trying to create good and sustainable governance within these fisheries. For the most part, regulations aimed at sustainable harvests are in place in each of the countries concerned. However, poor enforcement, an active illegal "sector", and a lack of voluntary compliance are all stumbling blocks to creation of good and sustainable governance of these resources.

In a survey of shore anglers on the South African coast, enforcement of regulations was shown to be poor in that part of the coast which falls within the Benguela Current region, with anglers being subjected to inspection of their catches on only slightly more than 1% (1.39%) of fishing occasions (Brouwer et al. 1997). The perception that the probability of being caught and prosecuted for illegal activities is very low (Lamberth et al. 1997) encourages illegal and unsustainable activities. Such a lack of enforcement arises primarily from a lack of financial resources to implement effective enforcement of existing regulations. On the South African and Namibian coasts, shore anglers are required to purchase a fishing license, but this requirement is not in place in Angola.

Governance failures can also be found at the root of degradation of habitats. Governance failures which allow the continuation of the use of destructive fishing methods include a lack of regulation in some

Figure 14 Trawling in the Benguela Current.
(Photo: P. Hockey)

instances and poor enforcement. The relatively ease with which members of the general public have access to explosives, and poor control over the use of these explosives, represents a further failure in governance resulting in destructive fishing methods and deterioration of environmental quality. A lack of awareness of the implications of these actions exacerbates the problem.

Economic

Inshore finfish fisheries can be important to local economies. The direct economic value of the fishery products creates an incentive for greater participation in the fishery and for larger catches. An increased demand and value generates greater incentive to catch. On the Angolan coast, for example, the high demand for species such as Soles, Croakers and White Groupers on the international market (Delgado & Kingombo 1998) make these species particularly attractive targets for fishers. Sauer et al. (2003) provide evidence that the value of six linefish species on the east coast of South Africa increased by an average of 173% between 1990 and 2001. Such increased value and demand is an interesting contributor to an excess of effort in the inshore finfish fishery in the Benguela Current region.

The indirect values of the recreational shore fisheries in Namibia and South Africa are substantial (Holtzhausen 1996, McGrath et al. 1997). The South African recreational shore fishery is estimated to contribute 1.3% to the Gross Geographic Product (GGP) of the coastal provinces and employs approximately 131 500 people (McGrath et al. 1997). This contribution to the economies of the coastal provinces leads to a reluctance to place restrictions on the fishery.

The ability of fishers to "cross-subsidise" between fisheries allows opportunistic fishing, thus increasing the number of participants in the fishery. Such increases may be temporally and spatially sporadic rather than continuous. They are nevertheless significant to the fishery as this greatly increases fishing pressure at times when CPUE is high, thus adding substantial fishing pressure and increasing the total catch.

Technological improvements of fishing equipment are also connected to economics. The increased value of the resource makes fishers more prepared to invest in technology which they perceive will increase their catch and hence their ultimate economic yield. In addition, as technology becomes relatively less expensive, more people can afford to utilise it. Many of the participants in the recreational fishery are wealthy individuals who are both willing and able to purchase the latest available technology, including boats, 4-wheel drive vehicles, fish finders, etc. if they perceive these will improve their catches. A detailed analysis of the influence of technology on overexploitation is given below.

The impact on biodiversity also has root causes related to economics. In the quest for the most cost- and time-effective method of capturing fishes, individuals resort to the use of destructive fishing methods. In some cases this is driven by profit incentives, while in others it is driven merely by the desire to generate a livelihood in areas where few alternatives exist. Such paucity of economic opportunities in coastal areas also results in destruction of mangroves for use as building material and firewood as local communities are faced with a lack of financial resources with which to purchase alternative materials.

Technological

Improvements in technology are a further contributor to overexploitation. Improvements in fishing gear, such as the availability of off-road vehicles, geared fishing reels, nylon line, fibreglass fishing rods and the advent of the prawn pump which allowed easy collection of prime bait organisms have previously been pointed to as underlying an increase in harvest potential and overfishing of inshore finfish by recreational anglers in the region (Bennett 1991, Griffiths 1999). The proliferation of privately-owned small motor boats fitted with modern devices such as echo sounders and GPS has undoubtedly made inshore fishermen far more efficient by allowing them not only to locate the fish themselves more easily, but also to accurately and repeatedly locate reefs and other seabed features where fish aggregate, and to target spawning aggregations, etc.

Not only has the technology to locate and capture fish become more advanced over the years, but it has also become more affordable and hence more available to a wider range of participants. In addition to this, an increase in scientific knowledge of the species involved in these

fisheries, accumulated in attempts to better manage them, has also allowed more efficient location and capture of target species, resulting in a form of "arms-race" between fishers and managers.

Demographic

The need for water at growing urban centres results in damming of rivers and abstraction of water, altering flow regimes and reducing the intensity, frequency and timing of critical flood events in estuaries. Population growth also demands an increase of food supply, which implies an increase in agriculture activity which in turn imposes negative impacts on coastal habitats. The civil war in Angola resulted in large-scale migration of people to coastal areas. Faced with limited financial resources and natural alternatives, mangroves became an important source of building materials, with a resultant severe destruction of mangrove forests.

Socio-cultural

Poor voluntary compliance by participants in the fishery exacerbates the problems of inadequate enforcement of regulations to avoid overfishing. Voluntary compliance with management regulations in the South African inshore finfish fishery was found to be poor (Sauer et al. 1997, Brouwer et al. 1997). In the part of the South African coast which falls within the Benguela Current region, between 39 and 44% of 983 anglers interviewed admitted to disobeying the prevailing regulations with regard to size and bag limits and closed seasons (Brouwer et al. 1997). The commercial linefishery in South Africa was found to regularly under-report catches by a factor of three (Sauer et al. 1997), while only a mere 3.6% of catches in the gill net and beach seine fisheries are reported (Lamberth et al. 1997). In those parts of the South African coast which fall within the Benguela Current region, an estimated 23% of the gill nets in operation are being used illegally (Lamberth et al. 1997). To some degree the low level of voluntary compliance may arise from a lack of awareness regarding management regulations. In their studies on the South African coast Sauer et al. (1997) and Brouwer et al. (1997) found that participants in the fishery generally had a very poor knowledge of existing regulations. Much of the lack of compliance, however, also stems from poor attitudes associated with common goods, and the perception that the sea holds an inexhaustible supply of fish on which individuals cannot make a substantial impact, with little thought to or understanding of the cumulative effects of the large number of participants. A lack of visible and effective enforcement certainly also encourages poor voluntary compliance and illegal activity.

As resources in a commons become increasingly scarce, so competition increases between individuals each wanting their share. The heightened competition both within and among user groups targeting inshore finfish leads to the use of more extreme measures by fishers, and the development and purchase of technologically more advanced equipment. This phenomenon is not only created by economic incentives, but is a result of prevailing attitudes to common resources which are becoming increasingly scarce. Each fisher perceives that his/her right to capture fish is being impinged on by others, resulting in a selfish attitude. Participants in the fishery feel that most other participants are "cheating" and that the only means of ensuring his/her own rightful share is to do likewise.