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<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>ASPM</td>
<td>Age structured production model</td>
</tr>
<tr>
<td>BIon</td>
<td>Billion</td>
</tr>
<tr>
<td>BPUE</td>
<td>Bycatch per unit effort</td>
</tr>
<tr>
<td>CCAMLR</td>
<td>Commission for the Conservation of Antarctic Marine Living Resources</td>
</tr>
<tr>
<td>CCSBT</td>
<td>Commission for the Conservation of Southern Bluefin Tuna</td>
</tr>
<tr>
<td>CPC</td>
<td>Contracting Party Country</td>
</tr>
<tr>
<td>DIID</td>
<td>Department for International Development</td>
</tr>
<tr>
<td>DFO</td>
<td>Department of Fisheries and Oceans (Canada)</td>
</tr>
<tr>
<td>DWFN</td>
<td>Distant Water Fishing Nation</td>
</tr>
<tr>
<td>EEZ</td>
<td>Exclusive Economic Zone</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organisation of the United Nations</td>
</tr>
<tr>
<td>FFA</td>
<td>Forum Fisheries Agency</td>
</tr>
<tr>
<td>FMC</td>
<td>Fisheries Monitoring Centre</td>
</tr>
<tr>
<td>FOC</td>
<td>Flag of Convenience</td>
</tr>
<tr>
<td>IATTC</td>
<td>Inter-American Tropical Tuna Commission</td>
</tr>
<tr>
<td>ICCAT</td>
<td>International Commission for the Conservation of Atlantic Tuna</td>
</tr>
<tr>
<td>ICES</td>
<td>International Council for the Exploration of the Seas</td>
</tr>
<tr>
<td>IOTC</td>
<td>Indian Ocean Tuna Commission</td>
</tr>
<tr>
<td>IPOA</td>
<td>International Plan of Action</td>
</tr>
<tr>
<td>IUU</td>
<td>Illegal, Unreported and Unregulated Fishing</td>
</tr>
<tr>
<td>m</td>
<td>Million</td>
</tr>
<tr>
<td>MLE</td>
<td>Maximum Likelihood Estimate</td>
</tr>
<tr>
<td>MRAG</td>
<td>Marine Resources Assessment Group</td>
</tr>
<tr>
<td>NAFO</td>
<td>North Atlantic Fisheries Organisation</td>
</tr>
<tr>
<td>NEAFC</td>
<td>North East Atlantic Fisheries Commission</td>
</tr>
<tr>
<td>NFA</td>
<td>National Fisheries Association (Papua New Guinea)</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PNG</td>
<td>Papua New-Guinea</td>
</tr>
<tr>
<td>RFMO</td>
<td>Regional Fisheries Management Organisation</td>
</tr>
<tr>
<td>SEAFO</td>
<td>South East Atlantic Fisheries Organisation</td>
</tr>
<tr>
<td>t</td>
<td>Metric tonne</td>
</tr>
<tr>
<td>TAC</td>
<td>Total allowable catch</td>
</tr>
<tr>
<td>UD</td>
<td>Utilisation distribution</td>
</tr>
<tr>
<td>UNFSA</td>
<td>The UN Fish Stocks (Straddling Stocks and Highly Migratory Species) Agreement</td>
</tr>
<tr>
<td>VMS</td>
<td>Vessel monitoring system</td>
</tr>
<tr>
<td>WCPFC</td>
<td>Western and Central Pacific Fisheries Commission</td>
</tr>
</tbody>
</table>
1. Executive Summary

This report forms the second phase of work commissioned by the Department for International Development (DfID), aimed directly at assisting the High Seas Task Force (HSTF) in defining practical solutions to the problem of illegal, unreported and unregulated (IUU) fishing. The report addresses three issues: the extent of high seas IUU fishing and its ecological impact; methods for estimating these impacts; and future research needs.

Our companion report estimated that the annual total first sale value of IUU fishing worldwide (over the period 2003-2005) falls between US$2.4bn and US$9.5bn. The high seas component of this, worth US$1.2bn, comprises fisheries for tuna, tuna-like species and other large pelagics (e.g. swordfish), fisheries for shark, squid, and for groundfish (e.g. toothfish, cod, redfish, roughey and alfonsino). The most concerning of these fisheries are those which are unregulated. There is significant IUU fishing for tuna which is mostly taken account of by the RFMOs with responsibility for tuna and billfish. However, there are many other pelagic and demersal high seas fisheries, most of which are not regulated by RFMOs.

An analysis of current records of IUU activity identifies a short list of a number of DWFNs (China, Korea, Taiwan (Chinese Taipei), Russia and Spain) and open registry flag states (Belize, Equatorial Guinea, Indonesia, Panama, St. Vincent and the Grenadines and Togo) as being the flag states of vessels engaged in IUU (using a criterion of being active in more than one ocean and being associated with more than 4 recorded incidents, or listings on official RFMO IUU black lists occasions between 2004 and 2005). There is a need for increased high seas governance and increased compliance with UNFSA or RFMOs of flag states. In addition, new RFMOs are urgently required to incorporate currently unregulated (and potentially unsustainable) high seas fisheries for demersal species and pelagic species other than tuna.

IUU fishing clearly has negative effects on target stocks, as the composition and size of associated catches may not be accurately incorporated (if at all) into stock assessments. Any fishing over and above the sustainable yield may therefore go unreported, with potentially serious consequences for future stock status. This can also lead to management problems for fisheries within EEZs, if species targeted in the adjacent high seas form straddling or migratory stocks which extend into these inshore fisheries. Examples include straddling groundfish fisheries on the ‘Nose and Tail’ of the Grand Banks, and migratory tuna species which pass through EEZs of Pacific island and Western Indian Ocean coastal states. Additional vulnerability to IUU within EEZ fisheries stems from encroachment of high seas DWFN fleets beyond the 200nm boundary, for instance Taiwanese, Korean and Chinese jiggers poaching squid in the South West Atlantic and Pacific. The short-lived initial fisheries for orange roughy off New Zealand, Australia and Namibia and the boom and bust cycles in shark fisheries off Papua New Guinea (which ultimately closed in 1990) illustrate problems associated with unregulated fisheries.

Ecosystem effects of IUU include both direct and indirect impacts on dependent and related species. Species may be taken incidentally as bycatch, which has a direct influence on their populations, or they may be indirectly influenced by habitat modification caused by fishing gear or by changes in trophic functioning of the ecosystem resulting from the overexploitation of target species (or other bycatch species) which are critical ecosystem components. For example, modelling studies
exploring the extensive reduction in populations of sharks and other apex predators from exploitation have indicated population changes of species at lower trophic levels in the food web are likely to result. The direct effects of bycatch have been highlighted particularly for ‘charismatic megafauna’ such as sea birds, turtles, whales and dolphins, but there is also concern for lower profile, endangered, slow growing species such as sharks and rays, as additional bycatch can severely impede their ability to recover from exploitation.

Although separating ecosystem effects of IUU fishing from those of legitimate fishing operations is very difficult, we have been able to draw some tentative conclusions on the relative impacts in a number of areas. Mitigation measures aimed at reducing ecosystem impacts such as bycatch are either non-existent or are in the early stages of implementation for many RFMOs (CCAMLR is the exception), and therefore it can be assumed that rates of bycatch within illegal and legitimate operations are similar. The bycatch problem for seabirds stems primarily from interactions with longline fisheries in temperate seas, but as IUU activity in these regions is relatively low, bycatch of seabirds is low compared to that from legitimate operations (see Summary 1).

Summary 1: Likely impacts of different types of fishing on birds

<table>
<thead>
<tr>
<th>Birds</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>Moderate</td>
<td>High</td>
</tr>
<tr>
<td>IUU</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

Most incidental turtle mortality stems from longline and shrimp trawling fisheries in tropical waters, with the high seas component of this being high again due to the lack of mitigation measures within RFMOs. As high seas IUU in these areas is relatively low, the bycatch of turtles associated with this is also concluded to be low compared with mortalities resulting from legitimate operations (Summary 2). Relatively little information on the impacts of IUU fishing on cetaceans has been sourced. However, a recent review by the WWF (Reeves et al., 2005) indicates that the areas of primary concern for interactions with fisheries are within EEZ waters. We therefore, conclude that impacts from IUU fishing in high seas are low for cetaceans (Summary 3). Primary impacts of IUU fishing to habitat come from unregulated deepwater trawl fisheries and to a lesser extent deep set longlines. The extent of this damage is largely unknown, but could be expected to be high (Summary 4).

Summary 2: Likely impacts of different types of fishing on turtles

<table>
<thead>
<tr>
<th>Turtles</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>IUU</td>
<td>Moderate</td>
<td>Low</td>
</tr>
</tbody>
</table>

Summary 3: Likely impacts of different types of fishing on cetaceans

<table>
<thead>
<tr>
<th>Cetaceans</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>IUU</td>
<td>Moderate</td>
<td>Low</td>
</tr>
</tbody>
</table>

1 By legitimate we refer to all non-IUU activity.
Ecosystem problems associated with IUU fishing in the high seas currently have only a low to moderate impact because the largest proportion of fishing in these waters is carried out by legitimate vessels which by and large do not apply mitigation measures consistently. Although IUU vessels clearly cause additional impacts, current problems stem predominantly from ineffective conservation measures within RFMOs or regulated fisheries. Once these issues have been rectified, IUU will represent more of a relative problem.

Current methods for assessing IUU separate into accounting and estimation techniques. The former require catch, trade or documentation systems, e.g.:
- estimation of IUU fishing effort from various sources combined with estimates of catch rate from licensed fisheries;
- comparison of trade-based estimates (including documentation schemes) and reported catch;
- detailed investigations of the catches of states not party to RFMOs;
- incorporation of estimates of bycatch and bird/mammal interactions.

While estimation techniques require good information from observer and surveillance systems and may incorporate estimation with population models e.g.:
- estimates of unaccounted catches made using population models;
- quasi quantitative Monte-Carlo integration of all historical sources;
- models of IUU behaviour and surveillance encounter probabilities.

The effective assessment of the extent of IUU fishing and its ecosystem impacts remains a precluding factor in the development of the preventative management of IUU. We therefore, recommend the following:

**To monitor IUU fisheries and their bycatch**

1) Establish new international monitoring systems in high seas waters comprising:
   a) Scientific observer programmes in all fishing areas, especially high seas, which generate data which are widely available to relevant organisations (such as RFMOs). Observer programmes involving international observer exchanges are preferable to national observer programmes.
   b) International surveillance operations in high seas areas of relevant RFMOs, with sufficient remit under international inspection agreements to inspect all vessels fishing within the area of an RFMO, and with a remit to monitor IUU fishing activity and disseminate the results (including both encounters and non-encounters) in such a way as to assist scientific assessments of IUU activity whilst preserving necessary confidential surveillance information.
c) Documentation schemes and supporting trade measures for key target and bycatch species.

2) Enhance monitoring programmes of a similar nature in EEZ waters.

To increase the accuracy of estimates of IUU catch and its effects

3) Develop new methods to estimate IUU catch, based if necessary on a combination of data sources, capable of providing statistically rigorous, robust, estimates of IUU fishing and impacts on ecosystem components, as well as the variance of these estimates.

4) Rigorously document all methods used and disseminate widely in scientific and other publications, and use variance estimates in risk-based assessments.

5) Support estimates made using above methodologies with population models of target and bycatch species.

To enable these actions

6) Set up a network of institutions capable of undertaking monitoring of IUU activities in various categories for different ocean regions, and capable of disseminating their results, and influencing decision-making within a region and within relevant RFMOs, that will deliver the improved monitoring identified above.
2. Introduction

2.1. Background

Illegal, unreported and unregulated (IUU) fishing is a global problem affecting both Exclusive Economic Zones (EEZs) and the high seas. A number of initiatives have been taken to quantify and combat it, notably the 2001 FAO International Plan of Action on IUU Fishing. In 2003 following a meeting of the Round Table on Sustainable Development at the OECD, a number of Ministers decided to form a High Seas Task Force (HSTF) with the objective of defining practical solutions to the problem. The UK is directly supporting the work of the High Seas Task Force. Part of this support covers work commissioned by the Department for International Development (DfID) to examine two issues:

1. An impact analysis of IUU fishing including economic, social, environmental, ecological, biological, health and nutritional impacts;
2. An empirical assessment of issues related to ecosystem and management.

The report on part 1 was published in June 2005 (MRAG, 2005). This contained a detailed analysis of the likely scope of IUU fishing worldwide, and a review of likely impacts on developing countries based on 10 case studies. The project received significant contributions from the Norwegian aid agency NORAD. For sub-Saharan African developing country waters, a significant negative correlation was discovered between the state of governance of a country (Kaufmann et al., 2004) and the amount of IUU fishing it suffered. The first sale value of fish removed by IUU fishing for these countries was estimated to be $0.9bn (95% c.i. $0.4 - $2.3bn). Estimates for the value of global high seas IUU ($1.2bn) and various special issues such as cod, abalone, sturgeon, holothuria and misreporting within EU domestic fisheries (contributing $0.25bn), were added to the sub-Saharan estimate to make a minimum estimate of the annual total first sale value of IUU fishing worldwide over the period 2003-2005 of at least $2.4bn². A top-down application of our average value for IUU as a percentage of declared value (19%) yielded a maximum estimate of $9.5bn.

The results of the first study were discussed at a DfID/NORAD sponsored workshop held in London, 16-17 June 2005. The study and the workshop recommended a number of actions that might contribute to the reduction of IUU activity in developing countries. The target of these recommendations was both organisations having development as their focus, such as DfID, and the HSTF itself. The second study is very explicitly directed at assisting the HSTF Science Working Group with its work.

² Note that whilst this represents the first sale value, it might not necessarily represent the value that could be extracted by resource owners after elimination of IUU, for a variety of reasons. Firstly, in the case of developing countries, they are unlikely to be able to harvest these resources entirely themselves, and may instead only extract a proportion of the resource rent under foreign access agreements. Secondly, these resources may be overexploited in their current state, and responsible management following the elimination of IUU might require lower catches.
2.2. Structure of the report

The TOR (Annex 1) were developed in close cooperation with the HSTF Science Working Group and fall into three main sections. It is convenient to structure the report around these sections.

1. Description of the problem: the extent and ecological impact of high seas IUU fishing (Section 3).
   
   1.1 Broadly, what fleets and gear types are used in which areas, when and for what targets? Essentially who is doing the IUU fishing and how does it relate to legitimate fishing?
   
   1.2 What are the ecological and fishery consequences of failure to manage the IUU portion of the catch on the high seas?
   
   1.3 What is the relationship between IUU fishing on the high seas and fishing (legal or otherwise) within EEZs? What are the potential ecological and fishery consequences of high seas IUU on fishing in waters under national jurisdiction?

2. Methods in use for estimating IUU fishing and its impacts (Section 4).
   
   2.1 What existing approaches are being used to characterize IUU activities and especially to estimate IUU catch and effort for input into scientific assessment of stocks and provision of advice to management? What are the ecological and fishery consequences of the present level of understanding and ability to estimate the level of IUU activity, catch and effort? What could be done to either improve existing approaches or develop new ones to characterize IUU and estimate IUU catch and effort? What is international good practice in measuring IUU activities and providing scientific management advice where IUU activities are at a significant level?
   
   2.2 Is there a need for better science? How could this be achieved?
   
   2.3 What data and/or research is needed to fill these gaps and how would these requirements be prioritized? If these gaps could not be filled immediately (which is likely), are there approaches that could be used in the short to medium term to gauge the relative impact of IUU fishing?

3. Future research needs (Section 5)

   3.1 What combination of institutions is optimum for undertaking research functions? Would a centralized global scientific agency for the high seas be a feasible objective? What would be the purpose of such an organization; should it be focused solely on research to understand the oceans or should it have a role in advising regional fishery management organizations? If it provides input to regional fisheries management organizations, what are the links with governance issues that also need to be addressed?
   
   3.2 Assuming better management of high seas fishing (including minimizing IUU fishing), what is a realistic assessment of the potential gains from improved science knowledge to resource
management and, more broadly, to scientific understanding of the oceans as a whole?

3.3 How might one measure those gains in a meaningful way? What alternative indicators may the working group wish to consider using?

2.3. Definitions

The FAO IPOA to prevent, deter and eliminate illegal, unreported and unregulated fishing envisages several definitions for IUU fishing. Insofar as these are related to high seas fishing, the IPOA definition notes

a) Illegal fishing refers to activities conducted by vessels flying the flag of States that are parties to a relevant regional fisheries management organization but operate in contravention of the conservation and management measures adopted by that organization and by which the States are bound, or relevant provisions of the applicable international law; or in violation of national laws or international obligations, including those undertaken by cooperating States to a relevant regional fisheries management organization.

b) Unreported fishing refers to fishing activities undertaken in the area of competence of a relevant regional fisheries management organization which have not been reported or have been misreported, in contravention of the reporting procedures of that organization.

c) Unregulated fishing refers to fishing activities in the area of application of a relevant regional fisheries management organization that are conducted by vessels without nationality, or by those flying the flag of a State not party to that organization, or by a fishing entity, in a manner that is not consistent with or contravenes the conservation and management measures of that organization; or in areas or for fish stocks in relation to which there are no applicable conservation or management measures and where such fishing activities are conducted in a manner inconsistent with State responsibilities for the conservation of living marine resources under international law.

In strictly legal terms the second part of C contains a get-out clause, in that it relies on state responsibilities under international law, i.e. UNFSA. For those states that have not ratified UNFSA there may be no state responsibilities, and even for those which have the responsibilities are defined by the state itself and are not set by an international body (they are only generically set by UNFSA itself). Therefore the IPOA contains a note: Notwithstanding paragraph C, certain unregulated fishing may take place in a manner which is not in violation of applicable international law, and may not require the application of measures envisaged under the International Plan of Action (IPOA). In other words, whilst recognising them as unregulated the IPOA does not classify them as IUU.

In our view this does no service to high seas fish stocks, because it allows unrestricted exploitation of all high seas stocks that are not covered by RFMOs. In the current situation, as we show in MRAG (2005), this includes almost all high seas fisheries except those for tuna, salmon, and those covered by NAFO, NEAFC,
SEAFO and CCAMLR. For instance, the 1990s Madagascar ridge fishery for orange roughy was not regulated and suffered a rapid collapse as a result, and in our view should be considered as IUU even though it is generally not considered in that category. Therefore, we consider all unregulated fisheries to be a part of IUU fishing.

3. The extent and ecological impact of high seas IUU fishing

The issues to be addressed in this section are those in part 1 of the TOR (Section 2.2). We address these issues in two main subsections: the fisheries and their ecosystem consequences. The first part analyses the available information on the level of IUU fishing in several major IUU fisheries, cataloguing as far as possible the extent of the problem in relation to legitimate catch and catches with EEZs. The second part examines several different types of ecosystem impact, attempting to quantify them to the extent possible, and commenting on the links between high seas IUU fishing and effects on EEZ ecosystems.

3.1. Fisheries, fleets and gears

3.1.1. Types of fisheries

3.1.1.1. Tunas and tuna-like fish (large pelagics)

Since most tuna fisheries are now covered by RFMOs (Figure 1), with only the Eastern Central Pacific without RFMO coverage, IUU fishing for tuna is largely either unreported, because all vessels flagged in states that are party to these organisations should report catches, or unregulated by virtue of the flag states not being party to the relevant RFMO.

IOTC, ICCAT and CCSBT make estimates of IUU tuna catch based on the best information available to them. In the ICCAT Regulatory Area it is reported that since the introduction of the bluefin tuna document system, IUU on this species has dropped to relatively low levels of about 1% of the reported catch (Restrepo, 2004). These estimates were made using reconciliation of Trade Statistics and the document system statistics. However, there continue to be reports that there is considerable IUU activity in the Mediterranean, with more than 50% of the catch being unreported (Butterworth, pers. comm.). The IUU catch of bigeye tuna has also dropped since the introduction of the document scheme, although it is still estimated at about 5% of reported catches. If we assume the same for yellowfin tuna, we can estimate that there may be between 5000 and 10000 t of these tunas being taken by IUU vessels in the Atlantic. There are currently no estimates for skipjack tuna IUU in the Atlantic.

We note that in addition to RFMOs that cover all marine fish, there are several other high seas fisheries organisations that focus specifically on a single species, or group of related species that are not tuna or salmon. Examples include the International Pacific Halibut Commission, and the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea.
In the Indian Ocean, IOTC estimates IUU catches (NEI) to be about 10% of reported catches amounting to about 130,000 tonnes annually (Herrera 2003, OECD, 2005). At a conference organised by the International Collective in Support of Fishworkers (ICSF) and the International Ocean Institute (IOI) of India in 2001, Willman (2001) also suggested that for the Indian Ocean, IUU fishing amounted to 10% of all reported landings of tuna and tuna-like species, in this case nearly 100,000 tonnes. CCSBT estimates IUU amounts to about 33% of its reported catches (OECD, 2005), although this may now have dropped to about 10% with Taiwan recently gaining membership of the Commission.

In the Western Pacific, the bulk of IUU fishing probably occurs within EEZs and in particular within the waters of FFA members. This is mostly conducted by the vessels of distant water fishing nations, and there is likely to be some fishing by FOC vessels.
in high seas waters (Richards, 2004). FFA has not yet made an assessment of IUU fishing in its region, because of problems of standardising methodologies, but intends to initiate such a study in 2005 (A. Richards, pers. comm.). Greenpeace (2004) has estimated the IUU catch in the Pacific to be between 100,000 and 300,000 t with an estimated value of $134 - 400M, although this is a general estimate “assuming a conservative 5-15% IUU”.

All these tuna estimates include catches on high seas and within EEZs, because they are ocean-wide estimates. They do not, however, distinguish between the two and so for the purposes of this paper are considered to be primarily high seas catches.

Table 1 shows the percentage catch (in terms of weight) taken by the different gears used to target tunas within the areas monitored by each of the RFMOs. It is clear that the majority of tuna catches globally are taken through purse seine and longline gears.

Table 1  Distribution of catches between different gear types within the regional tuna organisations.

<table>
<thead>
<tr>
<th>RFMO</th>
<th>Purse Seine</th>
<th>Longline</th>
<th>Bait boat</th>
<th>Artisanal fisheries (gill net, Pole and line, troll), and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICCAT</td>
<td>38</td>
<td>28</td>
<td>27</td>
<td>7</td>
</tr>
<tr>
<td>IOTC</td>
<td>36</td>
<td>25</td>
<td>0</td>
<td>39</td>
</tr>
<tr>
<td>CCSBT</td>
<td>20</td>
<td>80</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>IATTC</td>
<td>90</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WCPFC</td>
<td>60</td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Due to the high value and operating costs for purse seine vessels as well as the increased risk of detection due to their size and method of fishing, it is unlikely that these vessels will conduct large scale illegal (e.g. unlicensed) fishing operations. Some degree of misreporting of the locations of catches between coastal state EEZs and/or under reporting of catches may, however, occur. IOTC records list unregulated activity on the high seas in the Indian Ocean by three Liberian flagged purse seine vessels, (formerly Russian flagged, and still owned and managed in Russia). These vessels are, however, old and in a poor state of repair and their longer term future is unclear.

The majority of IUU activity in tuna fisheries globally is now attributed to longline vessels. These vessels operate under a wide variety of flags including many open registries. Typically reporting from these open registry states has been poor. However, some improvements have been made in recent years through the provision of assistance to the more important open registry states (from a fisheries viewpoint) in collecting their flag state statistics and through port sampling programmes.
3.1.1.2. Sharks

Shark populations usually have low replacement rates and slow individual growth rates, and are therefore often vulnerable to overfishing\(^1\). Commercial shark fisheries are typified by boom and bust cycles ending in a population crash, such as the shark fishery around Papua New Guinea (PNG), which ultimately closed around 1990.

Tuna RFMOs regulate the catches of tuna and billfish, but they previously have not covered other pelagic resources such as sharks. A recent study of the shark fin trade in Hong Kong estimated that the total catch of sharks must be between 3 and 5 times that reported to FAO, i.e. between 1.1 and 1.9 million t per year. S. Clark (pers. comm.) estimates that this catch is worth $292-476 in shark fin value alone. This indicates that between 66% and 80% of the total global catch of shark is unreported and probably 50% of the total catch derives from high seas waters.

A recent submission to the IOTC (2005) documented the rise of shark catches in the Indian Ocean. It maintains that there are around 150-200 vessels catching shark with around 70% flagged in Taiwan and the remainder in Indonesia. Vessels targeting shark operate in the western Indian Ocean off the coasts of the more vulnerable countries of Somalia, Mozambique, Tanzania and Madagascar. In Mozambique, most of the longline fleet hold tuna licences in those countries where a license system operates, but some vessels target shark. Fishery patrols have come across long liners which have switched to nets in order to catch shark more effectively. This switch is also increasing turtle catches as evidenced by the number of beheaded turtle carcasses found as they have been cut out of the nets (see Section 3.2.2.2). This process has actually been photographed as have the numbers of shark fins hung out to dry on such boats. A legitimate bycatch of shark in directed tuna fisheries is allowed by the tuna RMFOs, as high as 20% (ICCAT; IOTC); although our own experience in BIOT suggests that under normal tuna fishing conditions (i.e. not targeting shark), only around 3% of catch by numbers are shark.

This upsurge of shark fishing is not confined to the Indian Ocean. The same unlicensed targeted actions are being found in the Pacific, for example in the vicinity of PNG, where Indonesian vessels are again implicated. The response of PNG has been to recognize the problem and to bring shark into the managed fisheries by formulating the “National Shark Fishery Management Plan”. This specifies a TAC of 3,600t head-off and, most significantly, includes bycatch from tuna and other vessels. The directed fishery has also been restricted to PNG citizens and data reporting is required. The TAC is pitched at a level below that of the earlier commercial fishery that closed in 1990. It is also notable, that the estimated IUU catch is almost twice the TAC (MRAG, 2005). Until more nations include shark in their monitoring and management systems the shark fishery will not only uncontrolled but catches will remain difficult to estimate, thereby compounding the management problem.

In recognition of the potentially high catches of shark that may be taken specifically for the shark-fin trade, and in response to the FAO’s International Plan of Action on Sharks, ICCAT has agreed a recommendation limiting shark fishing activities in

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\(^1\)Fishing at levels beyond those which are sustainable. Many k-selected species have high initial biomasses, so that initial exploitation may not significantly impact on the population or its reproductive potential. However, sustainable exploitation rates and recovery rates may be low, depending on the steepness of the stock recruit relationship. Therefore, if k-selected shark populations are depleted, they are likely to be at greater risk than similarly depleted r-selected animals, because they will take longer to grow out of the danger zone and are more likely to be vulnerable to depensation effects.
Atlantic tuna fisheries. Under ICCAT Resolution 05/05 “CPCs shall require their vessels to not have onboard fins that total more than 5% of the weight of sharks onboard, up to the first point of landing. CPCs that currently do not require fins and carcasses to be offloaded together at the point of first landing shall take the necessary measures to ensure compliance with the 5% ratio through certification.” The practicalities of supervising this process will be a considerable challenge due to the storage process i.e. fins are normally dried offshore then frozen in large sacks which may be difficult to detect/easy to conceal during the landing process unless provision for adequate monitoring is in place.

At the 72nd Meeting of the Inter-American Tropical Tuna Commission (IATTC) in June 2004, two proposals were put forward regarding sharks, one from the EU and the other from Japan. Both proposals expressed concerns of excessive shark fishing and presented a series of management measures, including special licenses, clear operational guidelines aimed at reducing the volume of landings of shark fin and a 72 hour notification port landing system which would facilitate monitoring of catches. Although most CPC participants expressed their agreement to regulate the removal of fins of sharks onboard vessels, neither proposal was approved. However, the issue remains on the agenda and will be revisited in subsequent meetings.

The Commission for the Conservation of Southern Bluefin Tuna (CCSBT) has also expressed similar concerns through work by the Ecologically Related Species Working Group (ERS WG). They have conducted a sensitization exercise and produced literature for fishers to encourage reporting and data submission. However, there are no definite resolutions in place and CCSBT only request fishers to collect and submit data according to their flag state authorities’ instructions.

The ecological impacts of shark catches over and above agreed limits are hard to assess. Sharks are top predators with unstable dynamics when exploited and liable to crash, as the PNG experience shows. The removal of top predators can have considerable impacts on ecological connectedness and trophic interactions of the remaining species. For example, recent modelling studies exploring food-web effects of tuna fishery expansion in both the eastern tropical Pacific and central north Pacific have indicated that biomass increases in intermediate (e.g. various tuna species such as skipjack, and small individuals of yellowfin and bigeye) and lower trophic groups have accompanied the reduction in biomass of upper trophic levels due reduced predations rates resulting from catches of the large tuna, billfishes and sharks (Hinke et al., 2004). This study also indicated that the role of longlining may be more critical to the conservation of sharks and billfish in the Pacific, while lower trophic levels respond more to alterations in purse seine fisheries (Hinke et al., 2004). Hinke et al. (2004) suggest that recovery of top predators could be more effectively achieved through longline gear modifications and stricter regulations on shark finning may be as effective as reducing longlining fishing effort.

3.1.1.3. Other pelagic resources

There is a significant unregulated high seas fishery for the squid *Illex argentinus* in the south West Atlantic Ocean outside the fishing zones of Argentina and the Falkland Islands. The high seas catch is jointly estimated by Argentina and the UK to be about 50-100,000 t per year (Barton et al., 2004). The presence of IUU squid jigsing vessels in high seas waters can be detected relatively easily through satellite surveillance because of the very bright lights that these vessels use (Boyle & Rodhouse, 2005). A relatively large fleet of Taiwanese, Korean and Chinese jiggers,
MRAG: IUU Fishing on the High Seas: Impacts on Ecosystems and Future Science Needs

and Spanish trawlers, in this area has lead to instances of poaching in non-high seas areas (see Annex A, MRAG (2005)).

There are other high seas fisheries for squid, principally in the Pacific and there have been very recent reports of an illegal driftnet operation by Chinese vessels in the north pacific targeting neon flying squid *Ommastrephes bartramii* (T. Ichii, pers comm.1). This method of fishing is banned by UN resolution. At its peak (1982 – 1992) this fishery caught between 100,000 and 200,000 tonnes annually (Ichii et al., submitted). The high seas fishery for jumbo flying squid (*Dosidicus gigas*) off the coasts of Peru and northern Chile has also raised some concern. FAO statistics show that China is a recent entrant into this fishery, taking a reported 81,000 t of squid in 2003. This compares to 40,000 caught by Japan and 5000 tonnes caught by Korea, mainly under licence within the Peruvian EEZ. Although the main fishery takes place in Peruvian waters, some of these catches are from high seas waters (up to 300 nm from the coast (Taipe et al., 2001)), and are therefore unregulated (there are currently no high seas RFMOs which regulate significant squid fisheries: only SEAFO and CCAMLR are capable of doing so). Recent arrests indicate that at least some of the Chinese catch, possibly about 40,000 tonnes (our estimate), is taken in high seas waters.

With the exception of the illegal driftnet fishery, large scale fisheries for ommastrephid squid use squid jigs. There are some suggestions of seabirds being caught on squid jigs, but jigging is considered mainly to be a relatively clean fishing method. There is some bottom trawling for *Illex argentinus* on the outer Patagonian shelf by mainly Spanish and Falkland Island flagged vessels, but ecosystem impacts are not thought to be large in this area.

Most small to medium pelagic fisheries (e.g. anchovy, sardine, jack or horse mackerel stocks) are confined to upwelling or boundary current areas within EEZs (e.g. the Namibian horse mackerel stocks) and thus suffer relatively little from unregulated fishing. An exception is the Chilean jack mackerel. In the early 1970s, it was believed that this species occurred only in the coastal waters of Chile and Peru. However, the activity of Russian fleet and their research experience during the late 1970s and the 1980s in the oceanic waters from South America to New Zealand, showed that the jack mackerel ranged right across the South Pacific ocean in a fairly broad band (10°–15°wide) from Chile to New Zealand and Tasmania (Bailey, 1989; Arcos & Grechina, 1994; Arcos et al., 2001). This discovery was followed by significant fishing effort in high seas waters principally by the USSR and Poland, with total international catches reaching about 1 million tonnes per annum (and a total catch of 4 million tonnes). The collapse of the USSR led to a withdrawal of this fleet starting in 1991 but there has recently been a resurgence of interest by Chinese, Korean and Spanish vessels in high seas fishing for this species (Xiansen et al., 2004). The Chinese catch in 2003 was 95,000 t, worth about $45m. The catch by Korea was 2000t.

There is no RFMO that covers the Southeast Pacific ocean. Although the Galapagos Agreement (14 August 2000) is formally open for ratification, it is only open for membership by the 4 coastal states (Chile, Columbia, Ecuador, Peru)6. The stated objective of the Agreement is the conservation of living marine resources in the high seas zones of the Southeast Pacific, with special reference to straddling and highly migratory fish populations. Despite applying to the high seas, the Agreement is not

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6 http://www.oceanlaw.net/texts/summaries/galapagos.htm
currently open to signature by non-coastal States. Thus, until such time as the agreement comes into force and can be joined by DWFN states, these high seas waters are effectively unregulated.

More recently, Chile has committed to join with New Zealand and Australia to lead the development of a regional fisheries management agreement that will help protect high seas biodiversity in the South Pacific. New Zealand will host the first intergovernmental meeting with interested states in February 2006, to discuss the establishment of the new organisation.

3.1.1.4. Groundfish

By contrast with the large pelagics, very little of the world’s high seas areas are covered by RFMOs that include responsibility for demersal resources (Section 3.1.1.1). The Southern Ocean is one of the few exceptions, coming under the jurisdiction of CCAMLR. IUU fishing for toothfish in the Southern Ocean has received a great deal of attention over the past few years. At its height, in 1997, CCAMLR estimates that 32,600 t was taken illegally by bottom longliners with a value of $160M (Agnew 2000). Since then, IUU catch has dropped: in 2004 CCAMLR estimated that the catch was about 3000 t, which equates to about $40M (CCAMLR, 2004). Thus, even at its height the value of this IUU catch was not particularly significant in world terms. The reason why this fishery attracted so much publicity is probably that IUU was well estimated and publicly discussed by CCAMLR and publicised by a number of NGO and industry groups (e.g. ISOFISH (Fallon and Krikoken, 2004)). The majority of this IUU catch was taken from EEZ areas within the CCAMLR Convention Area. A growing enforcement presence has forced IUU vessels to fish more in high seas parts of the Convention Area, especially close to the Antarctic continent.

Several years ago there was concern about IUU fishing in two high seas areas surrounded by EEZ waters – the famous donut hole in the Bering Sea, bounded by the EEZs of Russia and the US, and a smaller peanut hole in the middle of Russian EEZ waters in the Sea of Okhotsk. The "Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea" – also known as the Donut Hole Agreement - was signed in Washington on June 16, 1994, by China, South Korea, Russia, and the United States with Japan and Poland signing later that year. Under this agreement, the Donut hole has been closed to fishing since 1997 except to trial fishing, and there are regular surveillance patrols within it which have recently reported no IUU activity (USCG, 2005). The peanut hole was closed to fishing the following year by Russian action. US and Russian patrols are frequent and have not detected significant IUU fishing in these areas in the last few years.

Regarding the north Atlantic, NEAFC has reported IUU fishing for redfish within its area. Three species of redfish are currently exploited within ICES sub-areas V, VI, XII and XIV (S. marinus, S. mentella and S. viviparous). The latter is of only minor commercial importance within Icelandic waters. There is currently limited information on the distribution and status of redfish stocks in the NE Atlantic, which aggregate in both deep water and on the edge of the continental shelf. In 2004, a provisional total catch of 137,000 tonnes was reported for redfish (ICES 2004a). A recent study, however, concluded there was insufficient information to identify distinct stocks (ICES 2004b). At the present time the following have been described: a demersal unit on the continental shelf and a pelagic unit in the Irminger Sea and surrounding areas. The pelagic unit also includes what was formerly known as the pelagic deep-sea and

\[\text{Note there was a substantial increase in the price of toothfish between 1997 and 2004.}\]
oceanic S. mentella. The demersal unit is the deep-sea S. mentella occurring on the continental shelf and on the slope (Figure 2).

Redfish are vulnerable to IUU fishing within the High Seas (i.e. within pelagic and deep-sea demersal areas of ICES sub-areas V, VI, XII and XIV, but outside EEZs). Two recent studies conducted by the EC Joint Research Centre using satellite imagery vessel detection system (VDS) and compared to VMS position reports indicated that not all fishing vessels could be accounted for. The discrepancy between the two sources of information indicates that the unreported effort might be a significant amount and could be more than 25% higher than that reported to NEAFC (NEAFC, 2004). This could put the level of IUU fishing within NEAFC waters as high as about 15,000t, equivalent to $30 million. During 2002 and 2003, six Lithuanian vessels were reported to have fished within the NEAFC Regulated Area. Approximately 15,000t of redfish were taken as IUU, ten times above their quota (OECD, 2004).

![Figure 2](image)

**Figure 2** Schematic diagram to illustrate vertical distribution of Redfish (Sebastes marinus and Sebastes mentella) in the ICES sub-areas. Source: ICES (2004b).

In the Barents Sea there is an area similar to the Bering Sea’s donut hole, called the loophole, between the EEZs of Russia and Norway. There are continuing allegations about IUU bottom trawl cod catches (Esmark and Jensen, 2004), and although most of these appear to be illegal (unreported) catches taken in the Norwegian and Russian EEZs, they amount to an estimated 100,000 t each year.

Another important groundfish species group that is caught in high seas areas is orange roughy. Fisheries for this species developed first in New Zealand in the 1980s, then in Australia in the late 1980s and in other Namibian and European waters in the 1990s. Few of the stocks that were exploited in the 1980’s have proven to sustain long term viable catches, stimulating exploration by many flag states, including Australian and New Zealand vessels, in high seas areas such as the Madagascar ridge. In addition to catches of orange roughy these vessels also took oreos and alfonsinos. Catches from the Madagascar ridge were probably in the region of 10,000t per year between 1999 and 2002, but have reportedly declined since then. However, significant exploratory activity is ongoing in other deep-sea high seas areas, particularly in the Pacific (Lack et al., 2003).
A number of new fishing grounds for orange roughy have recently developed outside both New Zealand and Australian EEZs (Clarke 2004). This fishing effort occurs on deep water seamounts, particularly around the Lord Howe Rise, Northwest Challenger, West Norfolk, South Tasman Rise and Louisville (see Figure 3).

![Figure 3](image.png)

**Figure 3** The distribution of major new fisheries for orange roughy outside New Zealand and Australian EEZs. Source: Clarke (2004).

The total reported New Zealand and Australian catch of orange roughy outside the EEZ in 2000-01 amounted to over 4,711t. This however, included approximately 600t caught in the SW Indian Ocean. Overall catch levels were reportedly similar in the following year (4,017t), but showed marked spatial variations. More recently, catches have declined to under 2,700t in 2002-03. This was due primarily to lower catch levels on the West Norfolk Ridge, Northwest Challenger Plateau, and South Tasman Rise. The latest available data for 2003-04 indicate that Australian catches for orange roughy on the South Tasman Rise totalled just 2t from 67 tows. These figures suggest that none of these stocks can support a substantial fishery, and are particularly vulnerable from over-exploitation.

FAO data (FAO 2003) show non-EEZ catches of orange roughy and alfonsino of about 2,000t per year, including areas in the SW Indian Ocean. Comparison of these figures with other reported data from the SW Indian Ocean suggest that catches of orange roughy were under-reported. The current high seas (unregulated) catch of roughy and alfonsino is probably closer to about 4,000t per year, or $32million. These fisheries are prosecuted by bottom or semi-pelagic trawls often operating on seamounts at depths of 500m or more (See Section 3.2.2.4).

### 3.1.1.5. Summary of IUU fishing by fishery

Table 2 provides estimated total value of IUU fishing by major target species group calculated from these data. Below we discuss high seas IUU fishing in each of these major areas.
Table 2

<table>
<thead>
<tr>
<th>Species group</th>
<th>IUU annual value ($m estimated)</th>
<th>Gears used</th>
<th>Areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunas and tuna-like fish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bluefin</td>
<td>33</td>
<td>Pelagic Longline</td>
<td>Southern pacific and Indian ocean</td>
</tr>
<tr>
<td>skipjack, yellowfin, albacore, bigeye</td>
<td>548</td>
<td>Pelagic Longline, seines</td>
<td>Worldwide</td>
</tr>
<tr>
<td>Sharks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sharks</td>
<td>192</td>
<td>Pelagic Longline, Gillnets??</td>
<td>Worldwide</td>
</tr>
<tr>
<td>Groundfish</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toothfish</td>
<td>36</td>
<td>Demersal Longline</td>
<td>Southern ocean</td>
</tr>
<tr>
<td>cod high seas</td>
<td>220</td>
<td>Bottom Trawl</td>
<td>North Atlantic</td>
</tr>
<tr>
<td>Redfish</td>
<td>30</td>
<td>Bottom/semi-pelagic trawl</td>
<td>North Atlantic</td>
</tr>
<tr>
<td>Orange roughy / alfonsino</td>
<td>32</td>
<td>Bottom/semi-pelagic trawl</td>
<td>Southern Indian and Pacific oceans</td>
</tr>
<tr>
<td>Other pelagic resources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jack Mackerel</td>
<td>45</td>
<td>Seines and pelagic trawls</td>
<td>Southeast Pacific</td>
</tr>
<tr>
<td>Squid</td>
<td>108</td>
<td>jig</td>
<td>South Atlantic and Pacific</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1244</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.2. IUU vessels and fleets

Depending upon how IUU fishing is defined, fishers from almost all fishing countries have conducted or are conducting some form of activity that can be classified as illegal, unregulated and/or unreported. Illegal activity is not restricted to developing countries, open register countries or DWFN. In the European Community, for instance, infringements were committed by about 10% of the European fleet in 2003 (EC 2005). Of the 9,502 serious infringements (most of which were concluded with some type of penalty) 88% were reported by only 5 Member States (Greece, France, Portugal, Spain, and Italy), the last two being the most important in both number and proportion of the fleet. Of course these statistics reflect both the level of non-compliant activity by a fleet and the efficiency of the fishery management in implementing EU fisheries policy and the enforcement service in detecting and prosecuting offences. France has recently been fined €20m for non-compliance with EU fisheries policy over a number of years. In a number of cases, especially where high value resources are concerned, domestic poaching has become organised crime: examples are abalone and sturgeon, and there are even suggestions that there is an organised crime component to IUU toothfish fishing (Austral Fisheries, 2002)

Our first report on IUU fishing identified a number of different types of IUU activity, including:

- Unregulated fishing on the high seas or within an RFMO, carried out by

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• Parties to the RFMO
• Non-Parties or, often, open register vessels

• DWFN activity within EEZs often as a result of fishing on the 200nm EEZ border; and

• Border-hopping, within the 200nm EEZ between countries.

Several RFMOs have developed a list of vessels presumed to have carried out IUU activities: CCAMLR, ICCAT, IOTC, NEAFC and IATTC (IATTC resolution C-04-04 has yet to produce a list). Although older records and lists may have identified a number of flag states as carrying out IUU activities, we do not consider these lists to reflect current IUU activity. For instance, in the toothfish fishery Agnew (2000) identified in the period between 1995 and 1999, the following non-Contracting Parties to CCAMLR to have flagged vessels engaged in IUU fishing in the Convention Area and specifically around South Georgia: Panama, Belize, Vanuatu, Portugal, Namibia, Seychelles, Faeroe Islands, Namibia, Argentina, Honduras and Bolivia. Since that time, Belize, Portugal and the Seychelles have prohibited their flag vessels from fishing in the Convention Area; Namibia took action against its vessel and has joined the Commission; Seychelles has become a cooperating party; and Argentina has taken action against its IUU vessels. Thus, a number of these flag states are no longer implicated in IUU fishing in CCAMLR waters.

Bearing this in mind, we compiled Table 3 using the current lists of IUU vessels (“black lists”) published by the relevant RFMOs, combined with the results from our wide literature search over the period 2004-2005 reported in MRAG (2005), Annex A. The NAFO data set is somewhat different from the other data sets in that it records specific citations against vessels in NAFO Regulatory Area as reported by the Canadian Inspection Authorities. Common offences were misreporting, use of banned gear and targeted fishing for controlled species. Unlike the other RFMOs, NAFO has no specific black list of IUU vessels, so we have therefore added a single instance to the column “No. of Incidents” in Table 3 to represent those citations issued to the respective flag state.

The reference to NAFO provides an opportunity to explore way in which IUU activity is reported within RFMOs. The perception of IUU activity is normally of vessels of non-contracting parties operating within regulated waters of RFMOs with impunity. This is indeed the case, but IUU activity also applies to vessels of contracting parties which are not observing the technical and conservation measures of the RFMO to which they are bound. Once detected through surveillance operations i.e. inspections, the general procedure is for a citation to be issued to the vessel. If the citation is upheld through the procedural and organisational structure of the RFMO, the national FMA of such a vessel is notified and is responsible for pursuing legal action against the vessel representatives. Such an event occurred recently (May, 2005), during which Canada’s NAFO inspectors issued a citation to the Russian vessel Odoevsk for using an illegal net liner. The Canadian Coast Guard vessel Teleost was able to retrieve the net lost during the inspection. Russian authorities quickly recalled the ship to port and suspended its fishing licence for one year.

The figures in Table 3 are indicative, in that they are counts of the number of different incidents noted in our Annex A, or the number of times a flag state is implicated on an RFMO list either as a previous or a current flag for a vessel on the IUU list.
Table 3  Number of occurrences of a flag state within RFMO IUU lists or incidents involving a flag state listed in MRAG (2005), Annex A. Summary statistics are given in the last two columns, the total number of incidents and the number of different ocean regions in which incidents occur (out of a possible 4: Pacific, Atlantic, Indian and Southern).

<table>
<thead>
<tr>
<th>Flag State</th>
<th>IOTC list</th>
<th>ICCAT list</th>
<th>CCAMLR list</th>
<th>CCSBT named pre-2003 and in catch statistics</th>
<th>NAFO Citations 2004 to 2005</th>
<th>NEAFC A and B lists</th>
<th>Main report, Annex A</th>
<th>No. of incidences&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Number of different ocean regions (out of 4 possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
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<sup>2</sup> This includes a single incident for each of the NAFO entries and does not include the CCSBT data since they refer to pre 2003 and largely the incidents of IUU activity in CCBST waters has been eliminated.
<table>
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<tr>
<th>Flag State</th>
<th>IOTC list</th>
<th>ICCAT list</th>
<th>CCAMLR list</th>
<th>CCSPRT named pre-2003 and in catch statistics</th>
<th>NAFO Citations 2004 to 2005</th>
<th>NEAFC A and B lists</th>
<th>Main report, Annex A</th>
<th>No. of incidences</th>
<th>Number of different ocean regions (out of 4 possible)</th>
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</table>

Also in the table we have identified flag states (bold) having an IUU presence in more than one ocean area, and with more than 4 incidents recorded. This leads to a short list of a number of DWFNs (China, Korea, Taiwan (Chinese Taipei), Russia and Spain) and open registry flags (Belize, Equatorial Guinea, Indonesia, Panama, St Vincent and the Grenadines, and Togo) with vessels that have a wide reach and are repeatedly engaged in IUU fishing. However, our analysis is clearly somewhat subjective and not definitive. For example it does not take into account the details of the offences, nor the volume and value of catches. It is simply an indication, based on the information to hand, of which countries might be implicated in IUU fishing. China and Taiwan (Chinese Taipei) have not signed either the Compliance Agreement (1995) or the UNFSA (1995). Russia and Korea have not signed UNFSA. The EU on behalf of its Members, including Spain, has signed both agreements.

In our previous report (MRAG, 2005) 14 open register countries were identified as being particularly active with respect to fishing vessels. They are in order of the total tonnage registered Belize, Bolivia, Cambodia, Cyprus, Equatorial Guinea, Georgia, Honduras, Marshall Islands, Mauritius, Netherlands Antilles, Panama, St. Vincent and the Grenadines, Sierra Leone, Vanuatu. 11 of these are represented in Table 3, and out of these 11 only Georgia and Mauritius have signed either agreement (Georgia the Compliance Agreement and Mauritius both) (see also MRAG (2005) Table 11).

In terms of being party to international agreements, the High Seas Task Force has identified the following countries as being of particular concern because of their lack of ratification of UNFSA, even though they may be parties to one or more regional organisations: Belize, Japan, Poland, Bolivia, Korea, Saint Vincent and the Grenadines, Cambodia, Mexico, Sierra Leone, Equatorial Guinea, Nicaragua,
Vanuatu, Georgia, Panama, Venezuela, Honduras and the Philippines. 13 of these 17 countries are identified in Table 3.

### 3.2. Ecosystem and fishery consequences of high seas IUU

This section discusses the possible consequences of IUU fishing, as summarised in Table 4.

Table 4 Possible Negative Ecological Impacts of IUU Fishing on developing countries

<table>
<thead>
<tr>
<th>ECOSYSTEM COMPONENT</th>
<th>IMPACT</th>
<th>EFFECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target species</td>
<td>IUU fishing outside quota in EEZ waters.</td>
<td>IUU fishing obviously impacts the target species negatively. Sumaila and Vasconcellos (2000) provide an example where IUU fishing in Namibian waters depleted target stocks to very low levels, which impacted on legitimate vessel catch as well as IUU vessel catch.</td>
</tr>
<tr>
<td>Target species</td>
<td>IUU fishing in high seas waters</td>
<td>Similar effect as for EEZ waters, but transmitted only if the species concerned are straddling or highly migratory, and the stock exists both in high seas and EEZ waters; or if the depletion of the stock in high seas waters reduces fishing opportunities for developing states in those high seas waters under RFMO agreements.</td>
</tr>
<tr>
<td>Target species</td>
<td>Under-reporting catch, especially by DWFN in EEZ fisheries agreements</td>
<td>Under-reporting in any fisheries system (including the large-scale under-reporting in developed country waters) has the same effect as fishing outside of quota. Not only does it impact negatively on the stock, but it can severely compromise scientific stock assessments which usually rely on some reasonably good estimate of total extractions.</td>
</tr>
<tr>
<td>Target species</td>
<td>Unmonitored discarding.</td>
<td>The same issues relate to discarding as to under-reporting, but here impacts are often on the younger age classes of the stock.</td>
</tr>
<tr>
<td>Dependent and related species</td>
<td>Direct impacts of IUU fishing: bycatch</td>
<td>Large numbers of associated species can be caught in all fisheries. This has an effect on the populations of these animals. The issue is usually highlighted with respect to “charismatic megafauna” such as birds, seals, cetaceans and turtles; attention has spread to consider endangered, slow-growing fish recently such as sharks and rajids. But other species are similarly affected, and if they are slow-growing bycatch can significantly affect their ability to recover. For instance the barn-door and common skates in the northern Atlantic. There is considerable concern amongst conservation groups that turtles are negatively impacted by IUU tuna and shrimp fishing (see e.g. Lewison et al., 2004), and the development of IUU longline fisheries for tuna and demersal species has contributed significantly to the precipitate decline in populations of most albatross in the southern ocean. Obviously all fishing activity has the potential to cause these impacts, but IUU fishing is thought to be particularly destructive because IUU fishermen do not generally use management measures aimed at reducing the impacts, for instance turtle or seal/seal exclusion devices, streamer lines to keep birds away from nets and hooks etc.</td>
</tr>
<tr>
<td>Dependent and related species</td>
<td>Indirect impacts of IUU fishing: bycatch</td>
<td>These impacts are much more difficult to quantify than direct impacts. They arise because of the removal or overfishing of a target species (or bycatch species) which is a critical ecosystem component, causing a change in trophic functioning. Avoidance of this effect is often an objective of ecosystem management, and may be termed maintenance of the ecological relationships between harvested, dependent and related populations or maintenance of ecosystem diversity function – i.e. biodiversity.</td>
</tr>
<tr>
<td>Habitats</td>
<td>Destruction of habitats by IUU vessels</td>
<td>Vessel gear, particularly trawls, may often destroy habitats, such as the deep water coral habitats now being discovered on many seamounts and deep shelf slopes around the world. Unregulated fishing in deep waters is particularly damaging, as the 2003 New Zealand Conference on Deep Water fishing (FAO, 2003) exposed. As with other direct effects, IUU</td>
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</table>
vessels are probably more destructive than licensed vessels because they ignore management actions such as closed areas which aim to reduce habitat destruction. Habitat destruction may have far-reaching impacts, because many sensitive habitats such as inshore shallow seas, maerl, coral and seagrass beds, act as nursery and settlement areas for other marine animals including juvenile fish.

### 3.2.1. Effects on target species

Section 3.1.1 includes some discussion of the effects of IUU fishing on target species. Clearly any fishing over and above the sustainable yield will have negative consequences for the status of the stock. This is exacerbated in the case of IUU fishing because there is generally greater uncertainty about the size and composition of the catches and they may not be included accurately, or indeed at all, in the stock assessment. The consequences for stocks of non-inclusion of IUU catches can be serious. By and large estimates of IUU catches, if available, are included in stock assessments, but the presence of IUU catches may nevertheless have severe consequences. Further discussion is given in section 4.4.

### 3.2.2. Effects on non-target species and habitats

The biggest difficulty that we face in this section is identifying the incremental ecological impacts of IUU fishing over and above those of non-IUU fishing. The current state of world fisheries is such that very few are managed so as to minimise impacts on non-target, dependent and related species and habitats. Fisheries management in an ecosystem context is still being developed by RFMOs and domestic fisheries alike. Where management measures that aim to mitigate ecosystem impacts exist, it is unlikely that those engaged in IUU fishing are going to adopt those measures. However, in many regulated fisheries such measures do not yet exist in practice. For instance, Small (2005) has suggested rather few RFMOs are effectively dealing with bycatch reduction – CCAMLR performing best and IOTC worst. Therefore, separating poor ecosystem practice by IUU vessels within high seas areas from poor ecosystem practice generally is not an easy task. However, we focus in the following sections on some specific examples that are useful in highlighting the incremental damage caused by IUU fishing.

#### 3.2.2.1. Birds

The incidental catch of albatross and other sea birds during both demersal and pelagic longlining in both the Northern and Southern Hemispheres has been identified as a significant cause of population decline for a number of species (Brothers et al., 1999; Nel et al., 2002; Tuck et al., 2004a). Albatrosses, skuas and petrels attempt to steal bait from hooks during line setting (Brothers et al., 1999; Birdlife International, 2004) and to a lesser extent hauling operations (Tuck et al., 2004b) and may become caught on baited hooks and subsequently drown as the line sinks below the surface (Tasker et al., 2000). With some species of albatross breeding successfully only once every two years, the additional mortality associated with longlining threatens the survival of individual colonies and of some species (Croxall and Rothery, 1991).

High seas longlining operations with the potential to cause seabird mortality are those occurring in Southern Hemisphere waters south of 30°S, where the distribution
of several wide-ranging species of seabirds, including albatrosses, is greatest (Tuck et al., 2004a). The vast majority of these longline fisheries are pelagic and target tuna. For example, the foraging range for female wandering albatross lies between 35°-45°S, within the same latitudes as major tuna longlining fisheries targeting southern bluefin tuna (*Thunnus maccoyii*) and albacore (*Thunnus alalunga*) (Tuck et al., 2004b). In addition to tuna fisheries, demersal longlining operations for Patagonian toothfish also pose a threat to seabirds in the southern ocean high seas. Although toothfish fisheries predominate on shelf and slope areas, activities also extend outside the 200 mile EEZs around the Sub-Antarctic Islands where many of the breeding colonies are situated (Tuck et al., 2003). Interactions also occur between seabirds and demersal longlining operations elsewhere, in the South Atlantic, Southern Indian Ocean, South Pacific, North Pacific and North Atlantic, but these fisheries fall predominantly within EEZs on shelf or slope areas (Brothers et al., 1999) so will not be considered here.

The following five RFMO areas have been identified as the most important with respect to their overlap with the distributions of breeding albatrosses (in order of importance, highest first): CCSBT; WCPFC; IOTC; ICCAT and CCAMLR (Birdlife International, 2004) (Table 5 and Figure 4). The area regulated under the CCSBT for example, coincides with the ranges of 14 out of the 16 tracked species of albatross, and 70% of the total distribution of breeding albatrosses (Birdlife International, 2004). Based on the data that is available for petrels, ICCAT, CCAMLR and CCSBT represent the most important RFMOs (in order of importance, highest first), in terms of their overlap with the distribution of the Northern Giant-, Southern Giant- and White-chinned petrels (Birdlife International, 2004) (Figure 4 and Table 5).

Figure 4 Global utilisation distributions (UDs) of breeding albatrosses in relation to the areas of competence of selected RFMOs. A UD provides a probability contour indicating the relative amount of time birds spend in a particular area i.e. they will spend 50% of their time within the 50% UD. The dotted line represents the entire range, or 100% UD. This composite was created by calculating the utilisation distributions for each species and combining them giving each species equal

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*WCPFC – This commission only came into force in June 2004, and has not yet established management measures for fish stocks or bycatch species. Of the total tuna catch within this region 11% is taken by longline vessels, predominantly Taiwan, Japan, Korea and China (Small, 2005).*
weighting. (Figure from Birdlife International (2004), reproduced with permission from the data-holders of the Global Procellariiform Tracking Database11).

### Table 5

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<th>Species</th>
<th>Threat status</th>
<th>% global population tracked</th>
<th>% at sea spent in RFMOs</th>
<th>% in high seas</th>
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<td>E</td>
<td>17</td>
<td>68</td>
<td>88</td>
</tr>
<tr>
<td>Southern Royal</td>
<td>V</td>
<td>99</td>
<td>96</td>
<td>1</td>
</tr>
<tr>
<td>Tristan</td>
<td>E</td>
<td>100</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Wandering</td>
<td>V</td>
<td>100</td>
<td>61</td>
<td>84</td>
</tr>
<tr>
<td><strong>Petrels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northern Giant-I</td>
<td>NT</td>
<td>38</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>Southern Giant-</td>
<td>V</td>
<td>20</td>
<td>64</td>
<td>20</td>
</tr>
<tr>
<td>White-chinned</td>
<td>V</td>
<td>?</td>
<td>65</td>
<td>28</td>
</tr>
</tbody>
</table>

| NT: not threatened; V: Vulnerable; E: Endangered; CE: Critically Endangered |
|---|---|---|---|---|
| The percentage of global population tracked is calculated by summing the proportion of the global annual number of breeding pairs at each site for which tracking data was contributed. |

Species of albatross (for which 70% of the global population have been tracked by satellite), which are particularly at risk in the high seas, south of 30°S, include the Grey Headed, Indian Yellow-nosed, Tristan, and Wandering albatrosses, spending between 45 and 56% of their time in the high seas during the breeding period (Birdlife International, 2004) (Table 5).

Identifying the impact of IUU longlining on seabird mortality within the high seas compared with bycatch caused by legitimate longlining operations is problematic. In the first instance, we do not know with any accuracy the extent of IUU longlining versus legitimate longlining in high seas waters, and certainly not by latitude. Secondly, data on incidental bird mortality is limited even for the non-IUU fleet, since the level of on-board observation monitoring bycatch in most areas is poor or non-existent (Gilman et al., 2005). Estimates of seabird bycatch are based on the product of an observed bycatch rate (e.g. number of birds per thousand hooks) and the amount of effort in a fishery, but both of these components change substantially over time (Tuck et al., 2004a) in response to changes in both fishing practices and bird population status. For example, tuna longline fisheries for southern bluefin tuna (SBT) have undergone changes in recent years due to shifts in operational areas and seasons, technological improvements to the gear used and the expansion by longline vessels other than Japan (e.g. Taiwan and Korea) into the high seas (Tuck et al., 2004a). Finally, it is often assumed that IUU vessels do not use the mitigation measures implemented by legitimate fisheries. This may generally be true, but it is

11 See Appendix 1 for data contributors.
also true that ecological interactions are a nuisance for IUU vessels, which may therefore have an incentive to minimise them.

Actions to reduce seabird bycatch have been made both by longline DWFN and RFMOs.

**DWFN**

Currently Japan and Taiwan comprise the largest portion of pelagic longline fleets in the Southern Ocean (Tuck et al., 2003; 2004a). During the 2000 fishing season, 199 Japanese vessels were targeting southern bluefin tuna, with 52 on the high seas off Tasmania and New South Wales, 75 on the high seas off Cape Town and 72 in the southern Indian Ocean (Tuck et al., 2003; 2004a). Over 600 Taiwanese distant water vessels currently operate worldwide, with effort concentrating within the central southern regions of the Pacific and Indian Oceans and to the South west of South Africa and east of Uruguay in the western Atlantic Ocean, targeting both albacore and southern bluefin tuna (Tuck et al., 2003; 2004a). In the late 1990s, a monitoring study found that a large proportion of Taiwanese-owned vessels (monitored in Mauritius and South Africa) were operating under Flags of Convenience, while the large Taiwanese vessels replacing smaller traditional albacore longliners, were suspected of actively targeting southern bluefin tuna (as opposed to their quota-ed albacore) (Gunn and Farley 2000). A significant decommission and re-registration scheme has reduced this number significantly (see section 4.1 and Hanafasa and Yagi (2004)). Furthermore, since Taiwan gained membership within CCSBT last year, the effort from Taiwanese vessels has been incorporated into the regulated fishery, and therefore no longer represents a potential source of IUU fishing. Taiwanese vessels are currently on the CCSBT authorised list.

Taiwan recently introduced a scientific observer program for its high seas longline fleet that includes reporting of seabird bycatch (Tuck et al., 2003; 2004a). Vessels are also instructed to use tori lines (which have a streamer line attached to scare birds from the mainline during setting) and set at night when fishing south of 30°S; as a result bycatch rates are reported to have reduced from 0.15 to 0.036 birds per thousand hooks (Tuck et al., 2004a). However, there are various contradictory reports of the level at which such mitigation measures are implemented throughout the fleet, and one report of a vessel catching 100 birds in one day off Uruguay (Ryan and Boix-Hinzen, 1998; Tuck et al., 2004a) is cause for concern.

Tori poles were made mandatory for Japanese vessels targeting southern bluefin tuna in 1997 (Anon, 1997). In addition, Japanese fleets are encouraged by the Fisheries Agency of Japan to use weighted lines and bait-casting machines, night line setting and properly thawed baits to reduce bird bycatch (Tuck et al., 2003). The Real Time Monitoring Program (RTMP) set up in 1991 to improve information on catch and effort statistics for southern bluefin tuna stock assessment, included an observer program involving Australia, NZ and Japan on high seas vessels targeting SBT (Tuck et al., 2004a). After 1995, the RTMP high seas observer programme was altered to a national one run by Japan and since then estimates of seabird bycatch have been provided to the Ecologically Related Species (ERS) working group of the CCSBT (Tuck et al., 2004a). A recent submission to the ERS working group included estimates of bycatch for 2001 and 2002 as 6516 and 6869 birds per year, respectively (Kiyota and Takeuchi, 2004), from which an estimate of bird catch rate can be calculated as 0.139 and 0.172 birds per thousand hooks for 2001 and 2002 respectively.
RFMOs

CCAMLR is the only RFMO to have implemented comprehensive mitigation measures to reduce albatross mortality (Birdlife International, 2004) and to have placed observers on all vessels targeting Patagonian toothfish since 1994/95 (Tuck et al., 2003). Bird bycatch for the legitimate fleet operating within the CCAMLR areas 58.6 and 58.5.1 has reduced from 1.81 birds/thousand hook in 1998/99 to levels of around 0.118 birds/thousand hooks in 2002/04 (CCAMLR, 2004). CCSBT requires it’s vessels to use streamer lines and WCPCF is not yet active, but ICCAT and IOTC do not have any regulations enforcing such measures within their fisheries and do not assess their respective incidental bird mortality (Birdlife International, 2004). Therefore, it is reasonable to assume that in IOTC and ICCAT waters, legitimate and IUU vessels are using the same gear, and equally failing to implement any mitigation measures. Although, CCSBT does have a requirement for tori pole use, the extent of compliance with this requirement, and how effective the measures are, is unknown for the fleet as a whole, since there is limited feedback from vessels or observers to CCSBT (CCSBT secretariat, pers comm.). One might sensibly assume that IUU vessels fishing for southern bluefin tuna do not use these mitigation measures, as CCAMLR also assumes that IUU vessels do not use CCAMLR mitigation measures. Estimates made by CCAMLR on incidental mortality for IUU fishing activities within the convention area have been made by using the bird catch rates encountered by the licensed fishery in 1997, prior to the development and implementation of mitigation measures for the avoidance of bird catch (see 4.3 Estimating levels of bycatch and discard).

Nel and Taylor (2003) summarised published data of estimated or reported bycatch from various longline fisheries around the world in addition to incidental mortalities inferred or estimated from similar studies or fisheries. Summing this data, a gross estimate of incidental seabird mortality from all longline fisheries is approximately 106,659 birds per year (K. Rivera, B. Sullivan, pers comm.) and by removing estimates of bycatch from fisheries within EEZs from this figure, the number comes down to 34,327 birds killed per year. If this figure is then multiplied by the total percentage estimates of IUU fishing from the relevant RFMOs (IOTC, 10%; ICCAT, 1%; CCSBT, 10-33%) a range of between 7209-11328 birds per year results, depending on the reduction in IUU for CCSBT fisheries that has occurred since Taiwan gained membership.

Alternatively, taking effort data provided by the relevant RFMOs for the major longline fisheries occurring south of 30°S (e.g. IOTC, ICCAT and CCSBT) adjusted to constitute high seas effort only, and multiplying this by an average of the bird bycatch rates for 2001/02 calculated from the Japanese southern bluefin tuna fleet data (see Table 6), an estimate of bird bycatch for legitimate fisheries comes out as 36,360 birds per year (Table 6). When multiplied by relevant percentage estimates of IUU fishing occurring in each of the relevant RFMOs, we get an estimate of between 7,091 and 20,492 birds per year for IUU fishing within high seas areas south of 30°S (Table 6).

It is important to point out that these calculations assume that bird catch rates are constant both spatially and temporally and therefore should be viewed with caution. In the first instance, the sharp decline in albatross populations worldwide implies that encounter probability must also have declined over the last 15 years. For instance, the CCAMLR IUU bird catch rate, calculated in 1997, may now be higher than one would expect with reduced populations. In addition, the spatial density distribution of birds at any one time differs for species, life stage (breeding/non-breeding adults or juveniles) and sex (Birdlife International, 2004; Tuck et al., 2004b). For example, the
differing utilisation range between male and female wandering albatrosses, with males tending to forage within a more southerly distribution (50° - 60°S) than females (whose range coincides with major tuna fisheries between 35°-45°S), has been implicated in the higher mortality of females reported through returns of banded birds to breeding islands (Croxall et al., 1990; Weimerskirch and Jouventin, 1987).

Table 6  Estimates of seabird bycatch for longline fisheries south of 30°S for IUU operations within high seas.

<table>
<thead>
<tr>
<th>Fishery</th>
<th>Effort (no. of hooks per yr)</th>
<th>Incidental bird mortality (birds/1000 hooks)</th>
<th>Estimated legitimate bycatch (birds/year)</th>
<th>Estimated % of IUU fishing</th>
<th>Estimated IUU bycatch (birds/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indian Ocean albacore (IOTC)</td>
<td>72,549,738</td>
<td>0.155</td>
<td>11.245</td>
<td>10</td>
<td>1125</td>
</tr>
<tr>
<td>Atlantic Ocean albacore (ICCAT)</td>
<td>35,201,866</td>
<td>0.155</td>
<td>5,456</td>
<td>1</td>
<td>55</td>
</tr>
<tr>
<td>Southern bluefin tuna (CCSBT)</td>
<td>100,600,532</td>
<td>0.155</td>
<td>15.593</td>
<td>10 - 33</td>
<td>1,559 - 5,146</td>
</tr>
<tr>
<td>CCAMLR4</td>
<td></td>
<td>4.066</td>
<td></td>
<td>4,352 - 14,166</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36,360</td>
<td></td>
<td></td>
<td>7,091 - 20,492</td>
<td></td>
</tr>
</tbody>
</table>

1 averaged over years 1993-2001 for 30°-60°S with EEZ data removed by visually assigning the proportion of each 5°x5° grid square along land margins to land/EEZ or high seas.
2 calculated from Japanese Southern Bluefin Tuna longline fishery data 2001-02 (Kiyota and Takeuchi, 2004)
3 Taken from MRAG (2005).
4 Catch rates in legal and IUU fisheries have very different estimates of bird catch (CCAMLR, 2004).

Our estimate is that currently IUU bird catch is between 8% and 16% of the legitimate vessel bird catch or 16-36% of the total bird catch in the Southern Ocean. Although IUU fishing activities add to this mortality, we suggest that enforcement of mitigation measures upon the legitimate fleets should be the first step in reducing the impact on bird populations, as reduction in IUU operations alone will not have the biggest impact. Furthermore, incidental mortality of seabirds is likely to be higher within EEZs than in high seas areas due to proximity to breeding sites (e.g. birds killed in the Chilean EEZ toothfish fishery) (Brothers et al., 1999). Therefore, solving the issue of bycatch in EEZs both for legitimate and IUU vessels and for the legitimate fishery on high seas is the priority.

3.2.2.2. Turtles

Recently, considerable attention has been directed towards the impacts high seas fisheries, particularly pelagic longline fisheries, have on sea turtle populations (FAO, 2004b). Dramatic declines of leatherback turtles (Dermochelys coriacea coriacea) (>95%) and loggerhead turtles (Caretta caretta caretta) (between 80 and 86%) in the Pacific region are suspected to result from incidental mortality caused by interactions with pelagic longline fisheries (Lewison et al., 2004).

Turtles become caught in pelagic longlines, by becoming hooked externally on a flipper or entangled in fishing lines, or internally when they attempt to take bait (EJF, 2005). Observations of sea turtles taken by the Hawaii-based longline fishery indicate that piscivorous species such as loggerheads often ingest the baited hooks, while leatherbacks tend to get hooked externally or entangled in lines (NMFS-SEFSC, 2001a). Leatherbacks eat cnidarians (e.g. medusae and siphonophores), so they may be attracted to the light sticks used on the longlines at night to attract squid
Long term telemetry results indicate that turtles spend most of their time diving in the epipelagic zone (<200m), the same depth range targeted by longline fisheries (Hays et al., 2004). They also forage along productive fronts where their main prey, gelatinous plankton (jellyfish), are concentrated along with prey species of billfish and tuna, the predators themselves and the fishing boats targeting them (Lewison et al., 2004). Bycatch of turtles is reported to be higher in the upper 40m of surface waters; therefore longlines set to fish shallow, particularly in the tropical and subtropical are fisheries with the highest turtle bycatch (Murray & WWF, 2004). Previous research has revealed that longline sets that target swordfish have turtle bycatch rates approximately 10 times higher than bycatch from tuna sets (Crowder and Myers, 2001; Watson et al., 2004), although it should be noted that longlining effort targeting tuna is approximately six times that targeting swordfish (Lewison et al., 2004). Demersal longlines have not been implicated in turtle bycatch (Lewison et al., 2004).

Lewison et al., (2004) used catch data from over 40 countries and bycatch data from 13 international observer programmes to estimate the global take of loggerhead and leatherback turtles by pelagic longlining. Despite infrequent rates of encounter recorded among observer data, their analyses estimated some 200 000 loggerheads and 50 000 leatherbacks were likely to be taken by pelagic longlines in 2000 (Lewison et al., 2004). These levels of bycatch however do not necessarily represent lethal interactions between turtles and longlining operations. For this, estimates of the probability of mortality per bycatch are required and these remain uncertain for a number of reasons. Observer data reporting bycatch are few and far between (observer data exists for less than 25% of the pelagic longline gear deployed during 2000 (Lewison et al., 2004)), while determining the likelihood of survival of turtles released from longlines is difficult, as it depends on the nature of the interaction i.e. externally/internally hooked. Research to determine post-hooking mortality is based primarily on satellite tracking of (hard-shelled) turtles fitted with transmitters after hooking/entanglement and release (NMFS-SEFSC, 2001). Lack of a signal from such a turtle after one month is categorised as an unsuccessful track and probable turtle mortality (NMFS-SEFSC, 2001). Ranges of turtle mortality from tuna and swordfish fisheries for loggerhead and leatherback turtles have been reported as 17-42% and 8-27% respectively (NMFS-PIRO, 2001). However, it is proposed by the Office of Protected Resources that 50% of all longline interactions with turtles should be classified as lethal (NMFS-PIRO, 2001).

As with the incidental catch of seabirds, separating the mortality due to IUU and legitimate fisheries is very difficult and assumes that legitimate fishing operations adopt mitigation practices (i.e. mandatory mitigation measures, either imposed nationally on state fleets, or internationally by an RFMO) whereas IUU vessels do not. This is a conservative assumption but may not necessarily be correct.

Table 7 lists a number of measures that have been shown to reduce turtle bycatch in pelagic longline fisheries, with hook and bait modifications reported to be the most important gear parameter affecting catch rates of turtles. Fisheries experiments have indicated that circle hooks and fish bait (i.e. mackerel as opposed to squid) significantly reduce loggerhead and leatherback interactions by as much as 90% and 75% respectively in swordfish fisheries (Watson et al., 2004).
Table 7  Fishing gear and fishing practice modifications that have been shown to affect incidental catch of sea turtles in pelagic longline fisheries (FAO, 2004a).

<table>
<thead>
<tr>
<th>Fishing gear modifications</th>
<th>Fishing practice modifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hook type (e.g. circle versus J-hook)</td>
<td>Setting depth</td>
</tr>
<tr>
<td>Hook size</td>
<td>Water temperature</td>
</tr>
<tr>
<td>Bait type (e.g. mackerel versus squid)</td>
<td>Daylight soak time</td>
</tr>
<tr>
<td>Blue-dyed bait</td>
<td>* Results from behaviour studies that have not been confirmed in fishing experiments</td>
</tr>
</tbody>
</table>

US vessels fishing on the high seas around Hawaii are regulated by time and area closures with limited shallow-set swordfish fisheries required to use circle hooks and mackerel bait (WPRFMC, 2004)). However, this does not prevent vessels from non-US pelagic longline fleets fishing in these areas, and until the WCPFC becomes active these fisheries remain unregulated and possibly unreported if fleets do not report to their flag states. Out of the currently active tuna RFMOs, only IATTC has a resolution for the reduction of turtle mortality encouraging states to submit data on turtle interactions, release turtles wherever possible and conduct research on mitigation measures (Small, 2004). CCSBT has no mitigation measures in place for reducing turtle bycatch; IOTC bycatch working group is yet to meet and species codes for bycatch recording do not include codes for turtles (or dolphins/seabirds) (Small, 2004); some members of ICCAT include turtle interactions in their observer programmes, and it has been reported that loggerhead catch can be reduced by 92% using circle hooks (ICCAT biennial report, 2002-2003 Madrid, 2004), however, there is currently no resolution on turtles (Small, 2004). Therefore, it is perhaps more reasonable to assume that turtle bycatch from IUU fleets is comparable with that from fleets reporting their catches to tuna RFMOs and so, a ball-park estimate of bycatch for IUU longlining operations can be calculated from bycatch-to-catch ratios from these fleets as follows.

85 000 t of tuna and swordfish is believed to be caught by IUU vessels (Lewison et al., 2004 based on 2000 data from ICCAT, 2001; SPC, 2002; IOTC, 2003 and IATTC, 2003). Bartram and Kaneko (2004) have produced a number of estimates of bycatch-to-catch ratios for different fisheries, and are summarised in Table 8.

Lewison et al.’s (2004) estimate of legitimate pelagic longline tuna and swordfish catch per year is approximately 680 000 t, which when combined with the IUU estimates gives a total catch of 765 000 t per year. The IUU catch (85 000 t) represents approximately 11% of this, which if applied to the global estimate of loggerhead and leatherback turtle bycatch of 250 000 (Lewison et al., 2004), gives a figure of 13 750 loggerhead and leatherback turtles killed by IUU vessels (when multiplied by the 50% mortality rate given in NMFS-SEFC, 2001b) and a catch rate of 0.33 turtles per t target species, comparable to the average of catch rates given in Table 8 (minus the high catch rates of fisheries offshore from nesting sites (e.g. Brazil and Costa Rica)). However, it is important to note that this figure does not include all turtle species potentially caught by pelagic longline operations, and is estimated for a figure of total catch which includes catch data from EEZs.

Legitimate fisheries within EEZs are reported to pose considerable threat to turtle populations due to their proximity to nesting sites, with catch rate estimates as high as 43.1 and 30.9 turtles per t of target species from shallow-set longline fisheries for near nesting beaches in Costa Rica (mahi mahi) and Brazil (swordfish) respectively (Bartram and Kaneko, 2004). Thus, illegal operations in these areas will only compound substantial impacts caused by legitimate fisheries. There are additional
reports of longliners fishing illegally off the coast of Mozambique switching to gillnets to improve shark catches, with turtle mortalities evidenced by carcasses washed up on beaches which have been cut from nets during the hauling process (Klepsvik, 2005), however the extent to which this activity extends into high seas waters is unclear.

Table 8  Sea turtle bycatch-catch (B/C) ratios for selected pelagic longline fisheries, taken from Bartram and Kaneko (2004). B/C ratios are calculated by dividing BPUE (bycatch per unit effort taken from observer data) by CPUE for each fishery. See Bartram and Kaneko (2004) for detailed information on data sources.

<table>
<thead>
<tr>
<th>Area</th>
<th>Flag state</th>
<th>Longline Fishery</th>
<th>B/C Ratio Sea turtle (takes/t target catch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtropical South Pacific</td>
<td>American Samoa &amp; Samoa alia</td>
<td>YF tuna deep-set</td>
<td>0</td>
</tr>
<tr>
<td>Western Tropical Pacific</td>
<td>Japan</td>
<td>BE, YF tuna deep-set</td>
<td>0.02</td>
</tr>
<tr>
<td>Sub tropical central North Pacific</td>
<td>Hawaii</td>
<td>BE, YF tuna deep-set</td>
<td>0.017</td>
</tr>
<tr>
<td>Western Tropical Pacific</td>
<td>Taiwan</td>
<td>BE, YF tuna shallow-set</td>
<td>0.19</td>
</tr>
<tr>
<td>Western Tropical Pacific</td>
<td>People’s Republic China</td>
<td>BE, YF tuna shallow-set</td>
<td>0.26</td>
</tr>
<tr>
<td>Eastern Australia</td>
<td>Australian</td>
<td>swordfish shallow-set</td>
<td>0.05</td>
</tr>
<tr>
<td>Sub tropical and temperate central North Pacific</td>
<td>Hawaii</td>
<td>swordfish shallow-set</td>
<td>0.16</td>
</tr>
<tr>
<td>Tropical eastern Pacific</td>
<td>Costa Rica</td>
<td>offshore mahi mahi shallow-set</td>
<td>14.8*</td>
</tr>
<tr>
<td>Temperate eastern Pacific</td>
<td>California</td>
<td>swordfish shallow-set</td>
<td>0.14</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>Brazil</td>
<td>offshore swordfish shallow-set</td>
<td>4.8*</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>South Africa</td>
<td>swordfish shallow-set</td>
<td>1.58</td>
</tr>
</tbody>
</table>

*Note higher catch rates from fisheries offshore from nesting beaches.

Out of a total of seven fisheries that the FAO (2004a) put forward as requiring particular management attention to significantly reduce the impact of fisheries on the most threatened sea turtle stocks, only one falls within high seas - pelagic longline fisheries in Eastern Pacific waters. All other fisheries which FAO designated as requiring specific attention fall within coastal waters e.g. coastal trawl fisheries in southeast Asia; coastal gillnet fisheries in southeast Asian waters; coastal gillnet fisheries in south Asian waters; coastal trawl fisheries in south Asian waters; coastal gillnet fisheries in southeast Pacific waters; coastal gillnet fisheries in Baja California) (FAO, 2004a) but whether this is a true representation of bycatch hotspots or simply represents the greater level of observations from coastal waters compared to the high seas remains to be determined.

IUU Purse seine operations are unlikely to be wide scale due to the risk of detection and high operating costs (see Section 3.1.1.1). Those that might be considered with respect to turtle bycatch would be those utilising Fish Aggregating Devices (FADs) to increase catches. However, we have not been able to source any quantitative information on the extent of unauthorised use of these methods. Any resumption of illegal large-scale driftnetting would have an IUU turtle bycatch and some has been detected in the North Pacific Ocean (Ichi et al., in press), but there is no information on catch rates.

Therefore, the IUU proportion of total turtle catch is about 11%, similar to that of our estimate of the IUU proportion of total bird catch. Once again, the biggest impact is non-application of mitigation measures by legitimate vessels in EEZ and high seas.
3.2.2.3. Cetaceans

Cetaceans become entangled in fishing gear either passively or when attempting to feed on bait or on fish already hooked (depredation).

False killer whales steal fish from trolling lines of recreational and commercial fishermen and are taken by the Hawaii pelagic longline fishery (Crowder and Myers, 2001) and killer whales or sperm whales take fish from toothfish longlines (Purves et al., 2002). There have been conflicts between fishermen and cetaceans for decades, with clashes reported between Icelandic fishermen and killer whales back in 1956 (Anon, 1956) and more recently in the Bering Sea, between killer whales and Alaskan and Japanese fishermen over black cod/sablefish (*Anoplopoma fimbria*), and similarly with Brazilian fishermen in the Atlantic who target tunas (*Thunnus spp.*) and swordfish (*Xiphias gladius*) (Dalheim, 1988). Depredation by cetaceans on longline gear occurs worldwide, and with consequences including loss of catch, gear and time and increase in vessel operating costs (Donoghue et al., 2002), it is unsurprising that reports exist of aggressive actions by fishermen towards cetaceans engaged in these activities. Orcas, pseudorcas and sperm whales can be a considerable nuisance for longlining operations in tropical and polar waters, and there have been reports that IUU vessels attempt to deter these whales/dolphins by shooting them or attacking them with explosives (Donoghue et al., 2002). With this issue, there is cause for concern; deterring cetaceans by such methods requires little effort by fishermen and returns potentially large rewards if catches are maintained (catch rates have been shown to be significantly lower when killer whales are present during hauling of toothfish longlines, e.g. 0.15 kg/hook compared to 0.29kg/hook when cetaceans are not present) (Purves et al., in Donoghue et al., 2002), and with the low level of observer coverage in relevant fisheries, they are likely to remain undetected.

Fishing gear that poses the biggest danger to cetaceans with respect to incidental catch, includes: gillnets, set nets, trammel nets, seines, trawling nets and longlines (WWF, 2005a). Due to the indiscriminate nature of catches, WWF (2005a) states that ‘Experts agree that wherever there are gillnets, there is cetacean bycatch’. Pair-trawling has also been implicated in substantial numbers of dolphin deaths in regulated fisheries in EU waters (WWF, 2005b). Illegal high seas driftnets continue to be found by law enforcement vessels (Lewison et al., 2004) but quantitative information on bycatch from such activities has been difficult to source.

The US National Marine Fisheries Service (NMFS) categorizes every US commercial fishery by the level of incidental mortality or serious injury to cetaceans (and pinnipeds) that they cause (Crowder and Myers, 2001). To give an indication of species that might be impacted by illegal operations using the following fisheries methods in contravention of area regulations, Table 9 lists the three NMFS categories and gives some examples of fisheries falling into each from US fisheries in the Atlantic and the Pacific and the species potentially impacted by these fisheries and Table 10 is a summary of reports of interactions between cetaceans and non-US fisheries from a recent workshop discussing the problem of cetacean depredation for longline fisheries.
Table 9  US National Marine Fisheries Service fisheries classifications relating to potential biological removal (PBR) of marine mammals through interactions with fishing operations in the Atlantic and Pacific (produced from tables in Crowder and Myers (2001) and NMFS-NOAA (2004)).

<table>
<thead>
<tr>
<th>Fishery</th>
<th>Target species</th>
<th>Species reported to be incidentally killed/injured</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category I</strong></td>
<td>Mortalities and injuries = 50% PBR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gillnet fisheries (&lt;3.5 in mesh)</td>
<td>Angel shark/halibut</td>
<td>Common dolphin, short-beaked and long beaked</td>
<td>California, Oregon, Washington</td>
</tr>
<tr>
<td></td>
<td></td>
<td>California sea lion, Northern elephant seal</td>
<td>US California breeding</td>
</tr>
<tr>
<td>Longline/Set line fisheries</td>
<td>Swordfish, tuna, billfish, mahi mahi, wahoo, oceanic sharks</td>
<td>Humpback whale</td>
<td>Central North Pacific</td>
</tr>
<tr>
<td></td>
<td></td>
<td>False Killer whales, Risso’s dolphin, Bottlenose dolphin, Spinner dolphin, Short-finned pilot whale, Sperm whale</td>
<td>Hawaii</td>
</tr>
<tr>
<td>Northeast sink gillnet</td>
<td>North Atlantic right whale, Humpback whale, Killer whale, White-sided dolphin, Harbor seal, Gray seal, Common dolphin, Fin whale, Spotted dolphin, False killer whale, Harp seal Bottlenose dolphin Minke whale</td>
<td>Western North Atlantic</td>
<td></td>
</tr>
<tr>
<td>Atlantic Caribbean, Gulf of Mexico Longline fisheries</td>
<td>Large pelagics</td>
<td>Humpback whale, Risso’s dolphin, Long-finned pilot whale, short-finned pilot whale, common dolphin, Atlantic spotted dolphin, pan tropical spotted dolphin, striped dolphin, pygmy sperm whale bottlenose dolphin Minke whale</td>
<td>Western North Atlantic, offshore Canadian east coast</td>
</tr>
<tr>
<td><strong>Category II</strong></td>
<td>Mortalities and Injuries account for between 1% and 50% PBR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift gillnet &gt;14in mesh</td>
<td>Thresher shark/swordfish</td>
<td>Steller sea lion, SpERM whale, Dall’s porpoise, Fin Whale, Northern Pacific white sided dolphin, Gray whale</td>
<td>Eastern US</td>
</tr>
<tr>
<td></td>
<td></td>
<td>California/Oregon/Washington, Eastern North Pacific</td>
<td></td>
</tr>
<tr>
<td>Purse seine fisheries</td>
<td>Anchovy, mackerel, tuna</td>
<td>Bottlenose dolphin, Californian sea lion, Harbor seal</td>
<td>California/Oregon/Washington, US California</td>
</tr>
<tr>
<td>Pelagic longline</td>
<td>-</td>
<td>California Sea lion</td>
<td>California</td>
</tr>
<tr>
<td><strong>Category III</strong></td>
<td>Mortalities and Injuries account for 1% PBR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gillnet</td>
<td>-</td>
<td>Bottlenose dolphin, Spinner dolphin</td>
<td>Hawaii</td>
</tr>
</tbody>
</table>
Table 10  Reports of interactions between cetaceans and fisheries taken from a workshop on interactions between cetaceans and longline fisheries in Apia Samoa, 2002. (Donoghue et al., 2002).

<table>
<thead>
<tr>
<th>Fishery</th>
<th>Target species</th>
<th>Cetacean species</th>
<th>Nature of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taiwan’s distant water longline fleet in South Pacific</td>
<td>tuna/billfish</td>
<td>Killer whale, common bottlenose dolphin, rough toothed dolphin, Risso’s dolphin</td>
<td>Hooked</td>
</tr>
<tr>
<td></td>
<td></td>
<td>pan tropical spotted spinner and striped dolphins, Killer whale, false killer whale, pygmy killer whale, melon-headed whales</td>
<td>Entangled, Harpooned (IUU)</td>
</tr>
<tr>
<td>Pelagic longline fishery off Brazil</td>
<td>tuna and swordfish</td>
<td>Killer whales and false killer whales, Risso’s dolphins</td>
<td>Hooked/entangled fishermen shooting at whales</td>
</tr>
<tr>
<td>Patagonian demersal longline fishery, South Georgia</td>
<td>toothfish</td>
<td>Killer whale, sperm whale</td>
<td>Catch rates significantly lower when killer whales present.</td>
</tr>
<tr>
<td>Patagonian demersal longline fishery off Chile</td>
<td>toothfish</td>
<td>Sperm whale, killer whale, pilot whale</td>
<td>Depredation, reports of artisanal fishers shooting or ramming whales and pinnipeds</td>
</tr>
<tr>
<td>Japanese longline fishing in Indian Ocean</td>
<td>tuna</td>
<td>Killer whale, false killer whale</td>
<td>Depredation</td>
</tr>
</tbody>
</table>

Most estimates of marine mammal bycatch come from US fisheries data. For example, estimates for the US Atlantic pelagic longline fishery include 108 interactions with pilot whales and 49 with Risso’s dolphins in 2004 (NMFS-NOAA, 2004). Meanwhile a report by Reed et al. (2003) gives an estimate of mean annual bycatch of marine mammals (including pinnipeds) in US fisheries between 1990 and 1999 of 6,215 ± 1,415. By expanding these US bycatches with FAO data on fisheries landings and fleet composition, they conclude that the global bycatch of cetaceans and pinnipeds is likely to number in the hundreds of thousands (Reed et al., 2005).

Once again, it is difficult to assess how much of this catch is due to IUU fishing, and how much to high seas IUU. Unlike the bird and turtle problems, we have not been able to create estimates of IUU catch of cetaceans. However, it is telling that of 60 bycatch priorities for cetaceans advanced by WWF (Reeves et al., 2005), only 5 are likely to involve high seas IUU.

3.2.2.4. Effects on habitats

The potential effects from fishing activity on marine habitats can be categorised into several groups, including alteration of the physical structure, increase sediment suspension, chemical modifications, benthic community changes, and ecosystem changes (Johnson, 2002).

Although several studies have described the impact of disturbances on shallow water benthic organisms, few studies have looked at the impacts of fishing in deepwater, which are more closely associated with High Seas areas. There is also very scarce information on habitat destruction by high seas IUU fisheries.
Deepwater trawl fisheries, particularly associated with seamounts, have had a clear impact. Due to their relative position to the surrounding seafloor, seamounts have strong currents that attract a fauna dominated by suspension feeders, including scleractinian, antipatharian, and gorgonian corals (Koslow et al., 2000). A study on seamounts in Tasmania found that benthic biomass per dredge sample was reduced by 83% and the number of species per sample by 59% in a comparison of fished and unfished areas (Koslow and Gowlett-Holmes, 1998).

Particularly vulnerable are coldwater corals (Freiwald et al., 2004). A recent study has shown the distribution of cold water coral within the NE Atlantic taken from catch rates of commercial bottom trawlers and research cruises (Figure 5). There is a particular coincidence over the seamounts off southern Ireland associates with the recent upsurge in the largely unregulated orange roughy fishery there. Bottom trawling on deep shelves and along the continental margins down to 1500m depth and beyond have increased dramatically since the late 1980s and the potential damage to these deepwater ecosystems can be considerable. For example, on a 15 day trip to the Rockall Trough in the NE Atlantic a trawler can sweep 33 sq. kilometres of seabed (Hall-Spencer et al., 2002). Such trawling tends to smash and disrupt the coral through the combined action of the trawl doors, groundline rollers and the strengthened base of the trawl. The detrimental effects of trawling on deepwater coral systems are well documented from a number of locations including: the Oculina reefs off eastern Florida, (Reed 2002); Solenemilia reefs on the summit of some Tasmanian seamounts (Koslow et al., 2000); the oceanic banks in New Zealand waters (Shester and Ayers in press); Lophelia reefs in Scandinavian waters (Fossa et al., 2002) and similar reefs off Western Ireland (Hall-Spencer et al., 2002). This can be so severe that it has been compared to ‘clear felling’ in forestry and, similarly, the destruction of these habitat forming organisms has a consequent effect on the dependant communities (Friewald et al., 2002).

It is not only trawls which are damaging to these deepwater communities. ROV observations from coral covered carbonate mounds in the Porcupine Seabight and Rockall Trough at 700-900m depth show damage from bottom-set gill nets, which can be used for cod, pollack, flatfish and rays, including many remnants which present a ghost fishing problem (Freiwald et al., 2004). Similar problems are seen with bottom-set longlines which are used to catch redfish, tusk, ling, sablefish and groupers. Longlines are much less restricted than bottom trawls in terms of where they can be deployed. They can be laid over areas of hard bottom with vertical relief from which trawls are effectively excluded. These are areas where sessile organisms such as gorgonians tend to accumulate. Thus, on a local scale, bottom longlining may be more damaging than trawls. Coral heads are often broken off during hauling and, again, lost and discarded lines may give rise to ghost fishing (Fossa et al., 2002; Witherell and Coon, 2001). However, there is very little experimental work on the effective impact of longlines versus trawls.

**IUU impacts**

As previously indicated, it is extremely difficult to gauge the impact of IUU versus other fishing on benthic habitats. The majority of cold water coral examples given above are likely to fall within national jurisdictions. However, probably the best High Seas case study may well be the recent alfonsino/roughy/oreo fisheries on the southern Indian mid-ocean ridges. The catches in this fishery were declared (Lack et al., 2003) but we are unsure how much information is actually available on ecosystem impacts.
A second interesting example that we have recently come across is the carbonate mounds/ridges running along the Mauritanian coast at about 500 m depth, discovered by Woodside Petroleum in their sidescan sonar research in the area (Bowman Bishaw Gorham, 2004). The sides and tops of the mounds comprised sand/rubble substrates with a more diverse assemblage of epibenthic organisms. These included small gorgonians, ascidians and sponges. Some polyps, thought to be lone coral polyps, were observed, together with one small coral colony. Patches of tube worms and aggregations of pencil urchins were observed, generally on the tops of the mounds. Crustaceans were common, in particular, portunid and galatheid crabs. The rubble appeared to mainly consist of the dead remains of hard corals and, in places, was of sufficient density to indicate a past level of live coral greatly in excess of what presently occurs. What has killed the corals is not known, but it is certainly possible that IUU trawling in the area, which until recently was common, may have contributed to their destruction.

![Distribution of cold water corals derived from commercial bottom trawls and research surveys (Source: MRAG & UNEP, 2005).](BT1990)

Figure 5

There are also reports, again from Somalia, of massive dumping of toxic waste (otherwise an expensive business) with consequent damage to ecosystems and human life, especially when it is washed up on the shore.  

3.2.2.5. Summary

In this section we have attempted to outline the magnitude of each ecosystem impact within both legitimate and IUU fisheries. We can summarise our results by looking at the relative level of impacts, as far as we can determine, in EEZ and High Seas fisheries by both IUU and Legitimate fishing vessels.

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12 Ewan Dunn (RSPB), pers. comm., reporting on a statement by the Somali representative to COFI, 2005.
Most of the bird bycatch problem is associated with longline fisheries in temperate waters. As we have shown, there is considerable bycatch of birds in longline fisheries generally, with one estimate of ~100,000 birds per year. Much of this is in high seas waters, largely because RFMOs have not implemented effective mitigation measures for legitimate vessels. However, because IUU fishing in temperate zones is probably at a low level, the impact of high seas IUU on birds may also be lower than the impact of high seas legitimate fisheries on birds. Within EEZs equally there is likely to be less IUU activity in temperate zones than our estimates in tropical waters (MRAG 2005). On the other hand we know that there is considerable bycatch of birds in legitimate temperate water longline fisheries (e.g. in the Bering Sea (Fulmars) and around South America (Petrels and Albatross); Brothers et al., 1999).

**Summary 1: likely impacts of different types of fishing on birds**

<table>
<thead>
<tr>
<th></th>
<th>Birds</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>Moderate</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>IUU</td>
<td>Low</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

Most of the turtle bycatch problem is associated with longline and shrimp trawl fisheries in tropical waters. We have shown that the high seas component of this mortality is high, again largely because of a lack of legislation by the tuna RFMOs. But the IUU proportion of the high seas catch of turtles is likely to be low. In EEZs there is a moderate catch of turtles, because some domestic fisheries are implementing turtle mitigation measures such as exclusion devices and closed areas/seasons. Our earlier study showed that IUU activity is variable but potentially high in tropical and sub-tropical EEZs, and in these areas, as evidenced by the activity in Mozambique, and does not implement mitigation measures.

**Summary 2: likely impacts of different types of fishing on turtles**

<table>
<thead>
<tr>
<th></th>
<th>Turtles</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>IUU</td>
<td>Moderate</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

There is very little information available to assess the impact of IUU fishing on cetaceans. However, the WWF list suggests that the most critical areas for cetacean interaction with fisheries are in EEZ waters. Many countries, including the US and the EU, now have observer programmes and mitigation requirements for cetacean fisheries. IUU fishing, where it is occurring, is likely to ignore these and therefore will have a moderate impact.

**Summary 3: likely impacts of different types of fishing on cetaceans**

<table>
<thead>
<tr>
<th></th>
<th>Cetaceans</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>High</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>IUU</td>
<td>Moderate</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

Habitat impacts are widespread in demersal fisheries, but not in pelagic fisheries. Damaging deep water demersal fisheries are those that use trawls and bottom set longlines. Many demersal fisheries which have significant habitat impacts are in EEZs, but we consider their impacts to be moderate because there are also many demersal fisheries in EEZs which do not have significant impacts. Deepwater fisheries tend to require complex technological fishing gear which means they are not prosecuted (at the moment) in EEZs by large IUU fleets. However, there are also
high seas demersal fisheries, most of which are unregulated and therefore fall under IUU in our classification rather than the legitimate fishery classification. The impacts of these fisheries are largely unknown.

Summary 4: likely impacts of different types of fishing on habitat

<table>
<thead>
<tr>
<th>Habitat</th>
<th>EEZ</th>
<th>High Seas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legitimate</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>IUU</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>

The above assessments of the likely impact of IUU fishing compared to legitimate fishing on ecosystem components is heavily influenced by the fact that most RFMOs have not yet adequately addressed the impacts of their legitimate fishing on the ecosystem, even to the extent of insisting on the use of measures that mitigate this activity. CCAMLR is the exception to this rule – the legitimate fleet uses mitigation measures that (with the exception of one Subarea) have virtually eliminated interactions with birds. IATTC has also made considerable progress with cetacean bycatch mitigation.

Should all RFMOs succeed in eliminating bycatch from their legitimate fisheries, clearly any residual IUU activity would become the major problem, as it has in CCAMLR.

3.2.3. Impacts of high seas IUU fishing on EEZs

Our main report (MRAG, 2005) and its Annex A provide many examples where high seas IUU fishing has occurred just outside an EEZ on fishing grounds that are in essence contiguous with those inside the EEZ. EEZ Fisheries close to the 200nm boundary may be particularly vulnerable to impacts from IUU fishing that occurs outside the jurisdictional control of the coastal state. There are two major categories of trans-boundary fish stocks that need to be considered: straddling stocks and highly migratory stocks.

3.2.3.1. Straddling fish stocks

Stocks are described as straddling when there is a more or less static distribution of a single stock that occurs either side of a boundary between an EEZ and the high seas. The problem in this case is that IUU fishing on the stock outside the EEZ can severely impact the status of the whole stock, not just the portion on the high seas. Therefore, even if the stock is well managed inside the EEZ, the fishery may not be sustainable due to fishing that is outside the control of the coastal state. The UNIA (Article 7 1(a)) states that: “with respect to straddling fish stocks, the relevant coastal States and the States whose nationals fish for such stocks in the adjacent high seas area shall seek, either directly or through the appropriate mechanisms for cooperation provided for in Part III, to agree upon the measures necessary for the conservation of these stocks in the adjacent high seas area”

Examples where there has been IUU fishing on straddling stocks include the groundfish fisheries on the nose and tail of the Grand Banks, just outside the Canadian 200 mile EEZ, the fisheries for toothfish around Prince Edward Island and Kerguelen Island and the pollock fisheries in the donut and peanut holes in the north Pacific and Sea of Okhotsk (see Section 3.1.1.4).
On the Grand Banks (Figure 6), species that have been fished on both sides of the EEZ boundary include cod, redfish (ocean perch), American plaice, yellowtail flounder, witch flounder, white hake, capelin, skates, Greenland halibut and shrimp. The fishery outside the Canadian EEZ falls under the jurisdiction of the Northwest Atlantic Fisheries Organisation (NAFO). Quotas for a wide range of species and stocks are agreed in annual negotiations between member states. Of the species listed above, only yellowtail flounder, white hake, skates, Greenland halibut and shrimp had quotas set in 2005 for both the Canadian EEZ and the adjacent portion of the NAFO Regulatory Area, the other stocks, notably cod and redfish, having been depleted by overfishing. Nine NAFO regulated fish stocks are currently at historically low biomass levels and as a result are under fishing moratoria in the NAFO Regulatory Area. Two others are under partial closures – closed to fishing in the NAFO Regulatory Area (NRA), but being fished inside the EEZs of bordering nations. Despite these closures, IUU fishing in NAFO waters continues. In 2003, currently the most recent year for which complete data on Contracting Party compliance with NAFO regulations are available from the Secretariat, a total of 26 citations were issued. Of these, the majority were issued to EU-Portugal (11). Five of these citations were issued for directly fishing on moratoria species, one citation was issued for illegally using smaller mesh and seven other citations were issued for misreporting of catch. Spain and Russia each had four violations for the following actions: direct fishing on moratoria species, illegal gear modification or illegal mesh sizes and misreporting of catches.

However, there is a wide range of opinions regarding the actual impacts of IUU fishing on the fish and fisheries within the adjacent EEZ. There are those for example, who cite the relatively small proportion of the Grand Banks that is actually outside Canadian jurisdiction, as evidence that the real problem lies in regulating fishing within the EEZ. The Canadian Government, however, has frequently expressed concern about “foreign” illegal fishing on the Nose and Tail of the Grand Banks, citing this as one of the impediments to the recovery of fish stocks in the area. In the past, Canada has closed its ports to the fishing vessels of the Faroe Islands and Estonia as a result of misreporting and overfishing of shrimp. Canada’s Standing Committee on Fisheries and Oceans has repeatedly proposed much stronger action, urging the withdrawal of Canada from NAFO and the establishment of custodial management over the Nose and Tail of the Grand Banks and the Flemish Cap outside Canada’s 200-mile limit. The Canadian Government has set out its robust arguments against such action, but, nevertheless, this is a measure of the depth of concern in the region over the impacts of high seas IUU fishing on the resources in the EEZ.

While the level of impact of high seas IUU fishing of straddling stocks on fish and fisheries within the adjacent EEZs may be uncertain, it is certain that there is some effect and scientists routinely acknowledge this by including estimates of IUU catches in the catch history when conducting scientific assessments of the status of these fisheries. For example, the stock assessment of Patagonian toothfish in Subarea 58.7 (Prince Edward Island) by South African scientists includes an estimate of the level of IUU catch in the historical record, although the proportion of this that is from inside or outside the EEZ is uncertain.
3.2.3.2. Highly migratory fish stocks

Migratory fish stocks are those that occur seasonally both within an EEZ (or multiple EEZs) and on the high seas. The archetypal example of this is the migratory tuna fishery in the western Indian Ocean that seasonally moves through large areas of high seas and the EEZs of Seychelles, British Indian Ocean Territory, Maldives, Mauritius, France (Reunion, Tromelin and various islands in the Mozambique Channel), Madagascar, Comoros, Mozambique, Tanzania, Kenya, Somalia and others. Other tuna fisheries in the Pacific and Atlantic oceans are similarly classified as migratory, although patterns of movement may be less clear. Other examples of migratory stocks include squid fisheries on the Patagonian shelf off Argentina and the Falkland islands and off Peru (Section 3.1.1.3).

The UNIA (Article 71(b)) states that “with respect to highly migratory fish stocks, the relevant coastal States and other States whose nationals fish for such stocks in the region shall cooperate, either directly or through the appropriate mechanisms for cooperation provided for in Part III, with a view to ensuring conservation and promoting the objective of optimum utilization of such stocks throughout the region, both within and beyond the areas under national jurisdiction.”
The effects of high seas IUU fishing on highly migratory stocks may be mixed and because of their transient nature are even harder to elucidate than those for straddling stocks. However, overfishing in high seas areas is likely to impact the catch rates and quota that is available within EEZs and therefore the potential income of coastal countries within whose EEZs the resource occurs for some part of its migration. This is the concern of many island states, including members of the Forum Fisheries Agency in the South Pacific.

In the south West Atlantic, *Illex* squid is caught in high seas waters by a mixed fleet of Chinese, Taiwanese, Korean and Spanish vessels. Although the two relevant coastal states with EEZ jurisdiction, UK and Argentina, have agreed mechanisms for in-season assessment and fishery closure to protect a target escapement reference point, the high seas fleet may continue to fish on spawning animals after the closure of the fishery in the EEZs (Barton et al., 2004). This undermines the conservation value of the closure, and probably contributed to the collapse of the fishery in 2004.

3.2.3.3. Effects on EEZ fisheries

As we have described above, the effects of high seas IUU fishing on straddling and/or migratory fish stocks is hard to quantify. However, we do know that all fishing removes fish from the stock. This will undoubtedly reduce the size of the stock. Many developing states in the Atlantic (e.g. St Helena) have some tuna/swordfish quota allocated them from ICCAT by virtue of their existence, rather than the occurrence of those tuna or swordfish in their EEZ waters. Over-fishing by IUU fleets on these stocks will have a direct effect on the amount of quota that is allocated to these states and therefore on their revenue, whether they catch that quota themselves or lease it to DWFNs.

The case of the “Donut Hole” in the Central Bering Sea is illustrative of what can happen when fisheries are unregulated. In the mid-1980s, foreign vessels displaced from the U.S. EEZ began targeting concentrations of pollock in the Central Bering Sea (the Aleutian Basin) which includes the so-called “Donut Hole,” an area of international waters surrounded by the exclusive economic zones of the United States and Russia (see Figure 7). Catches in the Donut Hole grew from 181,000 tonnes to more than 1 million tonnes in the two years from 1984 to 1986 and, the following year, exceeded the landed catch from the entire Eastern Bering Sea. The high seas catch peaked at about 1.45 million tonnes in 1989, before rapidly declining to less than 2,000 t in 1993. Since that time only trace amounts of walleye pollock have been taken from this area, which is under an international moratorium.\(^\text{13}\)

The high levels of unregulated removals in the 1980’s caused concern that stocks within the neighbouring EEZs would be adversely impacted. Research has shown that pollock harvested in the central Bering Sea move from the adjacent shelf populations, and the amount moving appears proportional to year-class size. In fact, the central Bering Sea fishery primarily harvested a strong 1978 year-class, and catches declined as the year-class aged. In principle, source-sink movements of fish are less of a concern than seasonal migrations, at least from the standpoint of sustainability of the target stock. If movements to the Donut Hole are genuinely one-

\(^{13}\) In 1993, the United States, China, Korea, Russia, Japan, and Poland negotiated the Convention on the Conservation and Management of Pollock Resources in the Central Bering Sea to govern the catch and management of fish stocks migrating between international waters in the Bering Sea (the “Donut Hole”) and adjacent waters under national jurisdictions (Buck, 1994).
way overspills of adults which subsequently do not contribute to the spawning stock of the population from which they originated, they can be considered to be “surplus” fish, and could be fished intensively without affecting the source population within the EEZ (Wespestad, 1993). But two main concerns remain regarding the spill-over theories for the Donut Hole.

First, most of the support for the source-sink concept in the Aleutian Basin comes from fragmented and or anecdotal observations (Bailey et al., 1999), and these “spill-over” theories have been contested. While juveniles are believed to be rare in the Aleutian Basin (Mulligan et al., 1989), spawning is known to occur in the central and south eastern parts of the basin (Hinckley, 1987; Sasaki, 1988; Mulligan et al., 1989). Pollock in the Aleutian Basin are also known to have different length-at-age and fecundity characteristics compared to the fish on the shelf, suggesting they could come from separate spawning populations. Shuntov (1992) and Dawson (1994) have suggested that large numbers of pollock make seasonal feeding migrations from the eastern and western Bering Sea shelves to the Aleutian Basin, so they could not be considered as a sink.

Second, the idea of intensively fishing a spill-over population takes into account only the effects on the target stock. Intense fishing may still have adverse effects on bycatch species and on those species dependent on pollock and non-target species as a source of food. In particular the declining status of the endangered Steller sea lion and the role played in this by the Bering Sea Pollock fishery has come under intense scrutiny in recent years (See for example [http://stellersealions.noaa.gov/](http://stellersealions.noaa.gov)).

Fisheries on straddling and migratory stocks create particular problems for enforcement. Many of the enforcement requirements for these stocks are by definition near the 200nm limit of the EEZ, and therefore require ocean going vessels, which even developed nations find to be costly. In some cases the fisheries are even more remote. For instance, the South African sub-Antarctic territory of Prince Edward Island has suffered considerable IUU fishing in the past and continues to suffer low levels of IUU, but until recently the only possible enforcement presence was aerial surveillance. Significant investment has been required to deliver a new patrol vessel capable of operating around the islands which are 1800km from the nearest mainland port.

Another enforcement effect is currently being experienced by the FFA (S. Dunn, presentation at the June DiFD workshop): while agreements for DWFN fishing in FFA waters stipulate the use of a VMS, reporting from this VMS is not obligatory when the vessel is in one of the high seas areas between the EEZs of FFA member countries. This means that it is impossible to know whether a vessel has switched off its VMS in order to engage in IUU fishing in an EEZ, or has moved into high seas waters, without corroborative information such as aerial surveillance.

Finally, the enforcement action that coastal states can take against high seas IUU fishing is relatively weak. They can close their ports to vessels suspected of IUU fishing, or unable to show clear records of non-IUU activity. For example, South Africa has required toothfish longliners landing in its ports to show uninterrupted evidence via VMS records, of where the vessel has been operating to ensure it has not been fishing in contravention of its or CCAMLR’s management measures. This often has the effect, however, of IUU vessels simply moving elsewhere. In this case they moved to ports in Namibia and Mauritius. These avenues have since also been closed, but the damage to the toothfish stocks around Prince Edward Island and elsewhere had already been done.
There is no power of enforcement on the high seas unless subject to the limited provisions in UNCLOS for hot pursuit or if the vessel is stateless. The latter category can apply to vessels on open registers, but may not. Therefore coastal states are almost powerless to stop IUU activity on their borders. Furthermore, it may be very difficult to get DWFN to enter into negotiations for RFMOs where straddling stocks are concerned, despite the intention of UNFSA, because there is essentially no economic advantage for them to do so.

![Map of the Bering Sea and walleye pollock stocks](image)

**Figure 7** Major features of the Bering Sea and walleye pollock stocks, showing the position of the “Donut Hole” between the US and Russian EEZs. Source: Modified from Wespestad (1993).

### 4. Estimation methods

By their very nature IUU activities are difficult to monitor and their effects are difficult to estimate. Methods to estimate IUU quantities can be divided into two major types: statistical accounting and evidence-based estimation.

#### 4.1. Accounting methods

Most RFMOs have secretariats and data management sections which have a mandate to record data on the total catches of target species, and in some cases on bycatch species. Where such catches include both reported and unreported catches,
a natural extension of their activities has been the estimation of the unreported catch, particularly for incorporation into stock assessments. Such estimation generally makes use of all available information sources and may be very detailed and involve complex investigations.

ICCAT was aware in the early 1990s that considerable quantities of bluefin tuna were being caught within the ICCAT area of jurisdiction by vessels flagged to countries that were not party to ICCAT and did not report their data. The lack of information about total extractions was significantly compromising attempts to assess and control exploitation of the regulated stocks. ICCAT therefore introduced a number of Statistical Document Programmes. Initially these tracked trade in bluefin tuna products (frozen product in 1992, extended to fresh product and re-exports in 1993 and 1997) and later bigeye tuna and swordfish in 2001 (Restrepo, 2004).

Calculations of unreported catch are made by ICCAT by comparing declared catch data and statistical document derived trade data:

\[
\text{Unreported catch} = a + b + 0.8 \times c - d
\]

where \( a = \) Imports to USA, \( b = \) Imports to Japan from wild fish, \( c = \) Imports to Japan from farming, \( d = \) Catch reported to ICCAT. All product types are converted to round weight using a series of conversion factors (ICCAT recognises a large number of categories, the principal being belly meat from wild tuna \( X \times 10.28 = \) round weight, dressed weight \( X \times 1.25 = \) round weight, fillets \( X \times 1.67 = \) round weight, gilled and gutted weight \( X \times 1.16 = \) round weight, other products \( X \times 2.0 = \) round weight). Double counting is avoided by not including bellymeat products from farmed tuna, and a factor of 0.8 is applied to farmed products to allow for a 25% gain in weight from fattening in the farms \((1/1.25=0.8)\) (Restrepo, 2004).

This sort of calculation could, in theory, be applied to any species using standard import/export statistics in the absence of specific Document Programmes. Indeed attempts have been made to undertake such calculations for toothfish and orange roughy (Lack & Sant, 2001; Lack et al., 2003). Such trade accounting exercises are also undertaken with respect to stocks largely fished within EEZs. For instance, Esmark and Jensen (2004) report that “Norsk Fiskerinæring", a Norwegian Fisheries Magazine, estimated that in the period from 1995 to1998, 300,000 tons of cod “disappeared". This estimate was based on total recorded landing of cod compared to how much cod was sold domestically plus export.

Factors that constrain the efficacy of this method include the absence of customs codes for many species of fish (meaning that import/export statistics are not recorded, or not recorded by product type), the inability to distinguish between primary trade (imports and exports) and secondary trade (re-exports), and the delays that arise between when the catch is taken and a product reaching its final destination. These problems are exacerbated when there are a large number of potential markets or intermediate (secondary processing) stages in different countries. Conversion factors for different product types may also not be known with the accuracy that they are for bluefin tuna, and one has to be careful to avoid double counting. For this reason the tuna RFMOs and CCAMLR have adopted species specific, detailed, documentation programmes to assist with tracking trade. Despite all these caveats such trade analysis has been useful in that it is often able to identify gross discrepancies between reported catch and total traded volume (Lack & Sant, 2001).
IOTC has addressed the problem of estimating unreported catch by estimating the size of the fleets that are not reporting data to IOTC, their likely effort and catch rates (Anganuzzi, 2004). About 30% of the catch of tuna and tuna-like species in the IOTC Nominal Catches database has come from non-official sources in recent years (Herrera, 2002). Four different fleets are considered:

- Catches of vessels reported by persons or organizations other than the flag state or responsible organization. This includes, for example, the catches of European owned purse seine vessels that are flagged with non-contracting parties, including open register countries. These data are reported to the EU, and through the EU to IOTC, even if they are not reported directly by the flag state. Therefore, they are not IUU fishing because they are reported.
- Ex-soviet purse seine vessels, flagged to Panama or Belize, of which there are only 9 now operational (Anganuzzi, 2004), estimated to have caught about 37,000 tonnes of tuna (mostly skipjack and yellowfin) in 2000 (Herrera, 2002).
- Deep-freeze longlining vessels, the number of which has been rapidly declining in recent years (250 in 2000, 100 in 2002 and 25 in 2004) due to a re-registration and scrapping programme initiated by the Japanese industry initiative the Organization for the Promotion of Responsible Tuna Fisheries (Sano & Harada, 2004, Hanafusa, & Yagi, 2004). Many of these vessels carry licenses to fish within the EEZs of both parties and non-parties to IOTC, from which data it is possible to trace them.
- Small (<200t GRT) tuna longline vessels, now about 180 vessels based in the eastern Indian ocean, many of them flagged to Indonesia but with Taiwanese ownership, but including also vessels from Malaysia, Thailand and Sri Lanka.

The basic methodology is to estimate, from reported data of similar fleets, the likely effort that each of these unreporting fleets will exert, and their likely catch rates and catch composition. This is a massive and highly complex accounting and detective task.

A slightly different approach has been adopted by CCAMLR. With IOTC and ICCAT the problems are really with unreported fishing by otherwise legitimate vessels; with CCAMLR the problem was to estimate essentially illegal and unregulated (as well as unreported) activity. Although some attempts were made to use trade statistics (Lack and Sant 2001), the usual problems of this method (see above) were exacerbated in the case of toothfish by there being substantial stocks of toothfish outside the area of application of CCAMLR; this was not the case with tuna and the tuna conventions. CCAMLR therefore adopted two complementary methods: IOTC-style estimate of IUU catches, and tracking trade with the Catch Document Scheme (CDS).

The former relies on estimates of the number of vessels fishing in each Subarea within the Convention Area, the estimated number of trips to the area that a vessel would undertake, the length of these trips (in fishing days) and the mean catch rate. The derivation of these parameters has made use of a number of data sources: surveillance operations, reports of landings and port visits worldwide, interviews and examination of logbooks from apprehended vessels; and information from legal vessels and data; for instance IUU catch rates can usually be assumed to be similar to catch rates of legal vessels, and trip duration inferred from hold capacity and catch
no attempt has been made to calculate bounds for these estimates.

Whilst the CDS does not provide an estimate of IUU catch, it is thought that almost all toothfish trade is now carried out under the scheme. IUU catch must therefore be being traded with false or erroneous documents. For instance, immediately following the introduction of the scheme toothfish started to be declared as originating from the southern Indian Ocean, just north of the CCAMLR Convention Area, in both FAO and CDS statistics. Over the last three years the catch in these areas has very closely matched the CCAMLR estimates of IUU catch from the Indian Ocean sector of the Convention Area. This suggests that the recent estimates of IUU catch from the Indian Ocean sector made by CCAMLR using the method described above are probably reasonable. Similarly, comparisons of CCAMLR and trade data by Lack & Sant (2001) suggested that CCAMLR estimates of IUU fishing were an accurate reflection of the amount of IUU catch in trade in 1997 and 1998. Unfortunately, there is evidence that around the time of introduction of the CDS (in 1999 and 2000) CCAMLR underestimated the quantity of IUU catch in its waters (Lack & Sant 2001).

4.2. Estimation methods

The vast majority of reports of IUU fishing are individual reports in the media from which it is very difficult to obtain an unbiased estimate of the level of IUU fishing (see our main report, Annex A). In an attempt to avoid this problem in our main study (MRAG, 2005) we used in-country specialists to provide additional supporting information for these types of estimates, and favoured estimates based on surveillance actions over general media reports. Within EEZs estimates of illegal or unreported fishing are frequently made by surveillance authorities or individual studies which result in some estimate of under-reporting, false landing declarations, discarding etc. These are often applied to the fishery as a whole to yield some estimate of global discard or bycatch. Some examples of these sorts of statements are:

- In the late 1980s, every haul of the trawl by Russian vessels was estimated to be under-reported by at least 10 tonnes (Internal DFO document, quoted by Harris (1998) in Pitcher et al. (2002)).
- Between 20 and 50% of the catch of Scottish purse seiners in the 1990s was illegal (two correspondents quoted in Pitcher et al. (2002)).

Often the accuracy of such estimates, and indeed the sources of information that are used to make them and their comprehensiveness, are unknown or are not made clear. This is a general problem with using surveillance information, and is not a satisfactory situation. This uncertainty can severely compromise the quality of assessments. For instance, it is estimated “from a range of industry and enforcement sources” that recent (each year from 2000 to 2003) catches of eastern Baltic cod have been around 35-40% higher than the reported figures (ICES, 2004c), and this makes the results of the assessment quite uncertain.

It is possible to estimate likely levels of unreported catch within assessments themselves. Payne et al. (in press) have taken such an approach to an assessment of toothfish around the Falkland Islands. They estimated a level of unreported catch for two years within an ASPM population model fitted to CPUE and length frequency data and for which the catch in all other years was assumed to be known. A more complex approach was taken by Plagányi (2004) and Plagányi & Butterworth (in
A different approach was taken by Agnew & Kirkwood (2004) to estimate IUU fishing at South Georgia. They treated surveillance visits by patrol vessels as random searches, and created a simulation model of IUU fishing in the area that enabled the estimation of the relationship between patrol vessel encounters of IUU vessels and total (seen and unseen) IUU effort. This enabled data on real encounters to be translated into estimates of IUU fishing effort, and through Monte Carlo treatments it also provided confidence intervals for the estimated IUU activity. Although this model did include a function for active avoidance of the patrol vessel by the IUU vessels, it did not provide any estimate for IUU catch in the complete absence, over a year, of encounters of IUU vessels by surveillance, which was included in a development of the idea by Ball (2004). However, the model was used by Agnew & Kirkwood (2004) to estimate IUU fishing both within controlled waters around South Georgia and in the adjacent high seas waters because patrol vessel encounters were recorded in both.

Clarke et al. (submitted) applied Bayesian statistical methods to trade data in combination with genetic forensic identification to estimate by species the annual number of globally traded shark fins, the most commercially valuable product from a group of species often unrecorded in harvest statistics. The method involved sampling fins being traded in Hong Kong, and estimating total catch volumes by combining this with data from interviews with traders and records of total traded volumes within a Bayesian framework. Somewhat similar molecular genetic analysis of market samples (but outside of a Bayesian framework) has been used by Baker et al. (2000) to estimate unreported incidental take of protected whale species taken as fisheries bycatch.

The final estimation method of which we are aware is that proposed by Pitcher et al. (2002). This is somewhat of a hybrid method, synthesising all available data on under-reporting and discarding and their uncertainty into a single analysis. Explicit recognition is made of the influence of regulatory regime on levels of discarding and under-reporting, so that each regime is assigned an adjustment factor associated with its likely influence on misreporting. Quantitative values are assigned to the adjustment factors, which are used as fixed anchor points when supported by reports and information explicitly attributed to a variety of sources, published and unpublished, and interpolated up or down when information is not quantitative. Confidence intervals around estimates of total misreporting for each period in the analysis are obtained using a Monte Carlo simulation based on likely error ranges. Pitcher et al. (2002) used this method with some success to estimate the level of Icelandic and Moroccan fisheries. This method has also been used in waters of British Columbia, Atlantic Canada and Chile (Ainsworth and Pitcher, 2005; Pitcher and Watson, 2000; Kalikoski et al. (in press) respectively).

Although this last method is not really an objective estimation, relying as it does on multiple, often qualitative information sources, it does have the strength of recognising that management regimes play an important part in the incentive for misreporting. For instance, in the Irish Sea, ICES estimates that there were no unreported catches in the early 1990s, when the TAC was about 10,000 t and the...
catch about 7,000 tonnes. When the TAC was significantly reduced (from 2000 onwards) unreported catch (including discarded catches and bycatches in other fisheries) increased to be roughly equal to reported catch (ICES, 2004c).

4.3. Estimating levels of bycatch and discard

Our examination of ecosystem effects of IUU fishing has highlighted the difficulty of separating the ecosystem effects of general high seas fishing from the effects of the IUU portion of it. Indeed, there is likely to only be an added IUU impact where that fishing takes place outside of management controls which are normally obeyed by licensed vessels, such as closed areas or seasons, restrictions on gear types etc. For instance, it is fairly obvious that the recently reported discovery of some Chinese vessels fishing for squid in the north Pacific with driftnets will have an environmental effect greater than that associated with other fisheries in the area because of the otherwise obeyed worldwide ban on the use of driftnets.

Some of the methods described above involve estimating the level of IUU fishing effort and calculating the catch associated with this assuming catch rates similar to those obtained by the licensed fleet. This method can be applied to estimated catches of bycatch or discards as well as to catches of target species if estimates of likely catch rates are available. Acquisition of these data is more problematic than for target species because these data are often unreported even for the licensed portion of the fleet. Furthermore, it is often assumed that where mitigation measures are used by the legitimate fleet they will not be used by IUU vessels. CCAMLR has made an attempt to grapple with this problem by using the bird catch rates encountered by the licensed fishery in 1997, prior to the development and implementation of mitigation measures for the avoidance of bird catch. Bootstrapped estimates of 1997 bird catch rates applied to IUU estimates have suggested that 176,000 birds (95% c.i. 143,000-516,000) were killed by IUU operations in the CCAMLR area between 1996 and 2004 (CCAMLR, 2004, Table 7.15). However, these estimates are highly dependent upon rather few data from 1997, and do not take account of changes in population status of the birds themselves which will affect their encounter rate.

4.4. Discussion

The methods reviewed above fall into two categories

Accounting methods, including
- estimation of IUU fishing effort from various sources combined with estimates of catch rate from licensed fisheries
- comparison of trade-based estimates (including documentation schemes) and reported catch
- detailed investigations of the catches of states not party to RFMOs
- incorporation of estimates of bycatch and bird/mammal interactions

Estimation methods, including
- estimates of unaccounted catches made using population models
- quasi quantitative Monte-Carlo integration of all historical sources
- models of IUU behaviour and surveillance encounter probabilities

The most widely applied methods for estimating IUU catch for whole RFMO areas are accounting methods. These are most powerful when they are combined with
document schemes so that trade data can be used to validate estimates of fishing effort, but they have the drawback that they are attempts at absolute estimation and do not come with estimates of variance. This is a significant problem because intuitively we understand IUU estimation as a very uncertain exercise, and some estimate of that uncertainty is useful in stock assessments. Unfortunately, alternative methods of estimation, including the use of modelling approaches, are difficult and time-consuming to construct and have only been applied to date on quite restricted problems. They carry their own biases associated with the data collection method, but at least that uncertainty can be quantified.

There clearly needs to be more research into methods of estimation that would be widely applicable. Many of the methods that we review above rely implicitly or explicitly on information from surveillance operations. Our experience with constructing a statistical model of patrol vessel encounters at South Georgia is that, self-evidently, records of surveillance activities that do not encounter IUU activities are equally important as records of encounters, and yet the latter are rarely reported. This is a similar problem to the estimation of compliance rates, where it is important to record the number of inspections and the number of infringements to calculate an infringement per inspection rate. Surveillance data by definition are usually highly confidential, and as a result it is often impossible to know even the sources of data, let alone the extent of the data, sampling strategy etc. Without this information it is difficult to judge the likely levels of uncertainty that may be associated with any estimate of IUU fishing.

To the best of our knowledge, where there are estimates of IUU fishing these are included into assessment models. However, they are usually included as absolute catches, i.e. they are treated with the same levels of certainty as declared catches, and this does lead to the introduction of much lower levels of uncertainty in assessment results than is actually the case. In those examples above where IUU is estimated by an assessment model (such as the integrated ASPM approaches) this problem is avoided. Secondly, although the calculation of future yields may often take into account likely bycatch in other fisheries or discards, it rarely takes into account likely IUU fishing. This is an extremely difficult problem, both in estimation and policy, but one that can lead to significant errors in the assessments. For instance, CCAMLR (2002, Figure 5.8) show that without adjusting future TACs to take account of anticipated IUU activity (i.e. continuing to set the TAC as if we have total control on the fishery) stock depletion will continue. Similarly, stock recovery plans are considerably compromised and lengthened when IUU fishing is not taken into account in determining harvest strategies within a recovery plan (Caddy & Agnew, in press).

The estimation of bycatch by IUU vessels is particularly difficult. The CCAMLR experience has shown that after bycatch issues are solved in the legitimate fleet there is no longer any information from which to estimate the bycatch impact of the IUU fleet, short of undertaking directed experiments. Therefore it seems obvious that the most essential first step is to get observers on all legitimate fleets which are currently operating in high seas waters. As most RFMOs do not have very good ecological impact legislation yet, the data from these observers should act as a baseline for current and future IUU ecological impact.

Revisiting the TOR, our above discussion has identified the approaches currently being used to estimate IUU fishing and the consequences of the uncertainty associated with these estimates. It is difficult to identify any particular “best practice”
although it would seem that a combination of methods, including statistical estimation methods and accounting using statistical document schemes, is the most pragmatic and currently achievable approach. There are some improvements that could be made to the current methods in the short term, and there is clearly a need for research into new methods. To progress these issues we would recommend

1. that where estimates of IUU fishing are made, attempts should be made to explicitly document current methods of estimation and, if they are not based on either validated accounting methods (such as comparison of catch data with trade data) or explicit estimation methods attempts should be made to move to such methods;
2. that further research should be undertaken to develop robust methods of estimation of IUU catch and bycatch which deliver statistically valid estimates and their variance and which can be widely applied to high seas IUU issues;
3. the establishment of documentation schemes for all significant high seas species to support trade based validation of IUU estimates;
4. the development of observer schemes on all RFMO fisheries and the central reporting of these results, so as to establish current levels of bycatch that may be applied to either current IUU or future IUU activities;
5. in addition to the use of target species population models, the development of population models of impacted bycatch species such as birds to allow independent estimation of likely encounter rates and IUU catch rates (unrecorded losses);
6. the establishment of joint surveillance activities in RFMO waters and the recording of activities (including non-encounters and encounters) in standard format;
7. that uncertainty in estimates of IUU fishing (where available) should be incorporated, at least as sensitivity runs, in assessments.

5. Future management and research options

5.1. Monitoring and research requirements

As we have seen, it is extremely difficult to estimate the level of IUU fishing effectively, and even more difficult to estimate its effect on ecosystem components such as bycatch species and birds and reptiles. By its nature IUU fishing tends to be unseen – particularly in the case of illegal operations. Unregulated fishing is perhaps the easiest to investigate, because often unregulated fishing is at least reported, there being no relevant legal sanction. Nevertheless, most studies to date have been piecemeal or restricted to certain areas or problems. In our view it is important that some system for synoptic monitoring the global IUU catch situation be set up.

Although the lost value of IUU fishing appears to be high (about $4-9bn according to MRAG 2005), relatively little of this is attributable to high seas IUU fishing. This is also likely to decline further as non-parties become parties to RFMOs and start to report catch and effort data, and also as more RFMOs are created. Keeping track of this process will be very difficult, unless the types of IUU of concern are clearly
identified. We therefore suggest that monitoring of IUU activities is divided by the following four categories:

- Illegal fishing in EEZ waters
- Illegal fishing in high seas waters
- Unreported fishing in high seas waters
- Unregulated fishing in high seas waters

Monitoring each of these categories is needed, because very often the history of IUU fishing has shown that once a problem in one area or category is solved that IUU fishing effort simply moves to a new area or category. Synoptic monitoring is required so that this transfer of effort is effectively recorded. However, each category or type of problem may require a different research or analysis technique (for example either one of those in Section 4 or a different one).

It is difficult to see how this can be done by a single institution, because a detailed knowledge of local IUU activities is often required. Therefore the optimum solution should be a network of institutions, monitoring IUU activity on a global basis according to standardised methods. This will avoid the need for a single institution, and ensure that research methods in monitoring IUU fishing are developed, tested and disseminated effectively. Inputs to fisheries management could be made on a regional basis through RFMOs, regional bodies or individual country assessments.

We would suggest that a suitable work programme would be to examine each of the issues identified at the end of Section 4 and, as appropriate:

- set up suitable observer schemes to monitor current levels of bycatch;
- develop appropriate estimation methods for the area and fishery concerned; and
- interact with relevant RFMOs and with other institutions to harmonise approaches and disseminate advice.

### 5.2. Consequences of solving the high seas IUU problem

We have shown that most of the damaging IUU activity in high seas waters – damaging both for high seas fisheries and for associated EEZ fisheries – comes from unregulated fishing. The cause of this is probably equally split between the following: that there are a number of flag states (principally states operating open registers) that do not participate within RFMOs, even though their vessels have an apparent interest in fishing within the areas of jurisdiction of those RFMOs; and the fact that large areas of high seas are not covered by an RFMO that regulates the relevant resource. A two pronged approach, advocated by many analysts, is required:

- Encouraging all non-Parties to RFMOs and/or to UNFSA, to join the organisations and ratify relevant agreements as appropriate
- Encourage the creation of RFMOs to cover all high seas areas, with full participation from all interested states

Solving the IUU problem will not necessarily lead to an improvement in resource management or to recovery of depleted populations. In the first place we have shown that the majority of the bycatch problem, at least with respect to birds and turtles, is

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15 Another important category is unreported fishing in EEZ waters, but this list pre-supposes that failure to report would be illegal under coastal state’s fishing regulations.
the current lack of management action, and control, by the RFMOs themselves. The exceptions to this are of course CCAMLR and CCSBT with respect to birds and IATTC with respect to dolphins. Thus solving the IUU problem will have a relatively small effect on most bycatch problems unless the RFMOs concerned also solve the bycatch problems of regulated fisheries.

This would not, of course, be the case were the RFMOs to be implementing effective mitigation measures. In that case the major bycatch effects would be created by IUU vessels, presumed not to be following the RFMO regulations. This is currently the case with CCAMLR, where the majority of the estimated bird catch is coming from IUU fishing rather than non-IUU fishing. In the early 1990s the situation was reversed, most bird catch coming from non-IUU fisheries, since mitigation measures were not being used.

In the second place, solving a bycatch problem may not lead to ecosystem recovery. It is instructive in this case to note that although dolphin bycatch has been reduced by 99% in the Eastern Tropical Pacific since the early 1990s following IATTC and US actions, there is as yet no sign of an increase in affected dolphin populations (Gerrodette & Forcada, 2005). Solving the IUU problem and the bird bycatch problem in regulated fisheries around South Georgia has not yet led to a recovery of black browed albatross populations around the island (John Croxall, pers comm.), even though bird kills is estimated to have declined from several thousand per year in the early 1990s to fewer than 20 per year now (Agnew, 2004).

Perhaps the biggest gain to solving the IUU problem in high seas is associated with solving the unregulated fishing problem, both in terms of gaining acceptance of international norms of responsible management of marine resources and the control of ecosystem impacts; and in terms of improving governance of high seas areas, especially in terms of generating new RFMOs with wide ecosystem-based remits rather than narrow species-based remits.

5.3. Measuring the gains

We suggest above that IUU fishing should be monitored by a network of institutions following standard or agreed methods of monitoring. One measure of the improvement of international governance with respect to IUU fishing will therefore be the estimated levels of IUU fishing by category, region and species.

Other measurements that might be utilised would be global ecosystem/ocean monitoring systems such as the Global Ocean Observation System GOOS. However, it will be very difficult to link improvements in the global ecosystem with specific actions against, or reductions in IUU. Therefore, there will certainly be a need to continue monitoring of individual issues, such as albatross or dolphin population decline.

6. Conclusion

The impact of high seas IUU fishing on target species and related ecosystems is potentially large. The only reason that the impact is currently estimated to be generally only moderate or low is that the ecosystem impacts of non-IUU fisheries are high, and the proportion of fishing activity undertaken by non-IUU fisheries is

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higher than IUU fishing activity. When all non-IUU fisheries are well regulated, and have a low ecosystem impact, the relative importance of IUU fisheries will increase.

One of the biggest problems in making this assessment is that the impacts of IUU fishing, and the level of IUU fishing, are both extremely difficult to estimate, there being no monitoring of this fishery. There is an urgent need to establish monitoring methods for IUU fisheries. There is similarly an urgent need to establish observer programmes for current fisheries, so that reasonable estimates of the bycatch in future IUU fisheries can be made (assuming that they behave in a similar fashion to current non-IUU fisheries without mitigation measures). We therefore recommend the following:

**To monitor IUU fisheries and their bycatch**

1) Establish new international monitoring systems in high seas waters comprising:

   a) Scientific observer programmes in all fishing areas, especially high seas, which generate data which are widely available to relevant organisations (such as RFMOs). Observer programmes involving international observer exchanges are preferable to national observer programmes.

   b) International surveillance operations in high seas areas of relevant RFMOs, with sufficient remit under international inspection agreements to inspect all vessels fishing within the area of an RFMO, and with a remit to monitor IUU fishing activity and disseminate the results (including both encounters and non-encounters) in such a way as to assist scientific assessments of IUU activity whilst preserving necessary confidential surveillance information.

   c) Documentation schemes and supporting trade measures for key target and bycatch species.

2) Enhance monitoring programmes of a similar nature in EEZ waters.

**To increase the accuracy of estimates of IUU catch and its effects**

3) Develop new methods to estimate IUU catch, based if necessary on a combination of data sources, capable of providing statistically rigorous, robust, estimates of IUU fishing and impacts on ecosystem components, as well as the variance of these estimates.

4) Rigorously document all methods used and disseminate widely in scientific and other publications, and use variance estimates in risk-based assessments.

5) Support estimates made using above methodologies with population models of target and bycatch species.

**To enable these actions**

6) Set up a network of institutions capable of undertaking monitoring of IUU activities in various categories for different ocean regions, and capable of
disseminating their results, and influencing decision-making within a region and within relevant RFMOs, that will deliver the improved monitoring identified above.
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8. Annex 1 Terms of Reference

The Consultant will produce a synthesis paper and [annotated] bibliography in order to assist the Science Working Group of HSTF in developing its conclusions. This will serve as a basis for discussion prior to and during the Workshop. While not involving any original research, the paper will present a thorough review of the literature, compiling empirical and other evidence sufficient to enable the working group to address several key issues summarised below. Given their mutual relevance and potential synergies emerging, this work will be implemented as far as possible integrally with the impact assessment A (above):

10.0 Fleets and gear types used and where, when and for what target species. Interface with legitimate fishing. Broadly, what fleets and gear types are used in which areas, when and for what targets? Essentially who is doing the IUU fishing and how does it relate to legitimate fishing?

11.0 Ecological and fishery consequences of failure deter high seas IUU fishing. What are the ecological and fishery consequences of failure to manage the IUU portion of the catch on the high seas?

12.0 Compare high seas IUU fishing with fishing (legal or otherwise) within EEZs; determination of potential ecological and fishery consequences of high seas IUU on fishing in waters under national jurisdiction. What is the relationship between IUU fishing on the high seas and fishing (legal or otherwise) within EEZs? What are the potential ecological and fishery consequences of high seas IUU on fishing in waters under national jurisdiction?

13.0 Existing approaches used to characterize and estimate IUU activities and impact of this on scientific stock assessment and advice to management. Improvements that could be made or the need to develop new approaches. What existing approaches are being used to characterize IUU activities and especially to estimate IUU catch and effort for input into scientific assessment of stocks and provision of advice to management? What are the ecological and fishery consequences of the present level of understanding and ability to estimate the level of IUU activity, catch and effort? What could be done to either improve existing approaches or develop new ones to characterize IUU and estimate IUU catch and effort? What is international good practice in measuring IUU activities and providing scientific management advice where IUU activities are at a significant level?

14.0 The need for new scientific approaches in measuring and tackling IUU and what might be implied. Is there a need for better science? How could this be achieved?

15.0 Critical gaps in current scientific knowledge:

15.1 Data and/or research needed and how these would be prioritised. What data and/or research is needed to fill these gaps and how would these requirements be prioritized?

15.2 Short-term (interim) solutions for potential use in gauging the relative impact of IUU fishing. If these gaps could not be filled immediately (which is likely), are there approaches that could be
used in the short to medium term to gauge the relative impact of IUU fishing?

16.0 The institutional needs to undertake research – type, purpose/role e.g. science and/or management support e.g. potential role and modus operandum in advising regional fishery management organizations. What combination of institutions is optimum for undertaking research functions? Would a centralized global scientific agency for the high seas be a feasible objective? What would be the purpose of such an organization; should it be focused solely on research to understand the oceans or should it have a role in advising regional fishery management organizations? If it provides input to regional fisheries management organizations, what are the links with governance issues that also need to be addressed?

17.0 Assuming better management of high seas fishing (including minimizing IUU fishing), what might be the potential gains to resource management of improved science. Assuming better management of high seas fishing (including minimizing IUU fishing), what is a realistic assessment of the potential gains from improved science knowledge to resource management and, more broadly, to scientific understanding of the oceans as a whole?

18.0 Measurement of gains – indicators etc. How might one measure those gains in a meaningful way? What alternative indicators may the working group wish to consider using?
9. Appendix 1 - Data-holders of the Global Procellariiform Tracking Database.

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