Desk study of the possible impact of fisheries and other human activities on the marine environment in Mauritania.
An exploration

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Institute for Marine Resources and Ecosystem Studies

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- Wageningen ***IMARES*** conducts research providing knowledge necessary for the protection, harvest and usage of marine and coastal areas.
- Wageningen ***IMARES*** is a knowledge and research partner for governmental authorities, private industry and social organisations for which marine habitat and resources are of interest.
- Wageningen ***IMARES*** provides strategic and applied ecological investigation related to ecological and economic developments.

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Wageningen IMARES has been contracted by Dutch Ministry of Agriculture, Nature and Food Quality with funding from the "BO PPP"-programme to make an inventory of existing and expected future human activities in that part of the Eastern Atlantic Ocean that forms the Economic Exclusive zone of Mauritania with respect to their possible impact on the marine ecosystem. The inventory will mainly be focused on the different fisheries in the area, but will not be restricted to these. Based on this inventory of activities this report will consider data needed to properly assess the impacts on the ecosystem arising from these and the studies required to gather that data.
Finally recommendations will be made on future studies and other possible actions to take.

Activities that are taken into to consideration include:

- Shipping and associated coastal pollution
- Offshore Oil Production
- Fisheries
    1. small pelagics
    2. cephalopods (octopus)
    3. demersal fish
    4. shrimp
    5. hake
    6. crab
    7. langoustes

Shipping, including fisheries, is associated with several sources of coastal pollution which are identified in this report. Suggestions are made to improve the handling of waste materials on land specifically that of waste oils from machinery. The offshore production of oil and gas is acknowledged as a valuable resource for Mauritania, it is however a resource that needs to be well-monitored to safeguard the fisheries resources. The fisheries are seen as equally important economically for the present, but have an edge over the oil and gas production in having the potential of being sustainable. In that way the fisheries will be earning the country money in decades well past the production life time of the oil and gas fields.
The fisheries themselves are identified as being in danger of destroying their own resources. Many stocks show signs of overexploitation. The scientific studies performed within the field of fisheries management is deemed very valuable, but in need of improvement. Most studies so far have been aimed at single species of commercial interest and many have only been published in 'grey literature'. This drawback is worsened by the fact that much of this work is in local languages and thereby inaccessible for the wider scientific community. It is suggested that the scope of the studies needs to be widened so that by combining all the work that is already being done, a comprehensive picture can made of the marine ecosystem as it functions in Mauritanian waters. This broadening of the scientific scope must include other species groups that have so far only been studied incidentally or not at all.
Another major problem regarding the fisheries is formed by the insufficient knowledge on effort and catch. Improvements in the process of collecting and (digitally) storing this data are seen as a prerequisite for getting a better grip on the industrial fisheries. Such data is needed for proper management of the fisheries resources and has strong links with amongst others fishing vessels based in the European Union. Similar difficulties are associated with the artisanal fisheries. However as this is much more a problem with the local economy, a programme of much more gradual improvements is suggested to achieve better knowledge and control of these fisheries while avoiding the collapse of local economies along the coast.

Summaire

A la demande du ministère Néerlandais de l'Agriculture, de la Nature et de la Qualité des Aliments et sur financement du programme « BO-PPP », Wageningen IMARES a réalisé l'inventaire des activités humaines présentes et futures dans la partie de l'Atlantic Est correspondant à la Zone Economique Exclusive de la Mauritanie, et de leur impact potentiel sur l'écosystème marin. L'inventaire traitera principalement des différentes pêcheries présentes sur la zone, mais ne se limitera pas à ce seul sujet. Sur la base de cet inventaire des activités, ce rapport déterminera quelles sont les données nécessaires pour estimer l'impact de ces activités sur l'écosystème et quelles sont les études qui doivent être menées pour collecter de telles données. Enfin, des recommandations sur les études à réaliser dans le futur ainsi que sur d'autres actions pouvant être entreprises seront exposées.

Les activités considérées sont :

- Le fret maritime et la pollution des eaux côtières qu'il engendre
- Exploitation pétrolière offshore
- La pêche
    - Petits pélagiques
    - Céphalopodes (poulpes)
    - Poissons démerseaux
    - Crevettes
    - Merlu
    - Crabes
    - Langoustes

La fret maritime, y compris celui associé à l'activité de pêche, est responsable de plusieurs sources de pollution des eaux côtières qui sont identifiées dans ce rapport. Nous formulons ici des suggestions pour l'amélioration du traitement des déchets à terre, spécifiquement concernant celui des huiles mécaniques usagées. La production de pétrole et de gaz offshore est une importante source de revenu pour la Mauritanie qui nécessite néanmoins un meilleur suivi afin d'assurer la protection des ressources halieutiques. La pêche constitue à l'heure actuelle une source de revenu aussi importante de l'exploitation des hydrocarbures, mais présentant néanmoins l'avantage d'être potentiellement une activité durable. La pêche gérée de façon durable continuera à rapporter de l'argent au pays bien des décennies après l'épuisement des gisements en pétrole et en gaz.

La pêche elle-même est menacées par la dégradation de l'état de la ressource quelle engendre. De nombreux stocks montrent des signes de surexploitation. Les études scientifiques réalisées pour la gestion des stocks sont menées de façon convenable, mais pourraient néanmoins faire l'objet d'améliorations. La plupart de ces études sont généralement menées de façon monospécifique et ne sont publiées sous forme de « littérature grise ». La publication de ces études dans la langue locale constitue un inconvénient supplémentaire car cela rend difficile l'accès de ces travaux à une plus large communauté scientifique. Nous suggérons d'élargir le cadre de ces études afin que, par la synthèse de l'ensemble des travaux déjà réalisés, une image d'ensemble du fonctionnement de l'écosystème marin des eaux Mauritaniennes puisse être dégagée. Cet élargissement du champ d'investigation scientifique devrait permettre d'inclure d'autres groupes d'espèces qui n'ont jusqu'alors pas été considérés, ou seulement de façon anecdotique.
Le manque de données concernant l'effort de pêche et les captures constitue un autre problème majeur. L'amélioration de la collecte et de l'archivage (numérique) de ces données est une nécessité pour le développement d'une meilleure connaissance des pêcheries industrielles. Cette information est

indispensable pour réaliser une réelle gestion de la ressource, et est fortement en relation avec des navires de pêche basés dans l'Union Européenne. Des difficultés similaires existent pour la pêche artisanale. Cependant, comme il s'agit là d'un problème à l'échelle de l'économie locale, nous suggérons que les améliorations visant à mieux connaitre et mieux contrôler ces pêcheries soient réalisées graduellement de façon à éviter l'effondrement d'économies locales le long du littoral.

1 Introduction

Wageningen IMARES has been contracted by Dutch Ministry of Agriculture, Nature and Food Quality with funding from the "BO PPP"-programme (MinLNV Beleidsondersteunend Onderzoek, BAS project code 4394200002) to make an inventory of existing and expected future human activities in that part of the Eastern Atlantic Ocean that forms the Economic Exclusive zone of Mauritania with respect to their possible impact on the marine ecosystem. The inventory will mainly be focused on the different fisheries in the area, but will not be restricted to these.
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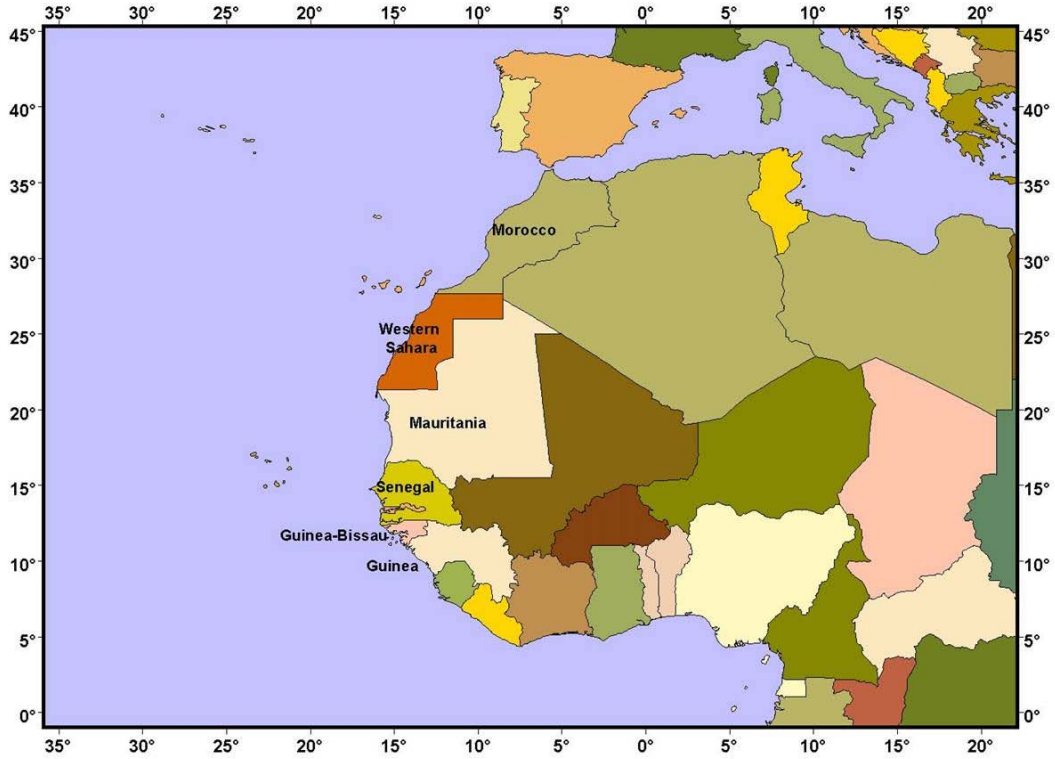

Figure 1 Location of Mauritania on the West African continent

Mauritania is a West African country located between the Western Sahara and Senegal (Figure 1). It has a desert climate with little, if any, precipitation resulting in a territorial area with an arable acreage of only 0.2%. Desertification in large parts of the country has forced a large part of the human population to a sedentary lifestyle, living with extremely limited economic prospects. This has made Mauritania number 22 on the Human Poverty Index and number 137 in Human Development Index in 2005 (UNDP, 2007). The country's southern strip along the river Senegal is where the 0.2% arable land is located and part of the Sahel, where subsistence farming and pastoral livelihoods are highly vulnerable to drought. Over the past decades, a series of natural disasters such as drought and locust invasion, have caused repeated food crises. In an area where the annual five to six month "lean season" always brings hunger and where rainfall is unpredictable, this has strained the resources of the rural poor. Food security in Mauritania is a complex issue with different levels of food availability, access and production across the country. However, the extreme poverty, which affects 68 percent of rural inhabitants, implies a high

vulnerability to food insecurity. The food deficit is structural, the means of production are limited, and traditional agriculture consists mainly of rain fed crops on floodplains. In an average year, the country imports almost 70 percent of its cereal needs.
Despite the fact that Mauritania is blessed with a large fish stock in its coastal zone and that 40% of its 2.9 million human population lives within 100 kilometres from the seashore, it has a consumption rate of fish per head of the population of only 9 kg per year. Fish is in general an export commodity in Mauritania earning the country hard currency and for that reason of great importance.

Mauritania as a fishery dependent country has the desire and will to have a healthy fish stock and the intention of exploiting these maritime resources in a sustainable way to the benefit off the people in terms of food, income and labour. The country has, despite limited resources, invested in its fishery management by means of a specialised Ministry of Fisheries, a fisheries law enforcement organisation and a research organisation with staff, vessels, offices and facilities. Despite frequent personal changes at the top of the ministry the fishery policy of Mauritania is an example of steady and consistent development.

Fishing in Mauretania is mainly done to serve an export market; over 90% of the catch is exported. As such it delivers an important part of the countries national income, contributing between 25 to 40 percent. The mainstay of the national economy is the mining industry, contributing between 60 to 75 percent to the gross national product. Mining consists of iron ore, oil, gypsum and some gold. The iron ore is the most import of these. It is won in the far north of the country and at the mining site processed to pellets. A 600 km long railway transports the ore to the coastal town of Nouadhibou where it is exported in an unprocessed form. The iron mine and the transport is controlled by the state-owned company SNIM and is financially the most important asset in the national economy. Oil is found offshore and will be dealt with in a later section. The other mining products are of only marginal importance for the national economy and will not be considered further.

Many impact studies which focus on fisheries or other human interventions have been made in Mauritania, however most of these studies are written for a small audience, are based on a limited data set, a limited issue or a particular interest. Many of these studies are not published in journals and remain in grey literature. On top of that are many written in not general accessible languages like Russian, Portuguese, Spanish, Bulgarian, Chinese, and Japanese.
This makes it very difficult to compile a complete and detailed overview of all available studies and their value with respect to environmental impact assessment. An effort is made to access the topics on which an important gap in knowledge is known.

There are several databases available within the research organisation IMROP in Mauritania based on their own data from surveys with research vessels (pelagic, demersal, shrimps, cephalopods, hydrology etc), but also from expatriate vessels and projects. These data were/are scattered in several databases of researchers but there was/is not one central database available. The digitally available databases also differ from each other as every individual database has undergone all kind of corrections and additions, while there is no record of these. This has resulted in an unknown number of editions of a once original database.
Between 2004 and 2006 an initial effort has been made to collect all historical paper databases, a process which is continued up to today. Several paper databases, in particular older ones, are not digitalised. Two projects have made an effort to alleviate this problem. SIAP, which has ended in 2007, and a Dutch project which has ended in 2008, executed via Corten Marine Consultants. Maintenance of this system remains a weak point in the Mauritanian context.

Besides IMROP and its databases the Ministry of Fisheries has a law enforcement and control organisation, “Le Délégation du Surveillance et de Control en Mer - DSPCM”. This organisation manages databases of all issued licences, records of all industrial fisheries vessel movements (via a VMS system) and receives all compulsory filled-in fishermen’s logbooks and declaration forms of the Industrial fisheries. Besides that there is a database of exported products within the ministry.
All these databases are not integrated and all are incomplete.

2 Research activities

Activities to consider:

- Shipping and associated coastal pollution
- Offshore Oil Production
- Fisheries
    1. small pelagics
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    4. shrimp
    5. hake
    6. crab
    7. langoustes

Figure 2 Waste oil on the beach of Cansado in the Bay the Lévrier is a regular phenomenon

Regarding employment the fisheries stands for many more jobs than the heavily mechanized mining industry. Especially the artisanal fishery with small craft gives employment to many. The number of employees in the fishing sector is estimated at around 36.000 persons of which 31% finds employment in the artisanal sector, and 12 % in the industrial fisheries. 57% of the workforce is additional posts to serve the sector.

Only recently (less than a decade ago) were oil deposits discovered in the area. As there were no known oil or gas fields in neighbouring countries no exploration for oil had been undertaken until then. In 2001 the Australian oil company Woodside found the Chinguetti oil field, which started production in 2006 from an FPSO installation (floating production, storage & offloading) where the Berge Helene is moored and linked with at least three production substations on the ocean floor. The field is presently operated by PETRONAS, the Malaysian state oil company that acquired the stake (47%) of Woodside in 2007. Several other oil companies and the Mauritanian government (12%) all have minority stakes in the field, which licensed under a PSC or Production Sharing Contract. Since the first discovery at Chinguetti, others like Thiof, Tevet, Aigrette and Banda as well as Faucon and Pelican were made, some of which contain both oil and gas or even mainly gas. All of these newer finds are presently still in the exploration phase. The expected production life time of the Chinguetti field is between 10 and 15 years.

(Sources: www.petronas.com, www.rigzone.com, www.offshore-technology.com)

3 Shipping and associated coastal pollution

Associated with the mining, but also with fisheries as well as with other more general trade is a considerable shipping activity. Shipping is the main route by which Mauritania receives its imports and is also how most exports leave the country. The port of the capital Nouakchott is a jetty in sea able to handle 4 vessels simultaneously. In this harbour fishing vessels are not permitted to come ashore. An artisanal fishing port exists on the natural beach north of the cargo jetty. On this beach 35% of the total landings are brought ashore. The most important harbour in Mauritania is that of Nouadhibou, located on the peninsula of Cap Blanc on the extreme northern part of the coast. Here approximately 65% of the fish catch is landed. Besides the ports of Nouakchott and Nouadhibou there are no ports in Mauritania.

Shipping brings pollution in to the area from anti-fouling compounds leaching from ships hulls. Also it is noted that there are no facilities to accepting waste oil from ships nor is there capacity for handling this material once accepted. This has resulted in very frequent pollution in the harbour of Nouadhibou (Figure 2) and discharges at full sea during fishing practices. Only the extremely large trawlers in the area have an incinerator onboard to burn spent engine oil. A rough estimate of the volume of discharge of waste oil based on the amount of fishing hours in Mauritanian waters results in minimum annual discharge of 8.000 tons waste oil.

Shellfish like the intertidal brown mussel (*Perna perna*) and the subtidal warty Venus (*Venus verrucosa*) are found in the Bay de Lévrier just north of the entrance to the Bay of Cansado and were fished in 2004. The stock proved to be unfit for consumption due to petrol taste of the meat.

Not exactly land based is the “ships graveyard” of Nouadhibou (Figure 3), which poses not only a navigational threat, but also an environmental problem. As these vessels are rotting and rusting away, all chemicals varying from freezing liquids, insulation materials, metals and coatings will enter the environment. The number of sunken and stranded vessels is estimated at around 580 and these are concentrated in two places: The Bay of Noaudhibou with the adjacent harbour and Buoy 2, an anchoring area just east of the tip op Cap Blanc. The number of wrecks increases annually as abandoned vessels are seen stranded every year. The ships are stripped of their valuable equipment and elements and left to rot. There are no Mauritanian companies with salvage equipment.

Figure 3 *Small number of the stranded and abandoned fishing vessels in the Bay of Cansado. Not visible are the sunken vessels under the water which form the most dangerous navigational threat.*

The port of Nouadhibou consists of three sections:

1. The iron ore loading facility, just a few miles south of Nouadhibou,
2. An artisanal fishing harbour and
3. An industrial fishing harbour with a facility to handle cargo vessels. This last is necessary as the bulk of the fish export is by deepfreeze containers overseas. Additional to the port facility is the anchorage site of large fishing vessels south-east of the tip of Cap Blanc. This is the place where large pelagic trawlers (almost exclusively Eastern European and Dutch vessels) offload their catch into reefer vessels at sea for direct export. These vessels cannot enter the port of Nouadhibou as they are too big.

Severe constraints for Nouadhibou harbour are the large amount of shipwrecks in the entrance of the port, the limited depth of the port and the limited capacity to handle cargo vessels (no cranes). Nouadhibou has a supply system for freshwater and fuels.

The majority of foreign fishing vessels that fish from a harbour outside Mauritania (Tenerife, Gran Canarias, Dakar) never enters into Mauritanian ports and fishes for a period up to 8 weeks in Mauritanian territorial waters before leaving to their home port.

The waters near the ports or Nouakchott and Nouadhibou and the routes to and from them are where most of the shipping related pollution is likely to occur. This includes releases of household-type wastes from ships, leaching of anti-fouling compounds from ships hulls and discharges of other substances.

The latter may be related to incidents, but may also be intentional. Large quantities of rubbish are found all over the beaches of Mauritania (Figure 4) although the major north-eastern wind direction is offshore and material is blown to full sea. A major component of this material is plastics which later contribute to the global total amount of floating ocean debris (Franeker, 1988; Blight et al, 1997).

Mass mortalities of fish are a regular feature in the Bay of Cansado, as a result of incidental pollution originating from the industrial harbour of Nouadhibou (Figure 5). These mortalities concern usually two species groups: Mullets and the clupeid Bonga Shad (*Ethmalosa fimbriata*). Specifically these species are surface dwellers feeding by filtering the water for planktonic algae. These mass mortalities are accompanied by mortalities of migrant seabirds like terns and gulls, which prey on these fish.

Figure 4 *Stranded rubbish on a sandy beach of Cap Blanc. The yellow brownish material is insulation foam from abandoned shipwrecks which are broken down by locals for the scrap metal market.*

Figure 5 *Mass mortality of bonga shad in the Bay of Cansado accompanied by a large number of dead surface feeding terns of different species in November 2007.*

Onshore sources of pollution need to be considered as a human activity that could influences the marine environment. In the case of Mauritania there are no large industrial complexes – with e.g. chemical production factories – to consider. Some pollution may however reach the marine environment from the river Senegal on which most of the agricultural area is located. Also the population of the capital of Nouakchott, up to 30% of the countries population, is likely to have a limited effect on the marine environment. The most likely threats arise in the ports of Nouakchott and Nouadhibou where shipping related waste arises. The main problem being treatment of waste machine oil, which is not accepted on shore for controlled disposal.

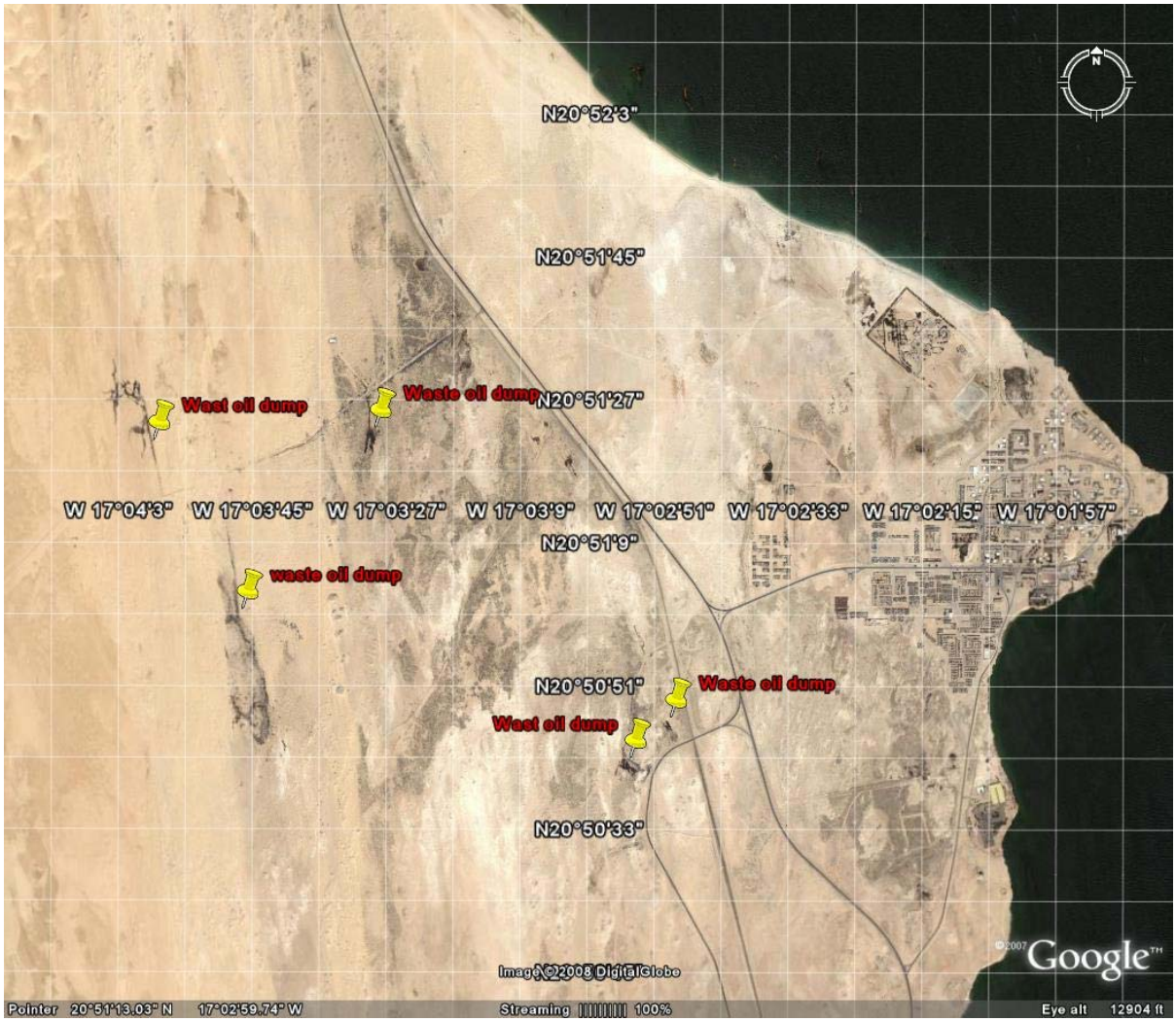

Figure 6 *A part of Cap Blanc in shown in Google Earth. Five large permanent waste oil dumps are indicated among many other small ones. The village on the right is Cansado.*

Onshore pollution that may eventually reach the marine environment is the unregulated dumping of waste machine oil with their chemical dopes and additives. These dumping sites are used by the railway company of the Iron ore exploitation company, Society National des Industrie et des Minières (SNIM), and from electric power plants. This practice has been going on for decades.

4 Offshore Oil and Gas

Following the discovery of oil and gas deposits offshore from Mauritania by the Australian Woodside oil company in 2003 the Chinguetti field has been developed and production has started in 2006. Presently the field is operated by PETRONAS, the Malaysian national oil company, who bought the stake of Woodside in 2007. A few other companies as well as the Mauritanian government (12%) also have minority stakes in the field. Production from Chinguetti is expected to last between ten to fifteen years. Since then other oil and gas deposits have been discovered in Mauritanian waters. The income from oil in Mauritania is estimated just below US$ 100 million a year and in that objective covers only a part of the income from fisheries.

Major oil spills can occur for several reasons. Amongst these the following can be identified:

- A malfunction in or on the production facilities can lead discharge of oil and other chemicals used onboard.
- A malfunction may occur during offloading of the produced oil from the FPSO Berge Helene to a transporting tanker.
- Other ships may loose their navigational capabilities either through loss of engine power (propulsion) or through a direct malfunction in the steering system. Wind and currents can carry such a ship toward either the FPSO or the unloading facility where damage can occur to the drifting vessel or the offshore facility or both. In every case a spill of oil products may occur and in case the damaged vessel in carrying a hazardous cargo also that may be spilled.

All of the above scenarios are based on some kind of mishap occurring, but most oil and gas fields do not only produce oil and or gas. A by-product is water. Water which is produced together with the product from the field and which is separated onboard the production platform and usually discharged to sea. This PFW or Produced Formation Water is not without risks to the environment. Depending on the separation techniques used, it will still carry some amounts of oil and gas products. When the separation techniques are chosen well, these are only trace amounts and not much risk to the marine environment is carried by the hydrocarbons (from the oil and/or gas) still present in the discharged water. Still there are other characteristics that may cause concern regarding the PFW. Usually PFW is extremely salty, devoid of oxygen and considerably warmer than the receiving water column. For both the hydrocarbon content as well as the other aspects the PFW of the Chinguetti field is no exception.

Earlier studies by IMARES (Korytar, 2006/7) have shown that the levels of hydrocarbons in the PFW of Chinguetti are near the level that may be perceived as generally save. Although this may not be alarming presently it also indicates that for the protection of the marine environment the Mauritanian authorities should make sure that proper monitoring measures are in place. They may either choose to perform this monitoring themselves (or have it done), they may also have the option of requiring the operator of the field (PETRONAS) to take care of this aspect. The government in that case will have effort to put in the monitoring, but they would probably still have to check some manner whether the operator is fulfilling its monitoring task satisfactorily.

Also a study of contaminants found in Sardinella – *Sardinella aurita*- (Korytar, 2007) comparing levels before and after the start of oil production and hence discharge of PFD did not find evidence for increased levels that appear to be associated with the PFW discharge and the oil production facility. However as is often the case with oil and gas fields, the amount of PFW increases during their lifetime. At Chinguetti oil production has already dropped and larger amounts of PFW are now being discharged. Once again continued monitoring for environmental effects is warranted. As *Sardinella aurita* is a highly

mobile long distance migratory species this is likely not a relevant choice as an example. Resident fish species or other benthic organisms may provide a better target for monitoring studies on the impact of oil production on the marine ecosystem.

Returning to the topic of an oil spill (accidental or otherwise) a concern is noted that there is no capacity nearby to contain an oil spill and combat it's spread in the environment. It seems therefore recommendable that a knowledge base is created within the region (i.e. in Mauritania or in neighbouring countries) on containing and combating oil spill and possibly other chemical spills as well. This knowledge base should have the benefit of having access to the proper tools as well. This could include specialized vessels, airplanes and other gear. Please note that Mauritania also has two internationally important protected areas on its shoreline: the Banc d'Arquin and N'Diawling (Figure 7).

These two coastal marine National parks are the only National parks in the country and depend heavily on expatriate funding. Banc d'Arguin (green on the map) forms 30% of the total coastline of Mauritania. N'Diawling (red on the map) is separated from the sea by a dune bar. The area is adjacent to the Senegalese Ndoudj National park.

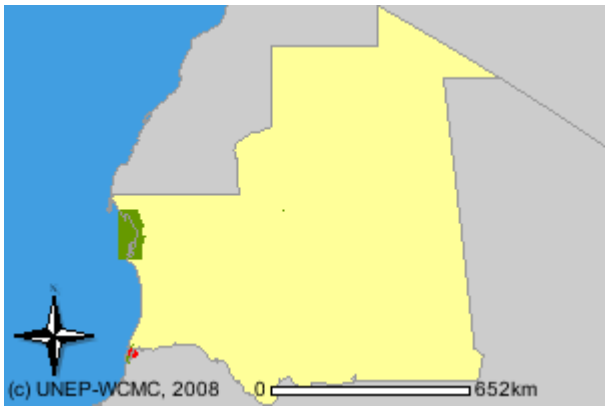

Figure 7 Location of Banc d'Arguin (green) en N'Diawling (red).

National parks in Mauritania

Banc d'Arguin is an area of over 12.000 km^2 including desert and sea territory located on the coast, roughly halfway between Nouakchott and Nouadhibou. The area became a National park in 1978 and a world heritage site in 1989.
It is a intertidal mudflat area with extensive seagrass beds. The area was recognized in the 1950 as an important breeding area for oceanic terns which nest in large colonies on the islands. During the 1970/80 the area was recognized as an important wetland for migratory wader birds from the arctic regions. 30% of the 7 million migratory birds on the eastern Atlantic flyway winter on the Banc d'Arguin. The area is also a step stone for migratory birds on their way to more Southern wintering areas. Within the park is a traditional non-mechanized fishery by the only ethnic Arabic tribe of artisanal fishermen (Imraguen). The areas is low in phyto- and zooplankton while crucial in the ecosystem is the production of seagrass. Pollution of these seagrass beds will have a far reaching influence on bird populations worldwide.
The intertidal zone and with that the seagrass beds are a nursery for juvenile fish and crustacean species. A present French project (PACOBA) tries to elucidate the role of the area for the commercial fisheries that take place outside the park boundaries.

N'Diawling is located in the utmost southwest corner of Mauritania at the mouth of the river Senegal on the border with Senegal. It was made a National park in 1991 for an area of 160 km^2. Until the early sixties the delta of the Senegal river was an area of extraordinary ecological richness. Consisting of a mosaic of dunes, floodplains and estuarine zones with mangroves, the area was known for its rich birdlife, important fisheries and dry season pasture. Several tens of thousand of people, practicing a variety of activities (hunting, fishing, cattle herding, collecting grasses for artisanal mats, etc.), found a livelihood there. Since then the environmental quality has deteriorated, first by the diminishing floods and rainfall that led to a food crisis in all of the Sahel, later by the alterations brought about by the large-scale hydraulic engineering of an artificial dam in the mouth of the river. Intended for irrigated agriculture and hydropower the results for the valley as a whole have as yet been far below expectations. In the Mauritanian lower delta the flood control infrastructures have had disastrous consequences for the biodiversity and productivity, effectively creating a saline desert. Though mitigation measures had been conceived and should have been in place prior to dam closure they were never implemented. In the absence of the natural flood the floodplain forest and pastures died, groundwater recharge was eliminated and village wells became saline, hyper saline conditions in the former estuarine areas virtually wiped out the mangrove, etc. In 1994, at the request of the Mauritanian government, IUCN, through a regional wetlands program financed by the Dutch Development Aid Agency (DGIS) started a field project, within the framework of the creation of the N'Diawling National Park, to restore the ecosystem and to elaborate a management plan for the whole of the Mauritanian lower delta.

The present economic value of the oil production to the Mauritanian economy is such that it is understandable that the country would want to benefit from it. However money and effort spent safeguarding the marine environment against detrimental effects of offshore oil and gas production is well spent. After all this will ensure that both during and afterwards the valuable fisheries can continue to earn money for the national economy as well. When both the offshore oil and gas production and the fisheries are properly managed, the total gain especially in the long term will be much greater.

5 Fisheries

Several types of fishery are undertaken in Mauritanian waters. A primary distinction to make is that between artisanal and industrial fisheries.

Industrial fishing vessels in Mauritania are defined as all vessels above 26 meter length and all vessels that practice pelagic or bottom trawling. This means that all motorised vessels below 26 meter in length, mechanised for fishing or not, are registered as artisanal and licensed accordingly. This is important for longline fisheries for hake and crab fishermen with crab pots/traps as they are all regarded as artisanal. Most of the artisanal fishing is done from pirogues. In general there are two types: the wooden vessels from Senegal and the plastic ones from Mauritania. Both types are driven by outboard engines.
The total catch and effort of the artisanal fisheries is not well known, nor is properly known what the total effort of the non-octopus fishing gear is. There is an on-going French research project into this topic. As the majority of the catch is landed at the artisanal harbour of Nouadhibou and the beach of Nouakchott it seems easy but as catches from different pirogues are combined at sea, it is not easy to access the effort. Along the coast of Mauritania are several temporary fishing camps but they form a minority in the volume of the total landings.

An observer programme (Hofstede, 2003a,b,c) on pelagic trawlers during the last decade has given detailed information on catch effort results and via total effort in the total catch. This was confirmed by the commercial data which were obtained voluntarily from a small number of vessels. Comparing these data with the official records showed a difference of 30%, with the official records being the lower estimate. Spanish research on Hake in which the official records from Mauritania were compared with the records from landings on Spanish harbours showed also at least a 30% difference. A Dutch programme to improve data collection and analysis is ongoing.
The confusion on total catch is also caused by the purpose of tax and export duty evasion by fishermen / businessmen. This is facilitated by disembarking the catch outside Mauritania.

Although fishing vessels are obliged to handover copies of their logbooks to the Mauritanian authorities, prior to export there is definitely an amount of unrecorded catch.

The volume of catch of the artisanal fleet is even more difficult to monitor then that of the industrial fleet as there are probably over 4000 canoes with licences. These licences are registered on the boat and the holder of the licence does not need to be the true owner of the vessel. Licences are valid for only a part of the year according to the validity of the licence. Frequent changes of ownership of boats, combined with changes of licence holder with or without boat makes the true effort of these canoes difficult to access.
Catch effort data can be investigated at the landing sites and in reality there are only 2 substantial sites in the country for the artisanal fleet: Nouadhibou where 62% is landed and Nouakchott beach where 35% comes ashore. For al the other 12 minor beacehes and villages where fish is landed an estimate of 3% is made (data from provisional results of IMROP in 2006). A French/Mauritanian ongoing project is attempting to achieve more accurate estimates.

Unregistered, unnoticed and unofficial are two types of fisheries in Mauritania: viz. the trade in shark fins and the trade in fermented fish.

- Sharks.
  There is an unknown amount of sharks caught in the Mauritanian industrial and artisanal fisheries. On the industrial freezing vessels all sharks are usually discarded after their fins are cut of by the crew, who take these as a private bonus. In this way the shark fins are part of the official landings of the ship. These fins are dried on land (Figure 8) and sold to specialised middlemen in Nouadhibou who export these to the Asian markets. Industrial vessels which fish for fresh fish (Glaciers) and the whole artisanal fisheries keep all sharks on board for processing and sun drying ashore. This volume is known (Khallahi, pers. com)

Figure 8 Shark fins from a mixture of species dried on a house compound in Nouadhibou.

- Fermenting of batoid fish.
  A particular aspect of the fisheries is the processing by fermenting of batoid fishes. Batoid fish are cartilaginous fish likes stingrays and skates and they are related to the sharks. These fishes are bought "fresh" from industrial vessels and taken from board by small canoes which transport them direct to a processing location outside Nouadhibou. The batoid catch of the artisanal fleet usually goes via the artisanal harbour to the processing location. The actual fermenting is done in cement basins under extremely unhygienic conditions and produces a very strong smell. The fermented product has one particular market which is Ghana and the whole production goes there. The volume of this unregulated processing and export is unknown.

Figure 9 Cartilaginous fish from different groups: Angel sharks, Mantas, Rays, Guitarfish prepared for fermenting outside Nouadhibou in 2006.

6 Importance of Mauritanian fish resource from a European perspective.

The fishing opportunities available in Mauritanian waters are of interest for Europe as they provide a place of refuge for the excess fishing fleet capacity within Europe. This counts in particular for the Spanish fleet for shrimps, octopus and round fish, as well for the Dutch and Baltic states trawlers which specialize on small pelagic species. In this respect it is interesting to note that presently a considerable number of Russian and Ukrainian vessels, is also active in the Mauritanian EEZ since the 1970s. Many of these vessels are in bad technical condition, and are likely to be decommissioned in the coming years. This will free up additional fishing capacity that can be taken by other European vessels, in particular Dutch pelagic trawlers.

European Union policy toward foreign fisheries agreements, is that in principle only un- or underexploited stocks are fished, which otherwise remain un- or under utilised. This principle is in Mauritania rightly applied for shrimp fishing and probably for small pelagics as well. This is definitely not the case for octopus and round fish. As there is little or no alternative for the Spanish fleet, commercial interest prevails over this principle. The EU–Mauritanian fisheries agreement provides for this by placing all EU vessels under this agreement.
European rules apply to European registered vessels but not for European companies. Several European trawlers changed flag to Mauritanian flag (via joint ventures) (Spanish) or to a flag of convenience (Dutch). In the last case a private agreement provides for such a vessel fishing in Mauritanian waters.

The European Union has fisheries compensation agreements with: Morocco, Mauritania, Senegal, Guinée-Bissau and Angola, but there are many fishing vessels from European and Asian origin which fish under local flag. The internal organisation of the companies for which these vessels operate, is not always that clear.

The Mauritanian coastal zone has increased in importance for the European fleet after the Moroccan EEZ was closed for Spanish vessels in 2000. The (re)opening in 2006 of the fisheries for European vessels in Morocco permits fishing but there remains a dispute over Moroccan authority over the coastal waters of the Western Sahara. These coastal waters are not recognised by any other country to belong to Morocco. As long as this is not settled, fishing in these waters remains illegal for EU vessels, increasing the importance of Mauritanian waters for the Spanish fishing fleet.

Export of fish and shellfish to the European Union is subject to sanitary inspection and control. The EU has issued a certification to the Mauritania organisation ONISPA (formerly a part of IMROP) for this control. The inspection concerns fish, octopus and shrimp, while an effort is made to add shellfish to the list of fishery products authorised for export to the EU. Within the topic of sanitary and hygienic conditions in relation to handling and processing of fishery products Mauritania is still in its infancy of development and ample room for improvements exists. The sanitary certification is according to Mauritanian officials also applied as a political instrument between the two partners.

Fishing agreements between the European Union (EU) and the Islamic Republic of Mauritania (RIM) impose that an independent joint scientific comity (JSC) composed of EU and Mauritanian scientists would meet on a yearly basis.

Dutch interest in Mauritanian resources is mainly in industrial small pelagics fisheries, shrimps and shellfish. The latter one is not included in the fisheries agreement.

The mission of the JSC is to review the work done to assess the state of the stocks in the Mauritanian EEZ which are included in these agreements, on the basis of existing reports, and provide advises for a sustainable exploitation of these stocks. The JSC also aims at answering a number of questions of particular relevance for the sustainable exploitation of Mauritanian resources, which may be indentified by the JSC itself, or asked by the Mixed Commission (European commission-Mauritanian government).

7 Fisheries and impact on biodiversity

The fisheries in Mauritania definitely have a strong impact on the biodiversity of the shelf area within the Mauritanian EEZ. The fish stock decline in Mauritania started in the 1930s (Balguerías *et al.*, 2000), when a Spanish fleet of Canary Islands based vessels fished in the waters of the, at that time, Spanish Sahara (now Western-Sahara) and outside the 12 mile coastal limit of the, at that time, French territory of Mauritania (Figure 10**Error! Reference source not found.**). The development of on-board freezing facilities and improved transport infrastructure during the 1960s together with the increase of industrial fishing and nylon fishnets has increased the fishing efficiency and the fishing mortality accordingly. The long term decline of piscivorous fish stock but also that of molluscivores and fish that feeds on *Octopus vulgaris* and shrimps inevitably must have had an impact on the prey species abundance. The composition of the fauna in the Mauritanian coastal zone is definitely not an undisturbed natural one.

Figure 10 Processing of fish by drying at Nouadhibou before 1940

Ecosystem functioning

The marine fauna in the Mauritania coastal zone is influenced by three hydrological factors:

1. The cold Canary current form the North,
2. The warm Guinea current from the South and
3. The upwelling of nutrient-rich waters from the deep.

The seasonally alternating influence of the two opposing currents causes an annual seasonal cold and warm period with an intermediate cold to warm and warm to cold season in the waters of Mauritania.

The dominant factor is the upwelling. This upwelling is caused by the equatorial air mass circulation which causes a dry wind from the north to move to the south. This wind is directed towards the south-west as a result of the rotation of the earth. As a result of this wind the surface water layer is blown offshore towards the open ocean and the water deficit is compensated by water from 40 to 50 meter deep by means of upwelling. As the wind velocity is not a fixed and stable factor in the region, the upwelling varies accordingly. This results in years with a strong and a weak upwelling as well as a geographic extension occasionally reaching into Senegalese waters. The area between Cap Blanc and Cap Timiris is regarded as part of a more extensive permanent upwelling zone located to the north.

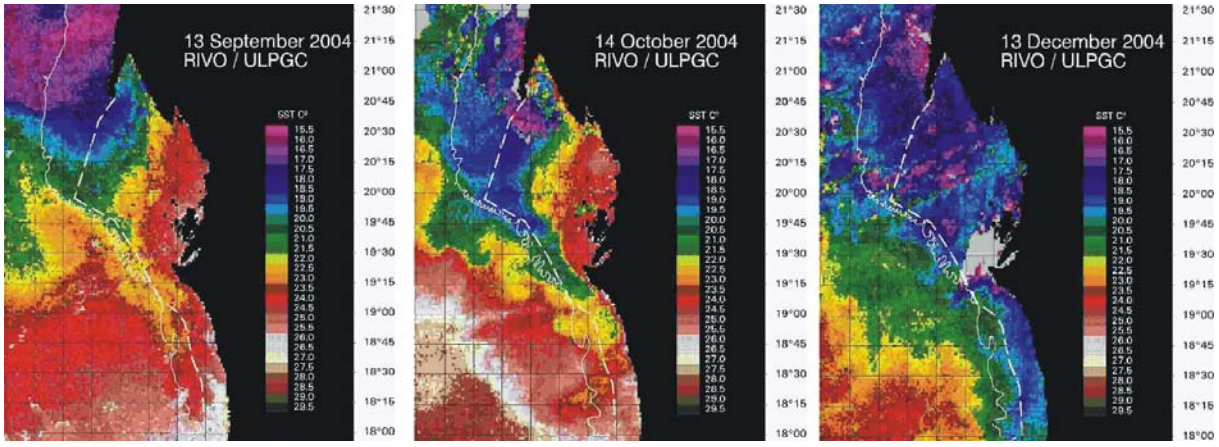

Figure 11 Three satellite images from the same area of the Mauritanian EEZ in different months of the year, showing the sea surface temperatures in colours and the landmass in black.

The present fisheries in Mauritania depend on three fauna elements: Fish, Crayfish and Cephalopods. The group of the Crayfish can be subdivided in to that of the Shrimps on one hand and that of the larger Crabs and Langoustes on the other hand.

Fish

There are probably over a 1200 species of fish found in Mauritanian waters. Over 694 species are found in the ongoing monitoring programmes for fish and shrimps which are executed by the research institute IMROP but there are several groups of fish of which the identity is not clear. This is also caused by the lack of recent comprehensive species identification work for the Mauritanian coast. Several species from family groups as Gobies and Blennies remain unidentified, while the species identity of several other fishes remains unclear e.g. species within the genus Triglidae and several small flatfish species. Nevertheless, the fish fauna is rich compared to other areas.

Shrimps

There are over a 100 species of shrimps found in Mauritanian waters. Of these 5 species are exploited of which *Penaeus notialis* and *Parapenaeus longirostris* are the target species. A bycatch of the fishery for *P. notialis* is a small quantity of *Penaeus kerathurus*. There is also a small fishery for *Aristeus varidens*, *Glyphus marsupialis* and *Aristeomorpha foliacea* which is only a profitable fishery due to the bycatch of *Lophius budegassa* and *L. piscatorius*. All other species of shrimps are discarded or not caught in the commercial fisheries.

Crab and Langouste

There are two species of langoustes in Mauritania: the inshore species *Panulirus rissoni* and the deep water species *Panulirus mauritanicus*. On the last species a very lucrative specialised fishery has existed in Mauritania, but the introduction and popular use of an efficient catch method in the rocky areas by Portuguese fishermen in the 1960s and 70s, combined with the habit of not returning immature and fertile animals, as practised by all fishermen, has reduced the stock to uneconomic levels. Where annually 30 licences were once sold, in 2006 only 1 licence was issued for 3 months which was not renewed.

Crab is fished with traps from small motorised vessels and is regarded as artisanal fishery. The number of traps might be over 30.000, which are in simultaneous use. The most important species is *Geryon maritae* (Diop *et al.*, 1995) although the impression exists that more species are retained on board. There has not been any research on this fishery and nothing is known on stock etc.

Cephalopods

There are several commercial cephalopod species found in Mauritanian waters of which the Octopus (*Octopus vulgaris*) is the dominant and commercially most important species. Other exploited species concern *Sepia* and *Loligo* species. All these species are harvested as bycatch, but stock estimates of these pelagic species have not been done in recent years. All together the number of cephalopod species is around 26.

All stocks of fish, shrimps and cephalopods in Mauritania show signals of overexploitation by declining catches (CPUE) and declining total landings (Tjoe-Awie *et al.*, 2006; IMROP, 2007). Stock estimates are done by the Institute Mauritanien de Recherches Océanographiques et des Pêches. The Institute annually makes bottom trawl surveys focused on octopus, shrimps and demersal fish, pelagic surveys focused on small pelagics stocks and additional surveys at the request of the Ministry of Fisheries (e.g. sea mammal census and Hake survey). The Institute has qualified crews and technicians and a routine of executing these surveys with their own (2) research vessels.

Sea Mammals

The EEZ of Mauritania is home for three groups of sea mammals: 1. Monk seals, 2 True whales, 3 Dolphins.

Mauritania has the only vital population of Monk seals in the world. Monitoring and research of this population is done by Spanish nature conservationists. Mauritania has an efficient means of protecting of this species, as the breeding place is shielded from intrusion by an uncharted minefield on the landward side.

The EEZ of Mauritania is included in the distribution range of cosmopolitan whales. The West African zone is sometimes mentioned as a maternity area for large fin whales during the northern hemisphere summer months. Regular encounters indicate an anecdotal impression of a rising stock (Waerebeek, pers. com). There are no recent annual censuses of large whales made in Mauritania waters.

Dolphins and porpoises are often encountered in all Mauritanian waters. Mauritania is home of the coastal Atlantic Humpback dolphin, a rare and threatened red list species. Several other species are known from incidental catches, either from pelagic trawlers (Hofstede 2003b, Hofstede *et al.*, 2004) or artisanal gillnet fishermen. There are no indications on trends of stock size for these animals in Mauritanian waters. Knowledge of incidental strandings of cetacean species is limited to anecdotal information and skeletal remains.
Ongoing research projects (Heessen *et al.*, 2007, Haan, 2008) are studying the possibilities of reducing by-catch of whales and other large species by means of fishing gear modifications. These specifically target the small pelagics fisheries, where such large specimens are unwanted bycatch and are often discarded.

Future Fisheries developments

1) Shellfish.

In the Mauritanian EEZ a stock of bivalves of *Venus rosalina* of at least 1.1 million ton is available for exploitation (Stralen, 2005; Goudswaard, 2008). The impact of the exploitation of this stock is not known but has been the subject of an extensive desk study (Goudswaard *et al.*, 2007). As there is no experience elsewhere on the exploitation of this species, there is a proposal for an exploratory fishery of a limited amount and a limited area with extensive monitoring.

2) Deep sea.

Almost the entire fishery in Mauritania takes place in the zone of the continental shelf and slope. The deep oceanic zone (> 1500 meter) is only incidentally fished by specialised fishermen for deep sea shrimps. The extent of this fishery is only 2 vessels and only during a part of the year. With worldwide declining catches and an increasing demand for fish, there is a commercial interest for exploiting this zone, in particular for deep-sea fish. Nothing however is known of the species composition, stock size or accompanying species of this habitat, which is generally regarded as very fragile and vulnerable to exploitation.

3) Pelagic fishing for unexploited stocks.

While there is a high level of exploitation for small pelagic fish species as well as a smaller number of vessels hunting for large pelagic species, there are two potentially "unexploited" stocks in the pelagic zone: Anchovy (*Engraulis encrasicolus*) and the pelagic squid (*Loligo vulgaris*). Anchovy is a bycatch of the pelagic fishery, but the catch volume and exploitation level is unknown. Anchovy is either handled as unreported discard (Dutch vessels) or converted to fishmeal (Eastern European trawlers). With the collapse of the Mediterranean anchovy stock and a high demand (7€/kg), there is interest of entrepreneurs. The exploitation in Mauritania would be illegal as it requires a smaller minimum mesh size than is permitted at this moment.
Squid is also a valuable bonus from the sea as bycatch of the pelagic trawlers. Stock size and biology in Mauritania are unknown.

4). Whaling.

Although there is at no present exploitation of whales in Mauritania and Mauritania itself has neither a history of nor experience with whaling, there is an existing commercial interest from Asian origin for whales in the area. Japan has an annual census of whales in a number of West African countries and in case the moratorium on the exploitation of whales is lifted, the country might start fishing for sperm whale and large fin whales. (St. Kitts & Nevis Declaration, 2006)

The marine fauna of Mauritania is rich in species, of which some are not commercially exploited. These range from whales and turtles to shellfish and crayfish, sponges and numerous other animal groups. There is only scattered information from incidental scientific studies on these animals on the continental slope (Duineveld *et al.* 1993a,b). Anecdotal information indicates changes in abundance of several species , usually a decline. In particular sessile elements appear to be suffering.

But there are no species lists, no registrations of abundance or abundance trends available for these species. Also the knowledge base within Mauritania on marine species diversity is lacking. The Mauritanian organisation, IMROP, which would be the most appropriate place for knowledge about these groups, does not have any person with species recognition knowledge for these groups. IMROP has no past experience with this topic and has no books of reference or a species reference collection.

A biological item of particular interest is Maerl, a type of calcareous red algae which form the basis for a specific and biodiverse habitat. As a slow growing species Maerl is vulnerable for physical disturbance e.g. from fishing gear. However as an alga it also requires light to grow and survive and is therefore sensitive to changes in siltation. These algae are known to occur in Mauritanian waters and are expected to occur mainly in water depths between 10 to 25 meters. As a result of this they may have been largely overlooked, as most surveying activities have been directed at deeper waters. More on the topic of Maerl can be found in Lavaleye and Duineveld (2007, in Goudswaard *et al.*, 2007).

Yet another area with specific biodiversity has been identified by Colman *et al.* (2005) who reports on finds of deepwater corals in association with carbonate mounds in occurring in water depths of around 500 metres on the continental slope. This occurrence has a geographical extent of around 190 kilometres along the Mauritanian coast. Colman *et al.* (2005) already point towards implications of this find for benthic trawling as well as oil and gas exploration activities. Also during regular demersal fish surveys with the research vessel Al Awam living and dead coral is incidentally found on the continental slope (Goudswaard, pers. obs.).

8 Studies

Many studies have been performed on fish stocks and other marine resources in Mauritanian waters. Many of these studies are initiated by commercial interest and problems ranging from declining fish catches to the effects of oil exploration. A constraint is that these studies are usually not published in journals and remain scattered as grey literature, e.g. in FAO CECAF reports and technical papers (FAO, 2004). A good exception is Gasquel *et al.*, 2007. Examples of Environmental Impact Studies exist for e.g. the exploitation of oil (Colman and Gordon, 2005) and the exploitation of shellfish (Goudswaard *et al.*, 2007). Regular surveys are undertaken by vessels of the Russian fisheries research Institute Atlantniro from Kaliningrad (twice yearly, all pelagic species), but no known records exist documenting their findings (See Box below). Spanish research in cooperation with the Mauritanians focuses on Spanish interest topics like surveys of shrimps and Hake (IMROP/IEO, photocopied reports). More examples are the many studies (often based on a very limited database) done on Thiof (*Epinephelus aeneus*), a predatory species of high commercial value that has declined during the last decades to insignificant levels (Telmidi, 2005; Laurans *et al.*, 2001). Without direct commercial interest is the acoustic research for small pelagic stocks performed by the Norwegian vessel "Dr. Fridtjof Nansen" operating under FAO supervision. This vessel is however no longer active in the region (Ybema, 2005). Now this leading FAO vessel has left the area the importance of local surveys will become essential but the quality is still highly uncertain. Reviewing the regional acoustic surveys has therefore become a priority. There is a wealth of inaccessible data from Polish, Bulgarian, Rumanian and former Soviet Union research efforts which are written in local languages. A Japanese study from 2000–2002 (Sanyo Techno Marine, 2002) studied many aspects of economic fish stocks and abiotic data but did not give a comprehensive picture of the total. It also did not give practical conclusions or tools for management actions in the field.
A special case is the publication of a book on Octopus in Senegal - Le poulpe Octopus vulgaris by Caverivière *et al.* (2002) which can be applied to the Mauritanian situation and stock.

Many of the above mentioned studies are focussed towards one single objective. Usually they are focussing on a "temporary" problem in commercial exploitation of a specific species group. They remain detail studies and are found lacking in providing an integrated overall picture.

Description of scientific surveys by Russian vessels from which results appear to be lacking in grey literature or otherwise.
September, 11, 2006. The **"Atlantida"**, a Russian research vessel**,** came back from Central East Atlantic. Assessment of abundance and of biomass of pelagic fish in EEZ of Morocco and Mauritania, and features of their distribution depending on environment conditions were obtained during the cruise.
June, 19, 2006. The research expedition on vessel **"Atlantida"** to CEA began. Cruise objective is assessment of abundance and biomass of pelagic fishes in Morocco and Mauritania EEZ.
January, 29, 2006. Russian research vessel **"Atlantniro"** returned from expedition in CEA. The aim of expedition was to obtain estimates of recruitment of pelagic fishes in Morocco and Mauritania EEZ. Data on distribution peculiarities and indices of abundance recruitment of sardine (*Sardina pilchardus*), round sardinella (*Sardinella*), Atlantic horse mackerel (*Trachurus trachurus*), Cunene horse mackerel (*Trachurus trecae*), mackerel (*Scomber japonicus*) are obtained.

Ecological research on bird populations in the two National parks Banc d'Arguin and N'Diawling revolves around the activities of expatriate researchers. The objective of this research is scientific and/or nature conservation. The research can be split in two parts:
1). Migrant wader birds and their associated habitat and

2). Resident piscivorous colony breeding birds.
The research on wader birds has been running for decades and focuses on the intertidal coastal zone and has little if any interference with the commercial fisheries which take place well outside the park borders (Ens *et al.*, 1990; Wolff *et al.*, 1993; Spaans, 2006).
The large breeding colonies of birds that nest in these parks depend for a large part of their food on fish. Some species remain in the park but quite a number of gulls and terns feed on the discards of the fisheries (Naurois, 1959; Veen *et al.*, 2003). The availability of food as a result of the discard of the fisheries might influence the numerical abundance of these birds.

Biological research on the functioning of the ecosystem of the Banc D'Arguin by a French group of Universities and Institutes (PACOBA) might throw a light on the importance of these areas as nurseries for the recruitment of commercial fish and shrimp species.

9 Evaluation and Integration

From the information presented above a picture arises of fragmented knowledge and an absent integrated long term approach on the ecology of Mauritanian waters. Population dynamics of only a limited number of commercial species is followed, often with the support of expatriate funding of commercial objectives, but long term historical developments are not known. Interactions between species groups and shifts in abundances as resulting from these interactions are fragmentarily understood and not the subject of scientific study As a result integrated management from an ecological viewpoint is lacking. Table 1may help to identify the level of available knowledge for the different types of fisheries and other human activities that have been considered in this report. Please note that an okay regarding data availability does not necessarily mean that some improvement in accessibility and/or quality is not needed. On the contrary even there improvements should be made.

It should be clear by now that the marine ecosystem of Mauritania is a rich and biodiverse system, which includes some internationally important nature conservation areas. Also the fisheries that are sustained by it provide an important and sustainable economic resource for the country. Therefore it should be worthwhile to the Mauritanians, both government as well as the population at large, to manage the system in a responsible manner. Considering the international importance of the Banc d'Arguin for bird populations worldwide also the European countries and Russia, as well as other countries, have a stake in keeping this system healthy.

Presently the pressure exerted on the system from the offshore oil and gas production is still at a low and most likely acceptable level. However as the more recently discovered fields are taken into production, proper monitoring of the environmental performance of this industry must be maintained. To avoid burdening the Mauritanian government with this task, they would seem well advised by including sufficient monitoring requirements in the permits issued to the companies operating the offshore oil and gas resources. Some level of government control will still be needed though.

Monitoring of environmental impacts of the offshore oil and gas industry should target not only commercial species, such as the migratory *Sardinella's*, but must include non-migratory and sessile species, e.g. demersal fish species and other benthic organisms.

Pollution and rubbish entering the marine system from land is also an issue that has been identified within this report. Improved capabilities for household waste collection and e.g. controlled incineration of such waste should be considered and need not be very costly. Also developing facilities in the ports of Nouakchott and Nouadhibou to receive and process spent engine oils and other hazardous wastes from vessels entering the ports is advisable. For this purpose the ports should include the beaches used by the artisanal fishing vessels.

Inclusion of the results of recent scientific studies as well as those of presently on-going studies into procedures to assess fish stocks and TACs (total allowable catches) is a requirement for improving the management of fish stocks towards a sustainable fishery. After all presently most stocks in Mauritanian water are showing signs of over-exploitation.
As many studies so far have focused on single topics, mostly on commercially important species, a more integrated approach is recommended. As a first step available scientific results could be processed to get a best available full system view, from which and optimal set-up for a more integrated approach can be developed.

Table 1 Assessment of required and available knowledge

Resource/ Species group/ Human activity	**Required knowledge**	**Availability**
Fish (demersal)	Stock	Okay
	Catch per Unit Effort (CPUE)	Okay
	Total Catch	Incomplete
Fish (small pelagic)	Stock	Okay
	Catch per Unit Effort (CPUE)	Okay
	Total Catch	Incomplete
Fish (large pelagic)	Stock	Incomplete
	Catch per Unit Effort (CPUE)	Incomplete
	Total Catch	Incomplete
Cephalopods	Stock	Okay
	Catch per Unit Effort (CPUE)	Incomplete
	Total Catch	Incomplete
Shrimps	Stock	Okay
	Catch per Unit Effort (CPUE)	Incomplete
	Total Catch	Incomplete
Shellfish	Stock	Okay
	Catch per Unit Effort (CPUE)	Not (yet) exploited
	Total Catch	Not (yet) exploited
Langoustes	Stock	Not known
	Catch per Unit of effort	Not known
	Total catch	Not known
Crab	Stock	Not known
	Catch per Unit of effort	Not known
	Total catch	Not known
Sea mammals	Annual census	Incomplete
	Trend	Incomplete
	Strandings	Incomplete
Birds		Incomplete
Sea turtles	Abundance	Incomplete
	Trend	Incomplete
	Stranding	Incomplete
Biodiversity	Species occurring within the Mauritanian EEZ	Incomplete
Oil & Gas production	Produced amounts	Okay
	Financial results (costs, profits)	Okay
	Environmental monitoring	Uncertain
Shipping	Tonnes imported/ exported per product group	Okay
	Financial results (costs, profits)	Okay
Fisheries	**Industrial**	
	Catch data	Okay (-)
	Financial results (costs, profits)	Okay
	Artisanal	
	Catch data	Incomplete
	Financial results (costs, profits)	Incomplete
	Deep Sea	
	Stock	Unknown
Pollution (land-based & marine)	Amounts of waste entering the marine environment (per type of waste)	Unknown
	Cost of environmental damage,	Undetermined
	Expected cost of improved waste management (possibly a benefit if smaller then costs of environmental damage).	Undetermined

10 Recommendations

As commercial species have the interest of those responsible for the exploitation and the fishermen who benefit from them, there has been considerable interest in these species from the objective of sustainable exploitation. Unfortunately reporting of the results is scanty and scattered. The impact of fishing on the non-target species is for many species not known.
The following list of recommendations has been arranged to show some prioritization, with fisheries related topics before those relating to the offshore oil and gas production. A more integrated level of knowledge of the ecosystem is required and some suggestions aim towards this integration, while others widen the field of research to include non-target species and other elements of the ecosystem that have so far been mostly overlooked.

1. A need has been identified for integrated knowledge of the marine ecosystem of the Mauritanian Economic Exclusive Zone, to achieve this goal it is recommended that a more integrated approach to marine biological research is promoted.
2. The impact of fishing for small pelagic species on their predators and the stock fluctuations of these species are not known. Additional to that are the effects on cartilaginous species like sharks and rays. Also the impact on large pelagic species of commercial importance – Tuna, Swordfish (*Xiphias gladius*) and large mackerels e.g. *Scomberomorus tritor* and horse mackerels Lichia *amia* – is unknown. Good management of these commercial expensive species requires information on their biology and stocks from the field. This subject seems ideal for a PhD student educational programme in which a relation between research institutes forms the basis of cooperation.
3. The impact of bottom trawling for cephalopods, fish and shrimps on the non-target species of invertebrates is only known from anecdotal observations as it remains unrecorded. The biodiversity of the area is rich and there are indications of decline, especially for sessile species (e.g. *Pyura dura*) (Figure 12).
   The objective of sustainable exploitation and management of the fish resource should be widened to include the conservation of biodiversity in the exploitation zone. A study to determine the abundance of the existing fauna, including all species groups, is necessary to provide a base line for monitoring. Systematic knowledge of the species assemblages is nonexistent in the offshore areas and only minimal effort is put into this field by specialists from expatriate origin. Within Mauritania there is a need for a nucleus of knowledge on all these fauna elements. This can be solved by institution building via transfer and capacity building of staff within Mauritania.

Figure 12 Examples of benthic macro fauna species, Pyura dura (left) and a Gorgonacea of unknown species identity (right) which are thought to decline in numbers due to bottom trawling.

4. Stock assessment and in particular monitoring of stock size of all exploited stocks in the EEZ of Mauritania remains a crucial tool in managing the fisheries and recognising changes in stock size and composition. The historic data form the basis in the analysis of trends and fluctuations in the stocks as the outcome of the results of the surveys forms the basis of decision making process. A proper data management system and adequate control of the basic figures is essential for a clear analysis.
5. The number of fisheries scientists in Mauritania is extremely limited. This is partly due to the French orientation of the country concerning science and the historic relation with the former Soviet Republic. The link with the Anglophone world of fisheries biologist is extremely weak. Those scientist who were sent by different Mauritanian Organisations for education abroad, appeared in high demand by the Ministries in the Capital Nouakchott and consequently most of them have changed jobs. This is a positive development for Mauritania as a whole but leaves the Research and Law Enforcement Organisations without the number of graduate staff as expected and needed. Institution building by means of capacity enhancement of staff via training nevertheless remains a vital instrument in the development of the fisheries in Mauritania.
6. Bycatch and discards of commercial species pose a problem in all fisheries and should be recorded. Both are an important tool in the management of the fisheries. There is only limited knowledge on discards in the pelagic and shrimp fishery (Goudswaard & Meissa, 2006), but the bycatch of the cephalopod, hake, crab and artisanal fisheries are completely unknown. The basic knowledge on the technology to prevent bycatch and discards is scant or complete lacking within Mauritania. The country is aware of the lost value. In 2009 is a Dutch financed project with the objective of finding a technological solution in the shrimps fisheries will end.
7. Observers. Within the framework of the European – Mauritanian Fisheries Agreement an amount of several million Euro is earmarked for fisheries research and monitoring via an observers programme. This programme has for a number of reasons been executed by the law enforcement organisation DSPCM. Neutral observation and law enforcement are however two incompatible entities and for that reason responsibility for the observer programme has been changed by ministerial decision to the research organisation IMROP. Within the IMROP a limited experience with observers is present as a result of a programme executed under the Dutch Pelagic and Shrimp project. Up scaling this activity with corresponding data management will be a challenge for IMROP, which is understaffed at present. Intervention from outside might be a substantial aid for IMROP and can result in a much improved monitoring system.

8. Review of the acoustic survey targeting small pelagic species: review of the protocols, coherence of the results between the surveys conduced by the different nations, and with the Nansen survey. As explained in the chapter "studies" the quality of national surveys results is highly uncertain but having a direct effect on the management strategy for these species. This recommendation has been acknowledged by the independent joint (EU- Mauritanian) scientific comity (JSC).
9. It has been shown in this report that much research is already done in Mauritania regarding the fisheries and the marine environment. However as a result of very diverse reporting methods and the lack of a standardized method of storing and retrieving scientific results, much of the value of the gathered data remains unused. A recommendation is made to improve the capabilities in Mauritania for adequately storing and retrieving all relevant data that becomes available from surveys and other types of scientific study. This will help in achieving both improved scientific knowledge of the integral system, as well as in keeping the financial efforts of Mauritania and it's partners at an affordable level.
10. A number of points of concern remain regarding the artisanal fisheries. There is a lack of knowledge on the species that are targeted by this fishery as well as on the total amount of fish caught. The artisanal fisheries form a difficult issue as controlling it is not only hampered by the difficulty of controlling numerous beaches where catch is landed around the country, but also by the sheer number of people involved. As far as economics go it also provides a source of income for many. As a result severe action against artisanal fishermen may have unwanted side effects. On top of this, this type of fishery is mostly limited to the coast and may therefore pose a risk to the existing national parks. Better knowledge and control of artisanal fisheries is seen as necessary. However a well thought out programme is called for, that slowly but gradually must work towards achieving its goal. At the same time care must be taken so that the coastal communities and their chances for economic development are not upset.
11. Tickler chain impact in the shrimp fishery. Commercial vessels targeting shrimps use a single tickler chain in front of the bottom trawl net to disturb the buried shrimps and chase them in the path of the net. This is illegal under the present Mauritanian law but tolerated. Research on the impact of the tickler chain on the catch efficiency for the target species and the additional fauna is needed for proper decision making.
12. Stock assessment of sharks and batoid fish. All cartilaginous fish species are vulnerable to exploitation in the fisheries due to slow growth rates and low reproduction numbers. This is a worldwide problem, which is focussed on countries that still have a rich population of these animals. Mauritania and adjacent coastal countries forms one hotspot for these species. The Mauritanian government has the objective to take action concerning the objective of conservation of the marine biodiversity but has not formulated a policy to achieve this. Within this objective an assessment of the stock and the developments of these vulnerable species is needed alongside the development of a management plan.
13. Emerging fisheries are to be expected in Mauritania in coming years, in particular deep sea fishing and shellfish exploitation. Fishing in the deep sea may pose a high risk to the local (benthic) fauna. There is however no experience in the exploitation of this fish stock. An impact study to be performed before this exploitation begins is essential. Also "Before and After Impact" monitoring is highly recommendable. For shellfish exploitation a desk study into the possible impact is already available but monitoring of the impact when the experimental fishing starts, is essential in the management of this fishery.
14. Aquaculture is a complete new concept and unpracticed in Mauritania. There are three fields: 1. Shellfish, 2. Freshwater and 2. Seawater culture. Experimental trials by former Soviet researchers have proven that there are excellent growth results for flat oysters and mussels in the Bay de Lévrier and possible also for *Tapes* species. Bottleneck for these historic projects

were the sanitary regulations which prevented export of the product. Although Mauritania is a desert country there is sufficient fresh water to provide water for recirculation systems as used in aquaculture. The absence of open surface freshwater and other fish creates a disease free environment. Seawater culture in open sea remains an unexplored field.

15. Oil exploitation within the EEZ will be a given fact for the coming decade(s). However the income generated by the fisheries is seen as more valuable than the oil exploitation, because the fisheries can be sustainable and the oil exploration is not. Therefore a threat exists to the economy of Mauritania when environmental contamination results from the oil exploitation. Monitoring of the effluent (contaminated water) is highly recommended to avoid long lasting contamination and to make sure no loss of income from fisheries occurs. Capacity building within the Institutional structure of Mauritania via twinning with an experienced laboratory seems the most efficient solution to getting the required monitoring programmes and related knowledge into place.
16. Creation of a waste oil facility at the two main ports in Mauritania, accompanied with a government regulation and enforcement of the regulation on the disposal of waste of vessels
17. Clearance of ship wrecks in the port of Nouadhibou, which cause a navigational problem and an environmental pollution problem as well. This should be part of an integrated programme in which Mauritania finds a legal solution in the responsibility and liability of these abandoned ships with often expatriate owners.

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12 Justification

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The scientific quality of this report has been peer reviewed by a colleague scientist and the head of the department of Wageningen IMARES.

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