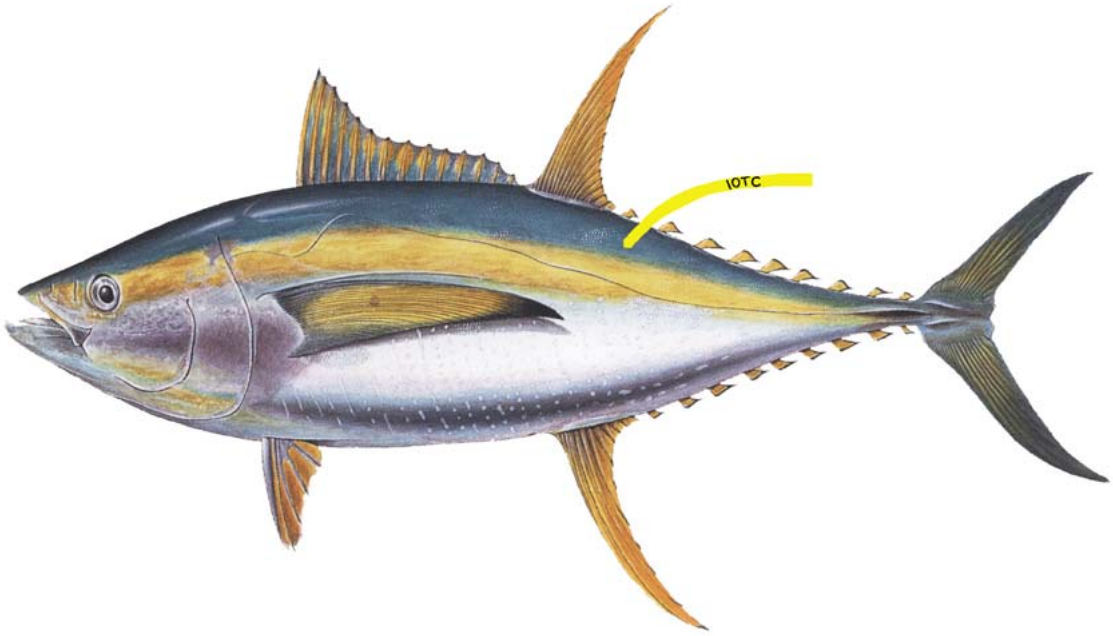
A Feasibility Study for a Proposed Indian Ocean Tuna Tagging Programme

Final Report

Submitted on the 31st January 2003, to European Commission Delegation in Mauritius



MRAG

Coopération Commission de l'Océan Indien / Union Européenne

iotc Indian Ocean Tuna Commission
ctoi Commission des Thons de l'Océan Indien

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1 List of Abbreviations

ACP	African, Caribbean and Pacific
AFRC	Albion Fisheries Research Centre
ARDA	Association Réunionnaise de Développment de l'Aquaculture
CFP	Common Fishery Policy (European Union)
COI	Commission de l'Océan Indien
COMESA	Common Market for Eastern and Southern Africa
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CWT	Charly Wijaya Tuna
DAF	Direction de l'Agriculture et de la Forêt (Mayotte)
DST	Data Storage Tags
DWF	Distant Water Fleet
DWFN	Distant Water Fleet Nation
EAC	East African Community
EDF	European Development Fund
EEZ	Exclusive Economic Zone
EU	European Union
FA	Fishing Agreement
FAD	Fish Aggregating Device
FAO	Food and Agriculture Organization of the United Nations
FIPL	FAO International Institutions and Liaison Service
FOC	Flag of Convenience
GEF	Global Environmental Facility
GDP	Gross Domestic Product
GNP	Gross National Product
HDI	Human Development Index
HSTP	Hawaii Seamount Tagging Project
IEO	Instituto Español de Oceanografía
IFREMER	Institut Français pour l'Exploitation de la Mer (France)
IGAD	Intergovernmental Authority on Development
IOTC	Indian Ocean Tuna Commission
IOTTP	Indian Ocean Tuna Tagging Programme
IPOA	International Plan of Action
IPTP	Inter Pacific Tuna Programme
IUU	Illegal, unreported, unregulated fishing
JAMARC	Japan Marine Fishery Resources Research Centre
LFA	Logical Framework Analysis
MCS	Monitoring Control and Surveillance
MSY	Maximum sustainable yield
MT	Metric tonnes
NIP	National Indicative Programme
NMFC	National Marine Fisheries Service
OFCF	Overseas Fisheries Co-operation Foundation
PFRP	Pelagic Fisheries Research Programme, University of Hawaii
PIT	Passive integrated transponder
PMU	Project Management Unit
RFO	Regional Fisheries Organization
RIP	Regional Indicative Programme
RFMO	Regional Fisheries Management Organisation
RTMF	Regional Technical Meeting on Fisheries
RTTP	Regional Tuna Tagging Project, SPC, South Pacific
SACU	South African Customs Union

SADC	Southern Africa Development Community
SFA	Seychelles Fishing Authority
SIDS	Small Island Developing States
SPEM	Service des pêches et de l'environnement marin (Mayotte)
SWIO	South West Indian Ocean
SWOT	Strengths, Weaknesses and Threats
TTA	Taiwan Tuna Association
TWDS	Taiwan Deep Sea Boatowner Association
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VMS	Vessel Monitoring System
WIO	Western Indian Ocean
WIOTTP	Western Indian Ocean Tuna Tagging Programme
WPT	IOTC Working Party on Tagging

2 Introduction

2.1 Regional Cooperation

Discussions commenced in October 1995 with the task of formulating a general framework for regional cooperation between the ACP countries of the Indian Ocean (Comoros, Madagascar, Mauritius, Seychelles and La Réunion) and the European Union and specifically to establish the Regional Indicative Programme (RIP). On the 4th November 1995 in accordance with Article 160 of the Lomé Convention the programme of aid to the region was formulated and signed, being referred to thereafter as the 'Lomé IV Convention'.

Programmeable financial and technical cooperation as provided for under Articles 160 and 281 of the Lomé IV Convention, amount to an indicative allocation of € 25.5 Million. This is available for operations carried out under the aegis of the Commission de l'Océan Indian (COI). Within the framework an additional indicative allocation of € 4.5 million is reserved for 'non-COI' operations for which financing requests must be presented by at least two ACP States, in accordance with Article 164. The total Regional Indicative Programme under the 8th European Development Fund (EDF) has therefore, a total indicative allocation of € 30 million.

Representatives of COI member states and the Commission underlined that cooperation must contribute to social, economic and cultural development in an integrated and sustained manner. Priorities for cooperation take the form of focal sectors, in which increased support is directed. Within the focal sector of Community Aid, over 50% of the regional indicative program allocation is allotted to the protection and management of natural and maritime resources, a further 35% to the development of trade in goods and services.

2.2 Framework of the study

Under the framework of a 'non-COI' program, a study was proposed issued by the Delegation of the European Commission in Mauritius on behalf of the Governments of the Seychelles and Mauritius (ref. Article 302 of the Fourth Lomé Convention, 2nd financial protocol 8th European Development Fund), entitled a **'Feasibility study for a proposed Indian Ocean Tuna Tagging Program'**.

The financial allocation for the tuna tagging programme is not limited to € 4.5 million. The programme qualifies and as such will be presented under community aid cooperation for further financing under the 9th European Development Fund.

2.3 References to TOR

The Terms of Reference for the study state as the main objective of the study, the provision of adequate information to the member states of the COI and the European Commission to enable them to accept, modify or reject the proposed Regional Programme for tuna tagging. The aim is to further strengthen the regional management of tropical tuna in the Indian Ocean in terms of finance and implementation. The Terms of Reference call on the study team to provide the following information:

- An evaluation of the project rationale in relation to improving the economic and social aspects of tuna exploitation and management.
- A detailed technical, financial, economic, environmental, social, organisation and institutional feasibility study of the proposed tagging programme.

- An assessment of the viability of likely results (biological, migration etc) that will be obtained from the tuna tagging programme.
- A detailed plan in which the objectives, indicators and expected results of the programme will be set out. In addition the project should identify the financial and management requirements for the successful implementation of the project. The project programme and implementation cycle will be presented as well as the responsibilities of different organisations with respect to the programme. Cost estimates for the tuna tagging programme will be produced as well as a logical framework analysis (LFA).
- Project proposals will be included in the final report. These include technical specifications (tagging platform, tags and other gear and equipment needs) and tender documents will be prepared for technical assistance, the project management unit (PMU), the tagging platform and other supplies.
- Recommendations will be given for the project phasing (we have assumed an implementation period of 5 years, including tagging and data analysis) as well as for future financing requirements to ensure successful project implantation.

A number of other factors are identified in the study Terms of Reference. These include the following:

- An assessment of trends with large migratory pelagic species in the Indian Ocean and notably in the EEZ's of member states of the COI.
- Resource management of COI member states and the role of the IOTC.
- Evidence on the over exploitation of the large pelagic resources and the measures necessary to reduce over exploitation.
- The future potential for large pelagic exploitation in the Indian Ocean and the relevance of the proposed tagging programme in this context.

The project Terms of Reference call on the study team to ensure that the proposed tagging programme is coherent with the policies of the COI member states, with the economic and social issues associated with the tuna fisheries and their coherence with EU policy and notably that of Lomé IV bis and the Regional Indicative Programme for the Indian Ocean[1]. The project should also identify the beneficiaries from a tagging programme (stakeholder analysis), the problems which confront stakeholders and the relationship between these and other problems relating to regional tuna fisheries management. In addition, the consultants are asked to review the commitment of COI member states to the management of large pelagic stocks. The latter includes the concrete contributions, financial, human and technical resources and support that member states are likely to bring to the tuna tagging programme.

Finally the study should ensure that the tagging methodology proposed will provide an effective standardised approach, that publicity and reward strategies should be addressed, and that attention should be given to resource assessments models for tuna in the WIO and how data from the IOTTP would be integrated at the level of the Indian Ocean. The study team benefited from consultation with stakeholders at the regional level (COI, IOTC, EC) as well as consultation with national stakeholders[2] in all the member states of the COI as well as the Collectivité Territoriale of Mayotte (France) which is one of the islands on the Comoros archipelago.

Additional consultation of the viability of tagging programmes and methodologies was obtained from the Secretariat of the Pacific Community, which was visited by Dr. Jose Cort, as well as consultations with the expert panel which consisted of scientists from the Renewable Resources Assessment Group (RRAG) at Imperial College, University of London, the (SPC) based at Noumea in the Pacific Ocean, AZTI, IEO, FAO in Rome, CSIRO in Australia and from the PFRP in Hawaii.

[1] Both these documents emphasise the need for regional economic integration. The tuna tagging study as a regional project will contribute to this objective and directly and indirectly will contribute to better resource management and therefore economic and social development, better food security, subject to certain other conditions which are discussed elsewhere in this report.

[2] This included discussions with specialists and scientists with experience in tuna tagging as well as possible fishing sectors that could be used for tuna tagging in Mauritius, Mayotte, Réunion and the Seychelles

2.4 Rationale

In economic and social terms, the rationale of the project is that most of the member states of the fisheries sector contributes at the macroeconomic level to gross domestic product generation, employment, value added (in the case of processing industries and other economic activities associated with the fisheries sector such as the construction and maintenance of fishing vessels, gear and equipment, port activities etc). For many of these countries, the tuna fisheries are important component of fishing activities. This is because of the value of landings, transhipment receipts, port dues and to some extent food security. This is particularly the case for the Seychelles and to a lesser extent Mauritius (tuna processing and transhipment, bunkering activities), Comoros, Madagascar, La Réunion and Mayotte. In the case of a number of these countries they derive access payments through licence revenues and tonnage payments from tuna fishing fleets, access payments from EU fishing agreements and in some cases revenues for bilateral fishing agreements and private fishing agreements.

EU fishing agreements are important sources of foreign exchange revenue for the Seychelles, Comoros, Madagascar and to a lesser extent Mauritius. In the case of Mayotte which is a *collectivité territoriale* under the French flag, there is a bilateral fishing agreement with Spain for the exploitation of tuna. At the microeconomic level, employment and in some cases artisanal and semi-industrial fishing fleets and fishing communities generate income from the exploitation of tuna stocks. Tuna also contributes to food security for fishing communities (Comoros, Mauritius and the Seychelles) and for nation states, through the production of processed tuna products, notably canned tuna.

However the future sustainable exploitation of tuna and other similar large pelagic species requires better scientific knowledge on tuna biology and migration if realistic fisheries management plans are to be prepared for tuna fisheries. It is now globally recognized that when valuable fisheries are not managed, subsequent overfishing reduces the profitability of the fisheries in the medium to long term. The existence of scientific knowledge will contribute directly to economic and social development of COI member states at both the macroeconomic and microeconomic levels on the assumption that other investments are made in effective MCS within the EEZ's of COI member states and beyond.

2.5 The Regional and National Political Climates

The regional political climate is gradually moving to greater economic integration, the development of which is also a feature of the 9th EDF. The development of COI, SADC (including the COI member states (MS's) of Seychelles and Mauritius), COMESA (including all COI member states except La Réunion) and other regional organisations such as EAC, SACU and IGAD, indicates that there are increasing opportunities for the exchange of ideas and cooperation in the fields of coastal environmental management, the management of EEZ's and the management of fisheries, including the management of shared and straddling stocks such as tuna.

In terms of specifically the regional management of tuna, the IOTC based in the Seychelles plays a vital role and will be instrumental in the management of the proposed tuna tagging programme.

While the tuna tagging programme at this stage, will concentrate on the member states of the COI, it will also be vital to develop regional and bilateral contacts at all levels with other tuna fishing nations in the Indian Ocean, including Tanzania, Mozambique, Kenya, Somalia, the Maldives, Oman, Iran, India, Australia, Thailand, Indonesia etc. This is clearly important given the spatial and temporal nature of tuna stocks and one that the IOTC in very well equipped to address.

Visits to the COI member states by the consultants suggest that there is a political commitment at both the regional and national levels to the tuna tagging programme. While financial contributions from member states (counterpart funds) are likely to be limited or non existent, other resources including fisheries research and management staff from each of the member states could play an important role in the project.

3 Context

3.1 Indian Ocean Tuna Fisheries Overview

3.1.1 The resources and their exploitation

3.1.1.1 The Fisheries

The Indian Ocean and associated tuna[3] fisheries are unlike any other ocean for two main reasons. Catches from the artisanal sectors are similar in size to industrial catches, and industrial catches are fairly evenly split, in terms of catches, between longline and purse seine fisheries. In stark contrast both the Pacific and Atlantic Oceans tuna fisheries are dominated by industrial catches. In terms of value, the Indian Ocean tuna fisheries are probably the most valuable in the world. This is primarily due to the proportionately high value of artisanal tunas over industrial catches, and the fact that half of the industrial catches are from longline fisheries that have values per MT five to ten times higher that of purse seine caught fish.

The Western Indian Ocean (WIO) supports the largest fisheries, tuna landings especially by the industrial sectors and in particular by the purse seine fleets are close to four times higher in the WIO than in the EIO. This is mainly the result of the higher productivity of the ocean, with nutrient rich upwellings along the Arabian and Somalia coasts.

Some 750,000 MT's of tuna, with a processed value in the region of 2 billion Euros, are harvested each year from the WIO. As a result, tuna stocks constitute the single largest marine resource available to the small island states of the region, with the exception of Madagascar. Sustainable management of tuna and associated resources is therefore regarded as a being of critical importance both to the coastal states of the WIO and to the markets of the European Union and Asia.

The tuna fisheries of the WIO comprise artisanal, semi-industrial and industrial sectors. It has only been within the last 50 years that catches from the artisanal sector have risen from their previous nominal catch rates. With the development of many new semi-industrial fisheries current catch rates of principal tuna species, now exceed 200,000 MT's per year. The most significant artisanal fisheries in terms of attributed catch, include pole and line and gillnet/small scale longline.

Distant Water Fishing Nation's (DWFN's) began longlining for tuna in the Western Indian Ocean in the early 1950's. This was initiated by the Japanese and soon followed by the Taiwanese (1954) and the Koreans (1960). Since then, Asiatic longline presence in the Indian Ocean has risen dramatically. Sri Lanka and Indonesia are also active with rapidly developing fleets.

The most significant increase in targeted fishing activity for tuna and tuna like species dates back to the mid-eighties reflecting the increase in industrial fishing fleet interest, particularly on the part of the EU purse seine fleet. Large scale industrial purse seining for tuna began in 1983 when the French and Spanish fleets moved into the Western Indian Ocean from the tropical Atlantic. By 1986 some 6% of the world tuna catch (143,099 MT out of 2,400,000 MT) was coming from the Western Indian Ocean purse seiners fleet; by 1997 this had risen to 14% and currently stands at 17%. The majority of the fleet is Spanish, Italian and French fishing under access rights linked to European Community agreements, private and bilateral agreements and in high seas areas. Others are registered in Belize (constituting 10 purse seiners owned by interests in the former USSR), Panama, Mauritius, Saint Vincent and Grenadine,

[3] Principal tropical tuna species being yellowfin *(Thunnus albacares)*, bigeye *(Thunnus obesus)* and skipjack *(Katsuwonis pelamis)*

Dutch Antilles and the Seychelles. In the past the fleet has also included vessels from Liberia, United Kingdom, the Ivory Coast, India and Japan.

World wide trends in tuna fishing activities, and the processing and trading of tuna products have been influenced by a number of driving forces, including resource availability, technology, and input and output processes. The dramatic expansion of tuna industrial fisheries by foreign fleets in the last twenty years, in parallel with considerable developments in the processing sector in the region, continues to have a significant impact on COI member states, specifically on their economies through fishing access, licensing policy and most significantly through downstream fleet expenditure in regional ports.

Annex A I, Figure 2 displays detailed catches by species from 1950 to the 2000. It is the last 5-7 years that the highest catches are being witnessed. Between 1995-2000 close to 1 to 1.2 million MT's of tuna and tuna like species are taken annually.

Annex A I, Figure 1 displays detailed catches by gear type from 1950 to 2000. Approximately 60% of captures are attributed to the longline and purse seine fisheries illustrating the important artisanal component. Catches attributed to both the longline and purse seiners as a proportion of total captures are displayed in more detail between 1995 and 2000 in Annex A II, Table 2.

3.1.1.2 Fleet dynamics

Fleet size by flag, IUU and year, for both longliners and purse seiners are detailed in Annex A II, Table 3.

Although declining in number, IUU vessels constitute the single largest sector within the longline fleet and account for approximately 50% of the vessels. The numbers of both active Japanese and Korean vessels have seen a decline in recent years reflecting limited development in national fleets. Purse seine fleets on the whole have been fairly stable over the last 7 years, only with moderate increases around 1997.

Total catches by fleet in 1999 (1000 MT's) in the WIO are displayed in Annex A II Table 4. Clearly the largest components of the licensed longline and purse seine fleets in the Western Indian Ocean are the Taiwanese (68%) and EU (70%), respectively.

3.1.1.3 Fishing areas

As discussed, it is the WIO that supports the highest catches. The major areas currently exploited are by purse seiners displayed both by year, and by 'free shoaling fish' and by 'FAD' catches are displayed in Annex A I Figure 3, together with a chart in Annex A I Figure 4, displaying the major areas to which catches correspond.

Charts in Annex A I Figures 5 to 12 display average fishing areas by quarter for both longline and purse seine fleets.

3.1.1.4 National fleets

Captures

Levels of exploitation in the region (COI MS's) is summarised in Annex A II, Table 5, displaying the regional dependence on tuna and tuna like species.

Fleets

COI national fleet sizes by sector are detailed in Annex A II, Table 6.

Fisherman involved

Employment in the fisheries sector by fleet in the region is displayed in Annex A II, Table 7

3.1.1.5 Fishing Agreements

With the European Community

All MS's of the COI, with the exception of La Réunion, have in place a fisheries agreement with the European Community for the exploitation of fishery resources. All agreements concern only the exploitation of tuna.

Current agreements between COI MS's and the EC, with the associated detailed information, is displayed in Annex A II, Table 8

Other private and bilateral agreements

Other private and bilateral fisheries agreements are in force within COI MS's exclusively for the exploitation of tuna resources (with the exception of Madagascar that has private agreements over prawn fishing).

Details of these are displayed in Annex A II, Table 9

Regional Infrastructure and Services

Annex A II, Table 10 details regional infrastructure and services, based on the exploitation of tuna resources, provided within each COI MS. Also detailed are the capacity of tuna canneries where appropriate, and tuna tonnages landed and transhipped for which the services and infrastructure in the region cater.

3.1.2 Fisheries Management

3.1.2.1 Global

FAO Compliance Agreement, 1993

As with any agreement drawn up under the auspices of the FAO, it is open to acceptance by any member or associate member of the FAO and to any non-Member State of the United Nations. This agreement has not yet entered into force, but is approaching the required threshold. The area of application is the high seas, and it is not restricted to species. It is attempting to address the ever increasing problem of overfishing on the high seas by means of introducing new rights and new obligations for the flag state of vessels, in a system of obligatory licensing.

United Nations Convention on the Law of the Sea (UNCLOS), 1982

UNCLOS encompasses a number of aspects of ocean law, including the facilitation of international communication, promoting the use of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources, and the study, and the protection and preservation of the marine environment,

UN Straddling Fish Stocks and Highly Migratory Fish Stocks Agreement, 1995

This concerns fishing in zones of national jurisdiction and on the high seas when straddling fish stocks and highly migratory fish stocks are being targeted. The agreement promotes International cooperation in respect of the exploitation of these stocks, so that conservation and management regimes adopted for the two jurisdictional areas (i.e., EEZ' and the high seas) have a high degree of complementarity. Furthermore, it creates an obligation for parties to join a RFMO that is concerned with stocks that they themselves harvest.

Code of Conduct for Responsible Fisheries, 1995

The code sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity. States and all those involved in fisheries are encouraged to apply the Code and give effect to it.

International Plans of Action

International Plans of Action (IPOA's) are voluntary instruments elaborated within the framework of the Code of Conduct for Responsible Fisheries. They apply to all States and entities and to all fishers. Four IPOA's have been developed to date; Capacity, Seabirds, Sharks and IUU.

3.1.2.2 Regional

IOTC

The IOTC is an intergovernmental organization established under Article XIV of the FAO constitution and is mandated to manage tuna and tuna-like species in the Indian Ocean and adjacent seas. The IOTC Agreement officially entered into force in 1996, followed by the permanent establishment of a permanent Secretariat in the Seychelles in 1998. By 1999 it was fully staffed and had 19 contracting parties, including the European Union, and since 2002 the number of parties has risen to 22.

South West Indian Ocean Fisheries Commission

Three meetings have occurred between SWIO states and FIPL; preliminary consensus for the establishment of a regional fisheries commission for the South West Indian Ocean for non-tuna fishery resources. The regional body will have the responsibility for the sustainable development, conservation and management of the regions resources.

3.1.2.3 National

The EEZ's of the MS's of the COI vary greatly in size. A chart detailing the region and the EEZ's of the COI MS's is displayed in AI Figure 20[4]. With the acceptance of the extensions to EEZ's in 1982 some states particularly those with offshore islands have extremely large EEZ's relative to land size.

All COI member states have in place a recognized fisheries law; however the capacity ad commitment to MCS in the region varies greatly between countries. MCS in the region has considerably been improved through 'targeted financing actions' under EC Fisheries agreements and consistent moves are in place to coordinate regional MCS development. A project is being proposed, by the EC, entitled the 'Regional Monitoring, Control and Surveillance of highly migratory species'. The project is looking to integrate, coordinate and develop MCS systems specifically within IOC member states.

[4] The Project is not however limited to operations within these areas

3.1.3 Regional fisheries research

There are a number of research centres located in the member states of the COI which are carrying out work on aspects of tuna biology and management. The main centres concerned with tuna resources are carried out in the Seychelles, La Reunion and Mauritius and their activities are described below.

3.1.3.1 Seychelles

Seychelles Fishing Authority

All fisheries and associated legislation surrounding them in the Seychelles are administered and managed by the Seychelles Fishing Authority (SFA). The SFA was created in 1984 during the exponential growth of the purse sSeine fishery at this time and other industrial fisheries development particularly DWF tuna fishing. It was mandated to become the Fisheries Division of the Government, with the role of developing the fisheries of the Seychelles to highest sustainable level.

The SFA has a Research Division composing of a team of 8, 2 biologists, 1 research officer and 6 technicians. They are responsible for the implementation of the SFA Monitoring Programme that currently incorporates two sampling projects:

- Tuna species and size sampling - In collaboration with Institut de Recherche pour le Dévelopement (IRD) and Instituto Español de Oceanografía (IEO), work is carried out in Port Victoria at the discharge sites of the purse seine fleet. Catches are sampled for biological parameters and verifications of catch submissions.
- Swordfish sampling - swordfish are sampled at landing sites for both biological parameters and catch trends. This work contributes to the current project in collaboration with IFREMER.

Institut de Recherche pour le Développement (IRD), (ex-ORSTOM)

The placement of two tuna scientists within the SFA (since April 2000) is intended to contribute to the management and research of Indian Ocean tunas stocks, in cooperation with IRD scientists based in La Réunion, through a new research project entitled THETIS. Current research focuses on the sustainable exploitation of tuna stocks in the Indian Ocean, and is derived from computer modeling of the stocks, at the same time encompassing migrational movements and ecological and environmental interactions in the region.

Institut Français de Recherche pour l'Exploitation de la Mer (IFREMER)

A joint project in collaboration with IFREMER began in June 2000, financed by the Government of France. It aims to support the development of the Seychelles semi-industrial longline fishery with associated research and monitoring.

3.1.3.2 Mauritius

Albion Fisheries Research Institute

The AFRC are involved with both tuna sampling (primarily undertaken on catches landed by foreign longliners) and research, most notably in the past within the PTR I and II.

3.1.3.3 La Réunion

Both IFREMER and IRD are involved with research and monitoring of the islands fisheries. Principal projects by institution are summarized:

IFREMER

Two programmes of research are currently operational:

- Programme Pêche Palangrière (PPP) is concerned both the biology and biometrics of the principal exploited species, being swordfish, tuna and dorado.
- SIHR (Système d'Information Halieutique Réunionnais) is involved with monitoring and control of the principal national fisheries

IRD

Three projects are currently operations, all focused on the exploitation of highly migratory species, including the three principal tuna species of SKJ, YFT and BET, and entitled:

- Unité de Recherche 109 (Thetis)
- Unité de Recherche 061 (Active)
- SEAGERH (Service d'aide à la gestion des ressources halieutiques)

3.1.3.4 Mayotte

The Direction de l'Agriculture et de la Forêt (DAF), Service des Pêches et de l'Environnement Marin (SPEM) have, under the IOTTP framework, recently carried out a pilot project on tuna tagging, furthermore are involved with research of live bait rearing, and options of species and supply suitability for the project.

3.1.3.5 Madagascar

Under the current EC fisheries agreement funding is directed to the Unité Statistique Thonière d'Antsiranana (USTA) based in the northern port of Antsiranana. The unit, through a shore based species and size sampling programme, collate information on tuna purse seine landings. The data is periodically relayed to the Institut de Recherche pour le Development (IRD) in the Seychelles, for further processing and analysis.

Formed in 1992 in association with the University of Toliara and the Ministry of University studies (MINESUP), the Institut Halieutique et des Sciences Marines (IHSM) has the task of training and applied research in development. It is equipped with laboratories, an aquaculture farm and a library; however there are currently no further research directed to tuna.

3.1.3.6 Comoros

No research of any kind is currently directed to fisheries resources.

3.1.4 Economic and Social Aspects of Tuna Fisheries in the WIO

3.1.4.1 Introduction

As we have pointed out earlier in this report, fisheries and tuna fisheries (being almost exclusively yellowfin (*Thunnus albacares*), bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*), have an important role in the economic and social development of COI member states as well as other coastal states in the Indian Ocean, including the Maldives, Indonesia, Australia, Iran, Oman and Sri Lanka. In addition, both the biological and exploitation parameters, in particular of the high value species such as yellowfin and bigeye, are poorly known or estimated. For example it is known that there are important fractions of tuna stocks that have seasonal movements through the Mozambique Channel and along the African coasts. Thus tuna resources are not merely important to COI states such as Madagascar and the Comoros Islands but also potentially to mainland African states such as Somalia, Kenya, Tanzania and Mozambique.

While member states receive income from tuna landings, processed tuna products, fishing agreements and access rights as well as port charges and facilities associated with tuna fishing activities, it is also clear from other studies that there are a number of economic and social issues associated with tuna fishing. An analysis by the Association Thonière de l'Océan Indien (1995) made some estimates of the socio - economic importance of tuna fisheries in the COI countries. This analysis showed that the main economic impacts from tuna fisheries could be divided as follows:

- Port dues
- Customs duties
- Vessel and equipment maintenance and repair
- Storage and processing
- Salaries and wages
- Shipchandling and supplies
- Crew transfers
- Telecommunications and transport
- Fishing agreements

These subsequently include:

- Non maximisation of the economic rent from tuna fisheries exploited within the EEZ's of COI member states and beyond.
- Loss of potential value added within COI member states for tuna marketed and processed in European and Asian economies (e.g. the value of sashimi marketed in Japan and other consuming countries).

3.1.4.2 The International Dimension

The loss of potential economic rent and value added derived from their fisheries means that WIO states are not maximising employment, processing and other value added activities linked to their tuna fisheries. In addition the emphasis on the export of tuna may potentially jeopardise food security, when tuna species received higher prices on overseas markets, where incomes and purchasing power are considerably higher. If tuna stocks are overexploited or not exploited in a sustainable fashion, it is likely that in the medium to long term (over the next 10 – 30 years), nominal catches of tuna will fall, with dramatic economic and social impacts for countries such as Seychelles and to a lesser extent the other COI countries.

The economic benefits are by and large generated by; the sale of fishing rights and access to foreign fleets, predominantly from the European Union and Taiwan; transhipment and associated downstream activities of foreign fleets operating in the Western Indian Ocean, and the onshore processing and

canning of tuna and the activities of local semi-industrial and industrial enterprises. These processing facilities are fairly young in their development and are located in COI MS's of Mauritius, Seychelles and Madagascar. Given the nature of small island developing states and often limited marketable natural resources, and the potential value of the tuna resources, the optimum utilization of the fisheries resources to acquire absolute maximum domestic benefit is paramount. Options for a coherent regional strategy to optimize economic benefits derived from tuna exploitation and management are being proposed and discussed, within the development of the tuna industry in member countries of the COI.

The European market for fish and associated products is the largest in the world, and the gap between demand and domestic supply has increased significantly in recent years. Within the years 1983 to 1990, annual fish consumption per capita in Europe rose from 15 to 22 kg, in parallel, with diminishing marine resources in European waters, have reinforced the long tradition of activity of European distant water fleets. Imports from the DWF's are a primary source of supply feeding the European market, and imports to Europe from lesser developed countries, such as Islands of the Western Indian Ocean have increased by 900% between the years 1976 to 1996. These catches are integral in meeting the demand, and at present contribute at least 20% of the entire EU production of fisheries products.

European Union Fishing Agreements for tuna and tuna like species in the region are in operation within 4 of the COI member states, in an effort to compensate for the loss of access when the zones of jurisdictions were extended to 200 miles. France has the 8th largest catch by country in non-adjacent fisheries, with an attributed catch of 23% of the national fleet. Furthermore, the Spanish fleet is the second largest non-adjacent fishing fleet, accounting for 47% of the total catch of its national fleet. These figures compare with a global average of 5% of total catch from non-adjacent fisheries, displaying the significance of the EU fleet in exploitation within non-adjacent waters. Fishing agreements for the period 1993/1997 with developing countries have generated for the EU an annual averaging of 231.9 million euros as direct value added and 535.8 million as indirect value added. There are additionally considerable benefits generated from downstream activities most notably value added and employment, with an average creation of 14,182 direct jobs and 20,100 indirect jobs. Furthermore, the EU's budget for Fishing Agreements, and hence the activity of their DWF's, has increased substantially in recent years: 5 million in 1981, to 38 million in 1987, 163 million in 1990, 205 million in 1993 to 276 million in 2000. Specifically, within expenditure in 1998, 5% represented the total amount allocated to Fishing Agreements.

As is the nature of a resource that is highly migratory and free from boundaries, ownership rights within respective EEZ's and subsequent commercial trading can only be applied if resource exploitation remains sustainable in those areas. Clearly, the nature of activities within upstream and downstream areas, or adjacent high seas areas and neighboring EEZ's, are fundamental, underlining the importance of regional management, and the need for all coastal states in the region to provide a variety of inputs to management decisions taken at both national and regional levels.

3.1.4.3 Country profiles

Individual country profiles for the COI MS's are provided in Annex A III.

3.2 WIO Tuna Fisheries – The Issues

Knowledge in all areas of tuna biology and fisheries driven exploitation and interaction is poor. It follows that limited reference points in a stock, and thus weak management advice will lead to dangerous commercial trading in the resource. Sustainable optimisation of resource rent, and as such broadening of the economic base and socio-economic benefits in Western Indian Ocean island states, can only be developed once a clearer understanding is made of stock sizes.

Many tuna resources in the Indian Ocean may already be fully exploited or overfished with the exception of SKJ. However the socio-economic situation in the region may change, stimulating new exploratory fishing, an adaptation in technology and development of new fisheries. In support of this shift, it will be vital that regional technical advice will continue to form the basis of sound fisheries management. Thus it follows that scientific knowledge obtained from other better known species in the region will be the best instrument in help guide the management advice.

A specific issue relating to both longline and purse seine fleets is the rapid and significant development in fishing technology and capacity, such as the massive use of fish aggregation devices (FAD's) by purse seine fleets in recent years. Such increases in catchability pose problems in all stock assessment and tuna fisheries management as it is extremely difficult to adequately estimate changes in fishing efficiency.

Annex A I, Table 13 details through the use of a problem tree, the fundamental dynamics and issues associated with tuna fisheries in the WIO.

3.3 Tagging study origin and overview

Demersal fish stocks are often targeted by research vessels that provide, independently of fisheries, estimates of their recruitment and spawning biomass. Tuna stocks on the other hand cannot be sampled by research vessels, leaving fishery independent information and biological parameters obtainable only through tagging studies. As such, data from tagging studies constitutes the essential baseline for research on tuna populations around the world.

The requirement for tuna tagging becomes reinforced when stocks are heavily fished, and when precise information on levels of exploitation are urgently required. Furthermore, tagging is the only way to obtain adequate data to estimate changes in fishing efficiency. Conversely, unlike other oceans the Indian Ocean has never had large scale tagging programmes.

The Scientific Committee of the Indian Ocean Tuna Commission has made several attempts at thorough scientific stock assessments of bigeye tuna, and recently yellowfin. For all three principal tropical tuna species[5] it has also intensively reviewed the information available on the key biological parameters and fisheries catch and effort data that are the instrumental inputs for effective and robust stock assessments models.

> It is clear that knowledge is poor in all areas, and under no circumstances will existing systems for collecting biological and fisheries statistical information, resolve these problems in any timeframe that can be safely acted on without the implementation of a large scale tagging programme.

At its second meeting, the IOTC Scientific Committee set up an ad hoc working group on tagging, this was accorded formal Working Party status in the following year. At its meeting in 2000, the Working Party on Tagging (WPT) developed outline plans for an Indian Ocean wide tagging programme, the Indian Ocean Tropical Tuna Tagging Programme (IOTTP); this was subsequently endorsed by the Scientific Committee at its 3rd meeting. The Scientific Committee also supported the views of both the Working Party on Tropical Tunas and Working Party on Tagging that the scientific knowledge required for reliable stock assessments could only be obtained from a well-conducted wide-scale tagging programme of this type, as demonstrated by the results of similar tagging programmes in other oceans, most particularly the 'Regional Tuna Tagging Project', executed in the South Pacific in the early 1990's. No attempts in the past have been made either by the IOTC or any other organisation for a large-scale tagging incentive in the Indian Ocean.

[5] Yellowfin, bigeye and skipjack tuna are the only species targeted by this study

The IOTTP was tentatively proposed as a five year programme, encompassing the three main tropical tuna species, implemented over the whole Indian Ocean, and using a range of different tagging platforms. The total budget for the programme was assessed at just over 18 million $ USD.

It was also recommended that a series of pilot studies should be proposed to test different platforms and methodologies. Recommendations also included the need for training of staff, from Indian Ocean coastal and small island states, in tagging techniques. In addition, the need for wide-scale public awareness campaigns and publicity was also stressed. The cost of these preliminary studies was estimated at $430,000. Member states of the IOTC were encouraged to propose studies, and nominate tagging liaison officers to coordinate their development.

3.3.1 Objectives

In its original plans, the IOTTP aimed to provide data for the main Indian Ocean tuna stock species to address the following issues (IOTC, 2000):

- Crucial model parameters necessary for stock assessment, i.e. age specific estimates of natural and fishing mortality;
- Structure of stocks and movement of Indian Ocean tropical tunas;
- Exploitation rates and differential vulnerability by area and gear;
- Influence of FAD's, seamounts and areas of elevated vulnerability on the movement and exploitation of Indian Ocean tunas, particularly of juvenile Yellowfin and Bigeye tuna aggregated to drifting FAD's;
- Assessment of potential interactions between various fisheries.
- Estimation of growth rates, and validation of age estimates from hard parts.
- Role of the oceanographic and bathymetric environment on movement and exploitation of Indian Ocean tropical tunas.

Although tagging would take place over all five years, particularly intensive tagging was planned over a three-year period in order that (IOTC, 2000):

- Individual cohorts could be tagged over sequential years, an important element in estimating age specific fishing and natural mortality; and
- To ensure that regardless of major climatic variability (El Niño/La Niña), that might effect the distribution of the resources, tags could be released throughout the geographic range of the fisheries and across the size ranges of each species.

The IOTC supported the concept of the IOTTP and agreed to proceed with the implementation of the pilot studies. It was agreed that funding for the remainder of the programme would have to be sought from extra-budgetary sources as this would be well outside the capacity of the Secretariat. Proposals for funding were dispatched to both IOTC member states and international donors such as the World Bank/GEF, however by 2001, limited funding had materialized, and it appeared likely that there would be insufficient financing available to support implementation of the full IOTTP.

However in June 2001 the European Commission, through AidCo, to whom the government of Seychelles and Mauritius had applied, provided potential funding possibilities of €4.5 m through the 'non-COI' activities under the Lomé IV bis Convention. As such the WPT, within its subsequent sessional meeting began discussing a series of potential study objectives from such a source. The objectives were thus revised to include estimation of growth rates and movement patterns using both conventional and archival tags, allowing an assessment of potential fishery interactions.

Experience in other oceans has been that by far the most efficient and consistent method of tagging large numbers of tropical tuna has been from pole and line vessels using live bait, however, such vessels can

be extremely expensive with a large dependence on live bait, a resource unknown to be freely available in the WIO. Initial signs from experts, previous fisheries and resource surveys suggested that the availability of live bait in the study area could prove to be a significant constraint. In light of these events the objectives of the proposed pilot programmes were thus redefined to:

- Testing the feasibility of using small scale alternate tagging platforms, which would be used to test tagging methodology with various gears; and,
- Comprehensively investigate availability of live bait in the Indian Ocean suitable for use in a wide-scale tagging programme using pole and line vessels.

3.3.2 Past Tuna Tagging Studies

Details of tuna tagging programmes executed both geographically and historically are detailed, together with information on their contribution to fisheries research and management.

3.3.2.1 Indian Ocean

Maldives

As a result of the relative infancy of a regional tuna commission, the limited tagging that has occurred in the past within the Indian Ocean has been on a limited basis both geographically in the Maldives, and by species (skipjack). A total of 25,906 tuna have been tagged to date (Yellowfin, 22%, Bigeye, 6%, and Skipjack, 72%), with a total of 2,364 recoveries (skipjack 85%).

Localized tagging of SJK did not allow an analysis of fisheries interactions, inadequate measuring of recaptured fish failed to permit accurate growth estimates and too few YFT and BET were tagged to gain any biological parameters.

JAMARC, Japan

Japan conducted during the eighties a series of tagging cruises in the Indian Ocean using a dedicated purse seine vessel. The tagging has been primarily focuses on FAD associated tunas, and despite the low number so tunas tagged has produced valuable biological results.

PTR (Projet Thonier Regional)

Running in the early 1980's, the project contributed to good biological and environmental parameters for the three principal tropical tuna species. This was however only achieved though the use of sonic tags. Overall results and those from the use of conventional tags for estimates of fisheries indicators and mortality was lacking, mainly as a result of unsuitable platforms[6] and undefined specific objectives.

3.3.2.2 Pacific Ocean

Prior to the well known RTTP, SPC conducted a very successful tagging programme on skipjack from 1977 to 1980 where 150 000 tuna were tagged including 140 000 skipjack. A large Pole-and-line vessel from Japan was chartered during three years (ten months per year) and the all Western Pacific Ocean was covered for bait and skipjack tagging from Papua New Guinea to Pitcairn Island and from Guam to New Zealand. Results from this programme play an important role in the management of skipjack stock in the Western Pacific Ocean.

[6] A poorly maintained purse seine vessel modified for pole and lining, that suffered from operational restrictions (e.g. inadequate water jet pressures)

In the Eastern Pacific Ocean, the IATTC have also conducted since its creation in 1950, a large number of tagging programmes, primarily focusing on YFT and SKJ. Close to 250,000 tunas have been tagged in this area during this period, and the results have been accepted widely within stock assessment work conducted by the IATTC on these species.

Regional Tuna Tagging Project (RTTP), Secretariat of the Pacific Community (SPC)

The RTTP project is the clearest example of a well executed large scale tuna tagging project. Elements from all aspects have been researched and analysed for integration / comparison into this study.

For most islands of South Western Pacific, the fisheries resource in their EEZ 's is the only commercially exploitable natural resource, and many states in the late 1980's shared a considerable concern over the management of such, and how limited knowledge may impact on the generation on revenue from the resources and on food security. Tuna fisheries also traditionally occupied a central position encompassing cultural and social aspects in the lives of many Pacific Island countries. Since the widespread acceptance of the Exclusive Economic Zone, local control and dependence have taken on a new importance. New sources of foreign exchange through licensed access, the development of national capability, and diversified participation all depend ultimately on the magnitude of the tuna resource and the extent to which it can be exploited sustainably. Total tuna catches in the SPC area doubled between 1979 and 1984, due to rapid increases in purse seine catches overtaking the once dominant pole-and-line and longline sectors. (In the seventies, Japanese pole and line fleets were very active developed around Papua New Guinea, Solomon Islands and Fiji).

The origins of the project date to a proposal presented to the 17th Regional Technical Meeting on Fisheries (RTMF) in 1985. Through an extensive 3 year tagging programme the '*practical answers to the questions raised by fisheries interactions in the region*' would be addressed, and specifically would undertake '*an analysis of interactions between surface and longline fisheries*'. Following subsequent recommendations by the RTMF, the study met with significantly limited sources of financing. The secretariat recommended that alternative sources of funding should be explored, and it was not until Pacific ACP states agreed to allocate priority to it within the Lomé III Pacific Regional Marine Resources Development Programme, that any progression was made it is implementation.

The Final Proposal was submitted to the EC Delegation and approved by the ACP-EC Ministerial Meeting in April 1988. The financial proposal was approved for EC in late 1988, and a financial agreement for the funding between the EC and the South Pacific ACP states was signed in May 1989, with the Solomon Islands Government as Regional Authorizing Officer, the EC Delegation in Honiara the responsible EC Delegation and the South Pacific Commission[7] the Executing Authority.

The goals of the RTTP were first set at 40,000 tagged fish per year over two years. This nominal target was fairly loosely based on general considerations of numbers needed to address most objectives, with associated expected return rates of 10%. In practice it was hoped to tag/release 40,000 of each of the principal target species, being yellowfin, bigeye and skipjack. Yellowfin, if possible of a representative size range, was to be tagged and released as priority, recognizing that skipjack, which normally comprise of at least 90% of pole and line catches in the area would be readily available in the normal operational course of events. Bigeye would be tagged and released when available.

Skipjack clearly held the lowest priority in the RTTP, based on the results of a very large and successful skipjack tagging programme completed at the beginning of the eighties, as discussed.

A total of 132,777 tunas – 33,520 yellowfin, 92,381 skipjack, 6,794 bigeye and 82 long tail tuna were released throughout the main course of the RTTP.

[7] Currently named, Secretariat of the Pacific Community

Regional capital investment is small in the region compared to the DWFN's active in the region. In parallel with the ever increasing catch rates by these vessels the associated level of management required and subsequently now based on tagging results is being addressed. Nowhere have developing countries through their involvement in the RTTP (regional campaigns, information exchanges, publicity and institutional support) contributed to the overarching objective of managing shared resources for their own benefits (Hampton 1995).

The results of the programme will continue to be valuable, and results and further analysis and crucial parameters will continue to flow, contributing to the long term sustainability of the regions fisheries.

Hawaii

The Pelagic Fisheries Research Program (PFRP) of the University of Hawaii has financed two medium sized tuna tagging studies around the Hawaiian archipelago on the principal tuna species of yellowfin, bigeye and skipjack.

- The Hawaii Seamount Tagging Project (HSTP) was designed to address aggregation and interaction issues specific to the Cross Seamount which is the site of a productive fishery for bigeye and yellowfin tuna in the Hawaii EEZ.

- Hawaii Tuna Tagging Project (HTTP). This study was larger in scale than the HTTP and tagged yellowfin, bigeye over a two year period commencing in early 1998. Based on the tag-recapture simulations releases were planned at 500 tags at three primary locations. A target of 6,000 tag releases per year (12,000 for the project) was intended. During 1998, after only ten months of field tagging, the HTTP had released 9,385 tuna (4,301 bigeye, 5,084 yellowfin), thus far exceeding the proposed annual release target. Overall recapture rates for the HTTP at the end of calendar year 1998 were 9.14%. The project was been extended and now looks to close at the end of the 2002 financial year. Current release totals amount to 17,986 tunas (9,537 bigeye and 8,449 yellowfin).

Both programs have been a huge success significantly contributing to well founded stock assessments and sound directed fisheries management.

JAMARC, Japan

A large number of projects and cruises were conducted, commencing in the early seventies and using a range of platforms, which significantly contributed to the knowledge about stock structure of the species.

Work commenced in 1988 using a dedicated purse seine vessel for field operations. The tagging has been limited by number, nevertheless the information collected has been extremely valuable biologically, and has also demonstrated the capacity of a purse seine vessel to tag tuna, albeit, in small numbers.

3.3.2.3 Atlantic Ocean

US and Canadian Recreational fisheries

Commencing in the 1950's this tagging concerns a comparatively low number of several hundred bigeye and yellowfin each year. The results from these studies have been the only information available that has demonstrated yearly trans-oceanic migrations of adult YFT for spawning from the Western Atlantic Ocean to Eastern areas (Gulf of Guinea). Based on these results the ICCAT SCRS has abandoned its hypothesis of two distinct stocks in favour of one for the purposes of assessment and YFT stock management.

European Bluefin tuna project

Project carried out between Spain and Norway in the 1960's aimed at tagging giant bluefin tuna. Successful results on interactions of large bluefin tuna fisheries using pole and line, traps and rod and reel capture methods.

ICCAT 'Skipjack year programme'

Conducted during the period 1980-1982, 35,000 SKJ were tagged in the tropical Atlantic. The results obtained have significantly contributed to a well founded knowledge of biological and population parameters.

ICCAT Bigeye tagging.

Five years research program commencing in carried out in tropical Atlantic waters which included tagging of bigeye together with skipjack and yellowfin (these two latter species being tagged in greater number than bigeye). Program aimed at contributing to well founded stock assessments and sound directed fisheries management (in progress).

US Archival bluefin tuna tagging

Various studies commenced in the late nineties concerning the tagging of giant bluefin tuna using archival electronic tags. The results are beginning to display an unexpected complexity of movement patterns and distribution for this species, and as mentioned are placing an increasing level of pressure on the ICCAT SCRS to abandon its two stock hypotheses.

European projects (EIO / AZTI / IFREMER / GRECV)

Commencing in 1971 and continuing up to the present day, France and Spain have carried out seasonal tagging cruises in the Atlantic using predominantly pole and line methodologies. Up to now studies have been directed specifically to giant bluefin tuna and albacore using both conventional tags, pop-up and archival.

European 'Pop-up and Archival projects'

Italy, Spain & Greece have tagged hundreds of giant bluefin tuna in the Mediterranean using new tagging technology. Good results are contributing to a well founded stock structure and biological-environmental parameters (in progress).

4 Intervention – The project

4.1 Global Objective

The global objective of the project is to improve the contribution that tuna make and will make to the economic and social development of COI member states. This objective can be best achieved by strengthening regional management, leading to the sustainable exploitation of tuna resources in the Indian Ocean.

In the absence of robust scientific data on tuna growth, biology and spatio-temporal distribution patterns, there is a clear need for a scientific programme aimed at collecting these data in the shortest possible timeframe. This is the rationale for the proposed tuna tagging programme. It is clear that for the global objective to be achieved, other measures will also be necessary, including the political commitment to the management of marine resources, effective MCS and the development of more opportunities for local value added for products based on tuna and related species. In addition there is a need to ensure that tuna contributes to food security within the COI states.

4.2 Proposed Scientific Objectives

The effectiveness and desired study outputs are crucially dependant from the outset on the adequacy and relevancy of the specific scientific objectives and the quality of the experimental design. Therefore, particular care has been taken in planning this study to optimise the available resources. In this regard, all planning and analysis have remained closely associated with the goal of optimising the strategies and maximising the amount of useable data collected from the study.

Restricting any of the overarching scientific objectives is not recommended in this study. The study will therefore detail the specific objectives of the project and provide an operational plan, illustrating how they will be met in each area over time.

The objectives for this project should therefore mirror all of the original objectives of the IOTTP, and are summarised and prioritised as follows:

1. Fishing and natural mortality
2. Fisheries Interactions
3. Distribution range, stock structure, migration and movement
4. Growth
5. Effect of FAD's on behaviour and exploitation

Striving to obtain these parameters will optimise the effectiveness of the tagging programme, and ensure that the environmental, social, economic and financial benefits are maximised. Settling simply for estimates of growth and movement as the sole outputs of a clearly costly programme, will certainly address fundamental lacking in the biological parameters, but will not tackle the broader uncertainties of natural and fishing mortality, exploitation rates and interactions between fisheries.

4.2.1 Natural and Fishing Mortality

As has been illustrated in other programmes, such as by the SPC, juvenile tunas have displayed high levels of natural mortality; these observations are still under research. In the Indian Ocean virtually

nothing is known of aspects of mortality for any of the species and there continues to be an extremely limited basis for quantification of these uncertainties. Age specific natural mortality, such as in juveniles can have a broad range of impacts on the status of the stocks (essentially with low juvenile natural mortality, catches of juveniles will have a high impact on the adult stock and vice versa). In addition, accurate knowledge of age specific natural mortality is important to weight the impact of different proposed management measures, such as catch and effort restrictions in purse seine or longline fisheries, targeting younger or older fish respectively. High numbers of conventional tag releases in all areas will be the requirement to accurately address this objective.

Perhaps the most important product of stock assessment are estimates of fishing mortality or the rate of exploitation, and associated stock abundance and biomass size. Without an extremely high level of planning and technical expertise in the design of this study, this will not be achieved. The fundamental output will be a tagged population that is allowed to integrate, or assumed through parameter estimation models, throughout the entire stock. The following are essential requirements in the framework of the study.

- A high level of tagging precision and standardization among all tagging operations
- Accurate estimates of reporting rates, tag shedding and tag-induced mortalities

Implementation of the fieldwork must include the tagging of more than two cohorts over sequential years. This is vital to obtain robust estimates of both age-specific fishing and natural mortality. Past tagging programmes have often restricted the bulk of tagging to surface shoals, thus have tagged predominantly larger individuals of less than three years in age, and so reduced the chance of high recoveries (the tagging of larger sized tuna will result in higher recovery rates) since younger fish are subject to higher degrees of tag shedding and both natural and fishing mortality. This has subsequently created deficiencies in estimations of age specific mortality parameters. Therefore, in order to meet the objectives of the study, and estimate parameters over the desired range of size classes, it will be crucial that during the tagging programme a wide range of sizes by species are tagged, and adequate resources and tagging platforms are proposed with the aim of carrying this out.

To meet these objectives, tagging will need to be directed over broad size ranges in order to cover all age classes and species, on sufficient individuals, and over a long enough period to reduce the effect of possible environmental (e.g. El Niño/La Niña), geographical and biological anomalies.

4.2.2 Fisheries Interactions

Within the analysis, there is a need to assess the interactions between fisheries that are known to exist, such as those between YFT and BET surface (generally younger fish) and longline (generally older fish) fisheries. Information on the scale to which juvenile stocks are being exploited and their effect on recruitment and related fisheries will be dependant on accurate estimates of growth, exploitation rates and patterns and mortality as a function of age, and these parameters can be specifically estimated with the data from a large scale tagging programme. Assessments however, can only be made if age classes are well represented within all habitats and zones, and good reporting rates are obtained for each fishery.

4.2.3 Distribution range, stock structure and migration/movement

Results from a large scale tagging programme which can provide estimates of life history parameters (such as growth, F and M), together with parallel multidisciplinary studies such as genetics and morphometrics will provide reliable stock structure information, which clearly forms the basis for the rational management of these resources and effective management advice.

A large scale tagging programme throughout all the stock areas, with very large numbers of tag releases in all fishing areas is the only accepted way to accurately evaluate movement patterns of the tuna resources, such as large scale migrations to spawning or feeding areas or environmental flux in advective or diffusive movement. Conventional tags will be the primary tags used, however, the full movement of tunas independent of fisheries can only be assumed outside of areas of high exploitation or primary fishing grounds. The use of archival (pop-up and internal) tags can address these issues. Archival tags can also provide valuable information of the depth distribution and behaviour of tunas that are interesting to studies of availability to different gears, such as surface and pelagic.

This should be one of the primary areas of use for archival tags, as these tags can record the historical movement of tagged fish. As archival tags are expensive, they will be released in comparatively small numbers and therefore are unlikely to provide sufficient information to meet alternative scientific objectives, such as estimations of mortality rates.

4.2.4 Growth Estimates

It is accepted that good estimates of growth will be obtained from a large scale tagging study. Various technical considerations are vital here, specifically the need to accurately record size of the tagged fish at both the time of tagging and recapture. Also necessary will be to record precisely the date of release and recapture, especially for fish that have been at liberty during a short period.

Tagging teams will need to be trained and made aware of the importance of precise length measurements at the time of release and equipment and methodologies should be standardized utilising the optimum equipment available. The publicity campaign should emphasize the importance of returning the recovered tags accompanied by information on the size of the fish and the time of recovery. If area-specific and season-specific growth rates are required, tagging should be conducted throughout the entire known areas of exploitation and sufficient numbers should be released. A proportion of the targeted fish will need to undergo specific growth studies, including oxy-tetracycline or strontium chloride injections and the reading of hard parts (otoliths) to validate growth rings. Both the SPC and PFRP have compiled good estimates of numbers of fish that will need to be tagged to address these issues. Growth estimates are thus considered to be the most straightforward objective to be achieved.

4.2.5 Effects of FAD's on movement and exploitation

The high technical requirements needed for an evaluation of relationships between FAD's and the principal tuna species will require the evaluation of all the feasible options based on the best scientific expertise. With the new developments in tagging technology, particularly in the rapid evolution of conventional, acoustic and archival tags (DST, Data Storage Tags), an ever growing amount of data can be obtained on each fish and its environment. As such, it is vital that the optimum resources and technology are integrated within the IOTTP framework, keeping in mind however, that this objective will be specifically addressed both in the French and Spanish National Programmes (TAGFAD) and in the EC FADIO project, hence are considered of low priority in the context of this study, for reasons of study duplication.

However, the overarching objectives of such programmes are considered of interest within the IOTTP, and thus there should be clear coordination between the programmes and a sharing of results, in addition to tagging strategies, infrastructures etc. Archival tags should therefore be integrated into this programme should there be limitations in either the financing or the implementation of the afore mentioned project.

4.3 Proposed Tagging Equipment

The benefits and capabilities of an ocean going pole and line tagging vessel are well known, however a SWOT analysis has been carried out comparing the applicability of longline, purse seine and recreational vessels. It remains clear that no vessel has the capability to cost effectively tag the high numbers of fish required to address the objectives presented and sought under this programme.

To address the global objectives of the IOTTP, a range of pilot and small scale studies have been initiated, tasked with testing a range of methodologies, platforms and gear, as well as facilitating publicity infrastructures and knowledge.

The current status of the IOTTP pilot and small-scale projects are displayed in Annex A II, Table 11.

These studies are ongoing and are addressing area specific questions that in the overall scope of the IOTTP will run in parallel with the use of a pole and line vessel for large scale operations. Pilot and small scale programmes will admittedly provide access to a limited number of fish[8], however they will tag specific size classes not obtainable from a pole and line vessel (i.e. large YFT and BET). Furthermore they will be able to tag in areas or within seasons unsuitable for the pole and line vessel (i.e. before and after the Mozambique channel season using the artisanal Mayotte tuna fishery).

It still remains clear and accepted that a pole and line vessel is the only primary cost effective platform suited to tag (in a reasonable timeframe) the high numbers of fish required to address the scientific objectives.

This programme will therefore concentrate exclusively on the use of ocean going commercial pole and line vessels, however it is vital that pilot and small scale studies are further proposed and developed to complement and ensure all the objectives of the IOTTP are met.

4.3.1 Vessels

It is vital that the same vessel(s) is chartered for the duration of the project, as the quality of any research cruise undertaken on a commercial fishing vessel tends to improve with time, also repetitive costly vessel mobilisation fees will be avoided. Four suitable pole and line vessel options have been analysed in the context of this study, these being:

1. Spanish vessel from (single vessel) over 36 months
2. Spanish vessel from Cantábria (two vessels) over 30 months
3. French vessel from Dakar, Senegal (single vessel) over 39 months
4. Spanish vessel from Dakar, Senegal (single vessel) over 42 months

A detailed SWOT analysis was carried out that analysed each on economic, technical and suitability grounds, including issues considered relevant such as cultural acceptance.

In terms of technical capacity the vessels are fairly similar, although there are concerns over the age and extended capabilities of the French Dakar based vessels. Also the high number of joint venture operations operating in Dakar, and as such limited number of French flagged vessels.

The most preferable option is two Spanish Cantábrian vessels operating together over a two and a half year period.

[8] With the exception of the tagging operations proposed in the Maldives that will be larger in scale with higher numbers of tag releases.

The strengths of this option are detailed:

- Higher levels of programme redundancy
  - Operational constraints effecting one vessel will not compromise entire project
- Higher levels of vessel coordination contributing to higher tagging rates
  - Tuna searching will be more effective with two vessels
  - Exchange of technology and techniques
- Most appropriate option to meet project objectives
  - More likely to distribute higher numbers of tags by species, age class and by area
- Higher technical capability of the Spanish vessels
  - Good technology already installed (bird radars, colour sounders, lateral radar)
  - Range of gear already used, such as *boki ami* nets as well as purse seine (unlike French Dakar based vessels that are only equipped with purse seine nets)
  - Relatively newer vessels over French Dakar based vessels
  - Fewer vessel modifications envisaged
  - Vessel design more suitable for tagging (lower gunnels) over French Dakar vessels that are often converted purse seiners.

Minimum vessel specifications for the purposes of vessel procurement are detailed in Annex IV.

Further fundamental prerequisites to be clearly demonstrated by any proposed vessel should also include:

- Experienced captain in tuna pole and lining and bait fishing
- Experienced crew

It is advised that the nature of the Chartering Agreement for the procurement of the vessels should include:

- All fuel and vessel consumables for period of charter
- All food and onboard provisions for the period of charter (sourced locally)
- All agents fees, regardless of areas or operations
- All crew salaries, travel, and other expenditure
- All fishing gear, accessories and spares

Costs for the preferred option are discussed in more detail in Section 6.1, and displayed in Annex A V – Financing Plan.

Images of both the Spanish and French vessels are detailed in Annex 1, Figure 12)

4.3.2 Gear

The pole and line vessel will primarily use pole and line techniques to capture and subsequently tag and release fish, however alternate gears, that are flexible and not vessel specific, must also be employed to target specific length classes out of reach of surface pole and lining. This will not compromise or replace the necessity of pilot and small scale projects, moreover optimise the capability and capacity, and as such, the cost effectiveness of the pole and line vessel.

Pilot projects initiated and funded by the IOTC as discussed, tasked with investigating alternate gear utilisation, have been undertaken and in some cases completed. As well as meeting small scale/pilot objectives as detailed in Annex A II, Table 11, appropriate transferable gear types and their suitability in this regard, based on the results received to date are summarized:

- **Traditional longline** - Poor application mainly due to low catch rates, poor fish condition and long gear setting and hauling times. Although results have shown that short monofilament sets over short periods of time can tag tunas with low associated mortality rates.

- **Vertical longline -** With modified branch lines, application could be suitable for deeper swimming and larger yellowfin and bigeye, however like conventional longline suffers from timely operations (not quite as much as traditional longline, however catch rates can often be as low as traditional longline). Fish caught at depth are also subject to decompression mortality when fished below 300 metres.

- **Trolling -** With a suitable drag system fitted to reels could be very well applied, however targeting surface schools would poorly compete operationally with pole and lining. Although once pole and lining has been performed around FAD's, trolling at subsurface levels in the vicinity may provide access to a limited number of larger sized YFT. Trolling could therefore be used from small platforms around FAD's such as on the Seychelles Plateau and around Mayotte.

- **Handlining -** *Ika shibi* and *palu ahi* style handlining and vertical jigging will target large yellowfin and bigeye outside of the reach of pole and line vessels, and surface handlines will target smaller tunas. Both can be applied onboard a pole and line vessel either in parallel or independent of pole and line operations (Itano 2002).

- **Vertical rod and reel** – Good results on larger individuals however tagging rates can be low. In concept very similar to handlining.

As more pilot and small scale projects are executed, techniques suitable for application on the pole and line vessel can be analysed further, and applied where appropriate. However at the current time, it is proposed to implement large scale pole and line as the primary gear type, alongside onboard handlining and rod and reel methods.

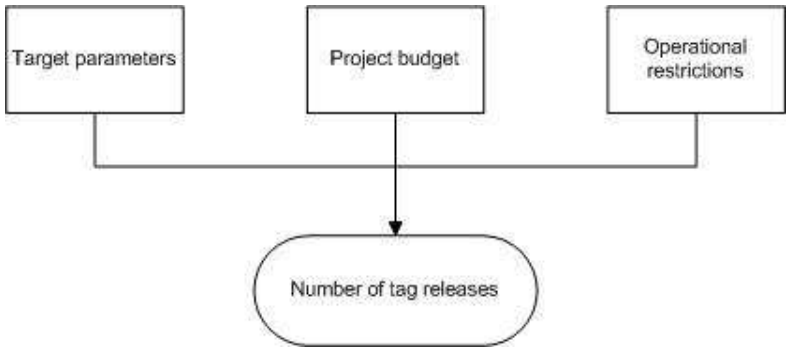
Prior to large scale application, it is recommended that an evaluation on the tagging of large tunas and associated mortality rates caused by handlining techniques, be carried out by fishery independent means such as sonic tracking (Itano 2002). A specific pilot project could be designed and coordinated with FADIO (FADIO project is discussed further in Section 4.9).

4.4 Tag Release Strategy

4.4.1 Optimum numbers of tag releases

The number of tags to be released within a large scale tagging study is crucial, as both the financial budget and the level to which any scientific objective can be achieved, are derived from accurate target estimates. Furthermore, a coherent design of the release strategy will optimise the cost/benefit ratio.

The three fundamental components that affect the number of tags that can be released in a large scale tagging program can be summarized as;



Target parameters will limit tag releases as only sufficient tags need be released in order to address the specific objectives being sought. Under-tagging will simply compromise the target objectives of a study and over-tagging will produce negative financial implications and budgetary over-spending. The project budget will have a significant effect on the scale of target releases, as the placing of the tags is the most fundamental and significant cost to a study (e.g. chartering of tagging platforms).

The largest operational restrictions for a pole a line vessel in the context of this proposed study is the supply of live bait. This subject has been up to now a significant issue within the IOTTP, concerns being adequate supplies of live bait resources and the suitability of tropical baitfish. The issues with live bait and supply options are discussed in more detail in Section 4.5.

Within a tag and release study it is the number of tag recaptures that determines the statistical robustness of the results obtained from the analysis of the data. Recovery and reporting rates are thus vital, and will be discussed in more detail in Section 4.6.

Large scale tag release-recapture programmes initiated to provide key parameter estimates for fisheries management can often be undirected at the outset due to a high number of assumptions and uncertainties, however computer simulations for guiding tag recapture programs are now becoming more widely used. They look to fine tune release estimates and the robustness of associated recapture data, by modelling possible scenarios concerning fish behaviour and dynamics and responses of the fishery to these. Also fleet participation (assuming recoveries are proportional to catch) and reporting rates can be adjusted.

Limited work has taken place for all the principal tuna species[9] and significant results cannot be expected between now and the commencement of this programme. Their application is however iterative, as such, they would clearly be valuable tools to develop as the project progresses as and when data is received and processed, to organize hypotheses and guide how best to use the tag releases to progressively discard some of the hypotheses. It is therefore imperative that the PMU embark on simulations as soon as possible once the program is up and running in order to better guide aspects of study progression. IOTC are proposing to embark on those for YFT and BET as soon as possible in the context of the pilot studies.

Simulation studies will therefore be used to estimate the reduction in the variance of key parameters that could be expected from the analysis of the tagging data (i.e. a certain number of recoveries). However at this stage it is not possible to specify such a target reduction in variance. Therefore the most cost effective option, within the limits of the funding available, is to optimize the allocation of the funds in order to maximise the reduction of variance. Including maximising tag release strategies and the number of tags released.

[9] Except the publication undertaken by Maury, IRD, 2000, specifically concerned with SJK, and Bertignac concerning YFT

A target of 80,000 fish is stated within the Terms of Reference of the study, similar in size to the SPC RTTP programme. However until the project is underway and target operational objectives become better defined, an exact number cannot be specified.

Subsequently all planning, costing and time management should therefore centre on achieving a desired minimum number of tags, in this case 80,000, with an unspecified maximum. This provides a framework for the project that will then be to be guided both by simulations, operations and objective meeting.

Within SPC's RTTP an average tag/release rate can be calculated of 220.85 per sea going day[10] (RTTP, 1993), with annual targets of 40,000. Furthermore, in the prospective cruises conducted by two Spanish pole and liners in 1981, and one in 2001, CPUE values[11] indicate average catch landing rates of 287 for days at sea[12] (Cort 1983), and 117 in 2001 *(FV Faro Vilano*).

During the field activities conducted prior to or after the main seasons, there is always a risk of lower than predicted tagging rates. Further studies, instigated by the PMU, are therefore recommended that will use environmental, oceanographic and operational data to evaluate on a case by case or area by area basis a more precise probability of meeting the target numbers. This will clearly be instrumental to the overall success of the field studies.

A sensitivity analysis has been constructed to better guide financial planning for the project. Various options for both total target numbers and daily tagging rates have been analysed. Although these do not necessarily represent limit numbers, tagging targets at 10,000 intervals ranging from 70,000 to 250,000 have been presented with associated daily tagging rates required to meet these targets (for each vessel operating over 2.5 years). The potential cost implications are discussed in more detail in Section 6.1.

4.4.2 Spatial and temporal coverage

To address the scientific objectives of the study it is clear that tag releases need to occur not just in adequate quantities but also across all age classes and within all known areas of exploitation. A fundamental assumption within a tagging programme with objectives such as these is that the tagged fish are representative of the population. As such there must be sufficient mixing of tagged fish with the population and good representation of tagged size classes (Hampton 2002).

As so little is known of the behavioral aspects of tuna in general it cannot be assumed that a high number of tag releases in one location will eventually be sufficiently mixed into the population in general. Furthermore, there is ample evidence that mixing levels are mainly a function of the time at liberty. As such, tag releases need to be scattered as much as possible geographically. Much of the decision making and target seeking therefore must stem from a good communications chain between the tagging vessel and the PMU.

This does not negate the fact that the cruise leader(s) must be a proficient scientist and always capable of making the 'best possible' decision at sea, that is, decisions such as whether to tag a certain shoal or when to move or undertake another task etc, should **not** ultimately lie with the PMU.

Maximising tagging rates while maintaining focus on the study objectives is paramount to the success of the project and coinciding intensive tagging with increased fleet activity is clearly a tool. It follows that

[10] This is an average as many days could be spent with extremely low tag/release numbers ranging up to a 1000 or more in a day

[11] Tagging rates will not be equal to CPUE rates, and are likely to be lower, as less rods would generally be available

[12] Tuna fishing days not days spent prospecting and catching bait

heightened surface catches of a pole and line vessel should be directly related to greatest level of purse seine activities by area.

Purse seine fisheries perhaps more so than other fisheries, have a large degree of spatial structure[13]. Therefore, releases should be in areas of concentrated fishing effort, because the fish are more abundant in these areas, or because such areas are more viable and accessible to both fishing fleets and therefore a tagging vessel (Hampton 1994).

Directing tagging close to or within areas of intense purse seine fishing will increase frequencies of tag recaptures from a tagged population that has not sufficiently mixed with the overall population. Tagging operations three to four months prior to peak purse seine fishing activity, as stated by Hampton (2002) might be sufficient to allow adequate mixing.

So a series of pole and line cruises around peak purse seine seasons in the Western Indian Ocean will maximize tagging rates, but the spatial and temporal strategy of releases must take into account the objectives of the project.

The main objectives are re-presented in Annex A II, Table 12 together with the corresponding requirements needed to meet them. These could be modified according to operational parameters such as environmental conditions, fleet activity, baitfish resources and relevant results of the pilot studies where appropriate.

A series of pole and line cruises should therefore be planned by the PMU in the WIO over a two and half year period, taking into account the specific autonomy and operational capacities of the chosen vessels. As the vessels move between areas, base ports from which they will then operate from and trip lengths will vary. Both the PMU and the cruise leader(s) must ensure that the overarching objectives being sought in each area are consistent with a coherent project cycle of implementation.

4.4.3 Tagging in the EIO

It is proposed that this study will concentrate on tagging in the WIO in association with the primary purse seine seasons as discussed. However as mentioned, tagging must really occur in all areas of exploitation. Limitations in tagging in the EIO may therefore directly affect the interpretation of results from the WIO, for example some movement or migrational estimates might well be misinterpreted as being natural mortality, and localised exploitation rates as global.

As such in the context of this study and in parallel to the IOTTP framework, it is recommended that every possible effort should be developed by the IOTC MS's to propose and conduct in parallel a similar large scale tagging programme in the EIO.

4.4.4 Tagging efficiency

An efficient use of both drifting and anchored FAD's will allow a higher number and diversity[14] of fish to be tagged. Furthermore both small and large size individuals of the three main species can be sourced from FAD's.

The operations of the pole and line vessel(s) should therefore utilise FAD's and seamounts and their effect to aggregate tunas. Both the SPC and PRFP used them to increase the efficiency of the tagging operation (Hampton 2002, Bailey 1993, Sibert 2002). In phases of the PFRP, FAD's and seamounts

[13] Fishing seasons are related to fishing area, and time stratification would imply area stratification

[14] Of the principal species of YFT, BET and SKJ.

were instrumental to the overall success of the program, as they contributed to the vast majority of both release and recaptures.

The IOTC WPT (2000) collated some excellent information on such strategies from other tagging studies, however every source of method to optimise and increase TPUE (tag per unit effort) should continue to be researched and tested by the PMU and the tagging vessel.

Construction materials and equipment costs for the deployment of FAD's to be used within pole and line field activities are thus detailed and quoted within the project budget, under Annex A V – Financing Plan, Tagging Equipment and Supplies.
To distribute tags in all areas, throughout all length classes, within multiple cohorts, and obtain optimal mixing rates, the tagging teams must be extremely flexible and skilled, and equipped to make decisions at sea to guide the cruises and optimize tagging efficiencies while maintaining the target objectives at all times.

As such the vessel contract should clearly define the responsibility of each party (boat owner and captain on one side, the PMU and the scientist (cruise leader (s)) in charge on the other side).

4.5 Bait resources

The operations of tuna pole and line vessels, as proposed for the programme, are totally dependant on a continual and adequate supply of live bait. Tropical live bait is normally caught by a vessel in lagoonal waters, or around coral reefs and banks. Between 2,000 to 4,000 individual fish (are needed for one day's pole and line fishing, depending on the size and the amount of bait also thrown over the side to act as chum FAO Technical Paper 282). Dead bait and alternatives are significantly less effective and hence not recommended unless absolutely necessary, as they would compromise the tagging potentials of the vessel (except when using alternate gear types).

A pole and line vessel is traditionally/commercially tasked with being self sufficient; in the sense they are equipped either with *boke-ami* (blanket nets) or purse seine nets to capture live bait, and specialist tanks in which to store it. As such a vessel will prospect, catch and store quantities of bait based on their operational needs[15]. It should be stressed that the majority of live bait species from the tropical Western Indian Ocean are fragile, underlining the importance of well founded experience of the vessel crew in the use of the *boke-ami*, as the preferable way to catch wild bait (even *Decapturus sp*, fished in La Réunion were found not to be that robust and subject to a high capture mortality if fished by purse seine nets (Taquet, *per comm.*))

Apart from a very well established pole and line skipjack fishery in the Maldives, the Western Indian Ocean does not have a long history for supporting pole and line commercial fleets, a brief summary of such activity with particular relevance to live bait is displayed in Annex A II, Table 13.

The acquisition of bait has been a significant factor responsible for limiting vessel operations. What is clear from looking at Table 13 is that when suitable baitfish has been caught, the resultant fishing has been encouraging.

The IOTC WPT has collated some valuable information on bait resources available, furthermore pilot studies proposed include a comprehensive desk study on baitfish resources in the region, and a sounding prospection cruise to be undertaken by the SFA Research vessel. Furthermore, it may be possible for a master fisherman in bait fishing to be sourced from Spain to undertake trials on the Mahé Plateau.

[15] In some exceptions operational pole and line fleets for example in West Africa, Bay of Biscay and the South China Sea, by French, Spanish and Japanese fleets respectively will on occasion depart port with adequate supplies for a fishing trip, thus negating the need to compromise fishing time to search for baitfish.

When the results of such are compiled the study will be much better placed to address these issues with more certainty, however a vessel equipped with the skilled resources and experience to trial a range of capture and holding techniques is clearly mandatory, and as such minimum specifications of both the resources and vessels must reflect this.

Should the vessel(s), however, be able to receive the supply of bait from regional holding/rearing/penning facilities then the situation very much changes. Bait can then be provided as and when the tagging vessel(s) fails to be self sufficient in a particular area thus optimising chartered vessel operations.

Furthermore, specific species of bait known to be effective for tagging purposes, can be selected for holding or rearing, providing the vessel with a more robust species that would suffer from lower holding mortality, and subsequently a higher tagging efficiency.

4.5.1 Supply Options

Given the large geographical scale the tagging vessels are likely to cover, a number of supply options for bait have been identified in the region, as detailed in Annex A II, Table 14. These are in addition to natural aggregations of bait that, based on previous campaigns (Cort 1983) and commercial ventures (COMANIP, 1971-1973), are expected to be available, particularly those within Northern areas of the Mozambique channel.

Procurement from operational penning/rearing facilities in Mayotte, La Réunion and Madagascar will be relatively straightforward, and it is therefore encouraged that the PMU coordinate with these organisations to instigate the logistical and species specific stocking and transporting arrangements.

Encouraging levels of *Sardinella* spp. have also been recently isolated in areas off Oman (*Anganuzzi* per comm., 2003.). This should be further developed and researched as this would appear to be a very encouraging source and supply for utilisation for field operations in the Somalia basin, an area previously thought to present the largest problems, due to distance from perceived bait grounds and bait holding/rearing facilities.

A feasibility study for the installation of bait holding facilities has shortly concluded in the Seychelles undertaken by ARDA based in La Réunion. As well as identifying suitable species suitable for tuna tagging they undertook a detailed study to assess a range of facilities in relation to the following aspects:

- **Physical** Concerning both physical and oceanographical conditions and their effect on bait holding structures in the Seychelles
- **Logistical** Concerning the relationship between chosen sites and the regional infrastructure required to service and access the facilities.
- **Environmental** Concerning any environmental issues that may impact on the facilities
- **Conflicts** How the facilities could conflict with other usage in the surrounding areas, such as tourism, fisheries and nautical traffic.
- **Administrative** Facilitation that may be required for implementation, e.g. legislation, permits etc.

At the time of this report both the IOTC and SFA are finalizing the preparatory and feasibility studies preceding installation in the Seychelles.

4.5.2 Costs

Costs of live bait options will be integrated into the programme at levels of dependence, as costs ideally should relate to a number of scenarios, ranging from a high vessel(s) self sufficiency at sea, (low supply), to complete dependence on penned live bait supplies (continual supply from all areas). As this information cannot be known at the current time, redundancy has been incorporated into the project to ensure that risk, of which this issue possibly represents the largest, is kept to a minimum.

As such bait costs have been costed on the assumption of total reliance from the pole and line vessels or continual supply, using preliminary costs provided by ARDA. They include infrastructure and equipment set-up in the Seychelles and full supply to the pole and line vessel while operating on the Mahé Plateau. Furthermore supply costs have been included from other sources in the region as identified in Annex A II, Table 14, for when a supply from the Seychelles is not feasible.

Costs for this item are detailed under 'livebait' within the project budget, summarized in Section 6.1, and more specifically displayed in Annex A V – Financing Plan.

4.6 Proposed Tagging Methodologies

4.6.1 Tag implanting

Although variable tagging mortalities will not directly compromise objectives centered on the primary biological parameters such as growth and movement (unless in extreme circumstances where too few are tagged), they will certainly prevent scientists from obtaining unbiased estimates of mortality and specific interactions. Although a pole and line is clearly the most suitable platform, the quality of the tagging technicians and methodologies implemented must be kept at a maximum at all times.

Therefore it is recommended that:

- Tagging technicians are skilled and experienced in intensive tuna tagging
- The numbers of the teams are kept to a minimum to maintain quality standardisation (4 teams of 4 people throughout the entire tagging campaign, each team will then be composed of three COI MS's technicians)
- The techniques are well founded and standards are agreed
- The presence of an experienced scientist is required onboard at all times as chief in charge of field operations (cruise leader(s)).

4.6.2 Estimating Tag Shedding

As discussed above, a standardized and high quality tagging methodology will reduce the mortality associated with tagging and will prevent high levels of tag shedding, or the loss of tags from targeted fish.

Above and beyond shedding as a result of faulty implanting procedures, estimations must still be carried out of the level of shedding that occurs as a result of any other cause, whether it is biological, environmental or a fault in the design of the tag. As such it is recommended that a proportion of the fish are double tagged, as this will enable the calculation of shedding rates. Hampton suggests that 1,000 – 2,000 fish are double tagged per species.

4.6.3 Tag recoveries

With such a multitude of fishers exploiting different species and sizes in such a range of fisheries, the opportunities for tags to be recovered are likely to vary greatly between fisheries.

4.6.3.1 Artisanal and small scale

Tag recoveries with artisanal fisheries are likely to be extremely difficult, mostly as a result of the vast number of landing sites in each location and country within the whole region. Recoveries are more likely in the smaller island states such as the Maldives, Mauritius, Seychelles, Comoros and Mayotte. It must be underlined that accurate measurements of recaptured fish are essential in order to avoid compromising the use of recoveries for estimating growth rates.

4.6.3.2 Longliners

Longline vessels will almost certainly recover tags while at sea as the methods by which they process fish is extremely thorough, and failing to observe a tag is unlikely. However, freezer vessels operate continually in high seas and offshore areas and transhipp their catches at sea rarely using ports in the region. They operate exclusively from the primary base ports of Kaoshiung and Singapore and undertake trips ranging between 12 and 36 months.

4.6.3.3 DWFN's – Purse Seine

Within Port Victoria approximately 84% of the annual total catch of Western Indian Ocean tuna (approximately 260,000 MT) is either transhipped and reefed to Port Louis, Diego Suarez or Mombassa, or discharged directly to the canning plant (approximately 30% of total captures). The canning plant in terms of its 465MT daily production rate is now considered to be the largest in the world. Direct discharges (vessel to plant) in Diego Suarez only occur in the main season in the Mozambique Channel from March to May, and are very rare in Mauritius and Phuket. The frequencies of direct discharges in Phuket increased throughout the last El Nino event displaying shifts in the fishery, however this is not common at other times.

Opportunities for recovering tags throughout purse seine operations (from capture to canning), with associated hypothesized shedding risks are displayed in Annex A I, Figure 14.

The nature of a purse seine operation at sea provides very few opportunities for the recovery of both tagged fish and tags, however if observed, it is at sea where the best opportunity is to find the tag still attached to the fish. With any increased handling of the fish in port, the risk of tag shedding increases, especially if the fish is transhipped rather than directly processed[16]. The most likely place to locate recovered tags is within a factory, associated with direct discharges in the Seychelles and Diego Suarez, over Mombassa and Phuket, or from any reefed supply.

The high proportion of tag recoveries originating from canning plants however can reduce the amount of information one is able to get from the fish, should the tag alone be retrieved. However with a responsive tagging unit and a high level of directed publicity within the factory, full biometrics of the fish should be straightforward to obtain if a tagged fish is observed. In addition it should be possible to reference the tagged fish, not just to the vessel, but also to the tank. Such information when cross referenced with logbook and vessel data will then provide both capture and location data.

[16] Tag design and material is becoming particularly adaptable to such conditions and is ever reducing the risk of tag shedding with handling (plastic is being made to withstand low temperature without breaking and once a fish is tagged within one or two weeks muscle and other tissues maintain a strong bond with good designs).

4.6.4 Estimating tag reporting rates

As a result of long trips getting tags back from longliners is clearly one of the most significant issues, but perhaps even more important is estimating the reporting/non-reporting rate. Any results of a tagging program must be representative of both the fishing and natural mortality of the whole population. Therefore accurate estimates of reporting rates must be achieved for all the fisheries that exploit principal tuna species in this area[17].

Factors potentially affecting reporting rates from WIO fisheries include:

- The high number and geographical range of artisanal fisheries
- The high number of DWFN longliners, particularly FOC vessels
- Low tradition of regional tagging programmes

4.6.4.1 Artisanal and small scale

Given the large variability in artisanal fleets operating in the region, it will not be possible to obtain accurate reporting rates for many of these fisheries. However, for the majority of the most important artisanal fisheries tag reporting rates will not significantly effect results *(Hallier per comm*.), and estimates could be close to 75% from this sector *(Fonteneau per comm.)*

Annex A II, Table 15 displays recent catches together with an associated prospect for tag reporting.

Artisanal catches from the Maldives represents close to 40% of total Indian Ocean catches and, this combined with previous successful tagging studies in the Maldives has illustrated that tag reporting rates from this sector can be encouraging.

4.6.4.2 Longliners

Korean and Taiwanese owned and managed freezer longliners pose the largest threat to estimations of reporting rates. Without some form of dedicated third party intervention/observation there is no probability of obtaining an estimate of reporting rate. Various schemes[18] have been experimented with for estimating reporting rates that do not require observers, but most involve cryptic tags (e.g. PIT tags) and port monitoring schemes. The Japanese have vetoed the use of PIT tags[19] for the tagging of

[17] This may not be completely necessary, as this will depend on the nature of overlap of selectivity patterns of the various fisheries.

[18] CSIRO and JAMARC

[19] In contrast to radio tags, which have a certain battery life, PIT tags contain a small computer chip that transmits its code only when induced by an external energy source (passive). Although only developed in the mid-1980s by NMFS scientists, PIT tags have already provided a wealth of information about the distributions, migration timing, migration rates, and survival of juvenile salmonids. There are currently two operating systems which are unfortunately not compatible: Trovan and Destron (http://www.electronicidinc.com/, http://research.nwfsc.noaa.gov/TM7/TM7-PIT_tag.html).

Regarding the size and design of tags 12 mm PIT tag, which have been the most widely used have limited detection ranges (18 cm maximum in water, 23 cms in air), these systems have the major disadvantage of having to restrict fish movement through a small area, and in the case of being applied above canning conveyor belts would be insufficient in range and practicality. Field applications of 12 mm tag technology have been limited (Armstrong et al. 1996; Armstrong et al. 1997) and most applications have been restricted to hydroelectric structures (Prentice et al. 1990a) and laboratory applications (Jenkins & Smith 1990; Fängstam 1993; Brännäs et al. 1994; Muir et al. 1994; Alanärä & Brännäs 1997). New, larger PIT tags (23 mm length x 3.4 mm diameter; manufactured by Texas Instruments http://www.ti.com allow a much longer read range than 12 mm tags (up to 1 metre in water, and possible well in excess of this out of water). Long-range PIT tag technology has been specifically developed to monitor movements of fish through large orifices (Castro-Santos et al. 1996) such as in DAMS; and multiple antenna arrays have allowed comprehensive monitoring of the entire width of a small stream (Zydlewski et al.). This system has been successfully implemented and validated for continuously monitoring seasonal movements of Atlantic salmon parr and smolts at 93% efficiency (Zydlewski et al.). Long-range PIT tag technology such as this may can be developed and possible introduced into purse seine supplied canneries.

southern bluefin tuna, and port monitors are useful only for those fleets that transship in port or discharge at home (Japan), and as such exclude the other Asiatic freezer fleets.

> The consultants have been in contact with JAPAN TUNA and discussed the technical grounds for which they vetoed the tags based on trials undertaken by CSIRO. It is the opinion of the consultants that with the availability of new technology in this field and the overall benefits the application off these would bring, that every effort is made to facilitate their application. It is therefore highly recommended that both the IOTC and PMU continue research towards the application of 'PIT' tags.

Further issues revolve around those freezer vessels that are classed as 'Flag Of Convenience' (FOC), where reporting rates are likely to be particularly unpredictable and non estimable, especially for those vessels that engage in illegal fishing activities, that will almost never report a recovered tag, irrespective of the level of reward.

Ultimately conceding that mortality estimates are unlikely to be under estimated due to estimation problems and non-reporting, one can conclude that tag returns will provide minimum mortality estimates, growth and movement data (albeit biased).

The most valuable source of reporting rate in longliner fisheries in other regional tagging studies facing these issues, has clearly been the data collected by observers, however in the context of this study this is a serious issue due to the logistical constraints faced by observer deployments on vessels that rarely use ports in the WIO and the large fleet size. This is compounded by the number of observers that would be needed, as estimates would be wholly based on observer reporting rates[20].

> Clearly this subject and any reliable outputs, categorically requires the advice and cooperation from Taiwanese/Korean and Japanese shipowners, and it is highly advised that links develop initiated by the IOTC PMU. (Such contact should in the first instance be directed to the principal boatowner associations, such as TWDS, EE&S, TTA, JAPAN TUNA and CWT, the largest associations in Taiwan, Japan and Indonesia respectively). Lack of cooperation particularly from FOC vessels will certainly present more grounds for increasing pressure to be placed on this sector.

The longline sector includes however, a number of smaller vessels, or 'ice' longliners that only undertake trips ranging up to two weeks. A large proportion of these vessels are already targeted by the IOTC/OFCF Port Sampling schemes (Sri Lanka, Thailand and Indonesia) or by national technicians (Mauritius, Malaysia and Seychelles). The infrastructure and framework is thus in place for reliable reporting from at least a proportion of this sector.

4.6.4.3 DWFN's – Purse Seine

Owing to the regularity of operations and the exclusive use of the regional ports of Diego Suez (Madagascar), Mombasa (Kenya), Port Victoria (Seychelles) and occasionally Phuket (Thailand) as mentioned, estimations of reporting rates from European managed purse seiners can be considered to be the most consistent. Russian fleets however, provide no data and statistics and transship at sea, this could affect the use of tags (and data) returned (if any are returned) from this sector.

Tag seeding

The weakest component of tag attrition models for assessing stock abundance is estimation of tag reporting rates as discussed. This rate varies by date, fleet and by landing location. Any biases of this

Displays a wide range of distributors and manufacturers of PIT tags
http://www.pittag.org/Software_and_Documentation/pitvendors.html; http://rapidttp.com/transponder/supplier.html

[20] Observed rates would not be used to fine tune fleet reporting

would be mirrored in estimates of stock abundance and natural and fishing mortality values. Analyses must therefore take into account results from tag seeding experiments to estimate reporting rates.

For some fleets and data sources in the Indian Ocean, particularly those mentioned within the artisanal sectors, data cannot be expected to improve in any reasonable timeframe. Comparisons of the tags returned to catch ratios both by fleet and area could therefore be made to attempt to estimate reporting rates for fleets and fisheries. Variances and anomalies should be calculated from the outset, this will reflect as much as possible the variations in any observed reporting rate. It is recommended that a suitable model be developed by the PMU to represent reporting rate as a function of landing/transhipment location, time and fleet, to allow estimations in cases where tag seeding is not possible.

The purse seine fleet in the Indian Ocean operating in the WIO presents an ideal basis for a tag seeding scheme within the tagging programme[21]. Seeding tags, (tagging and placement of tags at time of capture) will provide very good information to fine tune reporting rates and the PMU should specifically research and implement these experiments within suitable fleets and areas.

Based on literature and from discussions with the SPC it is proposed that monthly targets of between 75-100 seeded tags per month should be obtained throughout the entire programme.

Such experiments will also provide opportunities to implement different types of conventional tags. In addition to the use of spaghetti tags, BETYP tags were used within the ICCAT Bigeye Programme, which were devised to be implanted while fish remained in the water, with a lance. However, because of larger double barbs on the tag, concerns have existed over increases in tagging mortality (Hallier, *per comm.*). However, since these tags are more firmly implanted in dead fish than conventional (spaghetti) tags, they are more suitable for tag seeding experiments.

4.7 Publicity and Rewards Schemes

4.7.1.1 Publicity

Major components of an effective publicity campaign that seeks absolute maximum returns from a tagging program, should take into account:

- The isolation of all stakeholders in all areas
- The operational dynamics of all fisheries
- The un-proportional length of publicity campaigns to tagging field activities (they need to continue well after field operations)

The WIO has significant issues that are likely to directly affect both the direction of tuna tagging publicity campaigns and the length over which they are implemented. Current issues include:

- Absence of history of tuna tagging
- Large range of people groups and nationalities exploiting the resources (including languages, cultural and socio-cultural issues)
- Large high seas fisheries component of the industrial sector
- Large geographical areas involved

One of the most significant shortfalls of other regional/large scale publicity campaigns has been a lack of information actually reaching the target audience, hence compromised reporting rates. It therefore cannot be assumed that the situation will be addressed by distributing posters to commercial companies, processing and predominant marketing outlets. In the SPC and other tagging programs particularly those

[21] Observers used in the bycatch estimations within the EU National Programmes or other programmes already operational within these areas could assist for this purpose

conducted by CSIRO, tag returns are frequently coming from quite random areas, often including those not previously directed with publicity. In part this can be attributed to the particular behaviour with regard to tag recaptures by Philipino and Indonesian fisherman that would often keep recovered tags as 'good luck charms', in this regard the local populations can be considered to behave differently (Ardill 2003).

Posters detailing the nature of the programme, contact details, reward etc. and in all appropriate languages, such as those already developed by the IOTC would be very suitable (an example poster from the Mayotte pilot programme is annexed in Annex A I, Figure 13), and should therefore be distributed not to as many organisations as possible, but rather by selected or concentrated targeting. Although detailed statistics are needed for landings in any area where you are using recovery data for any objective other than growth or movement/migration, it would not be cost effective to over invest in areas.

Subsequently, efforts should be concentrated in the following areas from where statistics and sampling is established: Port Victoria, Port Louis, Antsiranana, Phuket, Penang, Colombo, Benoa, Muara Baru, Cilacap, Maldives, Oman and possibly Iran, together with areas where Indian Ocean tunas are known to be transhipped and landed, such as Spain, Italy and various Asian ports.

Distribution of posters/reward/publicity information within these landing sites, communities, market areas, and other outlets will take time and require local support and coordination. It is recommended therefore, that these countries nominate a 'Tagging Representative' within their research centre/organization that is responsible for publicity, and national distribution strategies and the distribution of rewards and tags. The project will not bare the cost of the 'Tagging Representative', as this is considered to be under the auspices of the IOTC framework (and this would be the responsibility of the respective government). However, the project will account for the cost of duty travel and communications, and as such is included in the project budget within the duty travel and operations of the PMU), Annex A V – Financing Plan, Regional liaison.

For countries that are not members of the IOTC, and have significant fisheries, such as the Maldives, it is recommended that the IOTC continually reinforce their links with them and encourage participation within the programme to facilitate future publicity.

With the development and execution of the IOTTP small scale/pilot studies fisherman are becoming sensitized to tagging programmes significantly contributing to effective large scale publicity and reward campaigns.

It will be necessary for the PMU to develop and concentrate on publicity research that takes into account not only all IOTC/OFCF Port Monitoring Schemes, but also other publicity from IOTTP small-scale/pilot studies and also the capacity and commitment of respective countries.

National semi-industrial and artisanal fleets

This will be primarily covered by national representatives and will be relatively straightforward as fishermen in the region were found to be particularly sensitive to such a programme.

Recommended publicity is detailed:

- Posters dispatched to all operators, handlers, storage companies and shipowners organisations
- Radio, newspaper and television campaigns
- Direct visits to vessels in port through 'port monitoring programs'

With the links and expertise the IOTC currently has at their disposal, it is clear that results will be obtained from this sector, and the objectives of the programme will not be compromised.

Distant Water high seas fleets

Clearly designing publicity for the multitude of industrial and high seas fleets exploiting tuna is a complex task, but with a high level of coordination, direction and applied experience, results can be very positive. Primary areas recommended for directed publicity are detailed in Annex A II, Table 16

4.7.1.2 Communication and Ground Truthing

Coherent results are very much dependant on continual communications with target fleets in the fisheries. The IOTC/PMU is extremely well placed in this regard as they will probably be able to communicate often (by fax) with target fleets.

Some offshore fleet associations, specifically Japan Far Seas, Japan Tuna, and TWDS fax regular newsletters to the vessels. Accessing these and appending tagging details and publicity is therefore highly advised. Such details will subsequently contain contact details for tag returns. Tag information can then be faxed directly from vessels to the PMU, with certificates promptly returned in the appropriate language to the skipper, detailing how the reward can be collected and also release information (copies should therefore be prepared in the appropriate languages). Such information to the vast majority of masters is likely to be more valuable than the payment itself. The skippers are then encouraged to return the tags to their national fisheries authority where the 'Tag Rep' is responsible for their return.

For most DWFN's a form of certificate is a good form of positive feedback to the fleets, and perhaps the only. It has proved a very successful tool in PFRP, SPC and CSIRO programs and continues to maintain good tag return rates.

Regularly visiting vessels where possible (with locally hired interpreters if necessary) can be very useful, as frequent communication with skippers will promote awareness of the programme. This will be fairly straightforward in ports where an IOTC/OFCF sampling programme operates. It must also be clear the way in which the samplers operate and what information they must strive to collect. Their main duties in this regard can be summarized as:

- Collection of tags and recapture data (from the fisherman)
- Collection of tags and recovery data (from the handlers and cannery workers)

This should then be followed up with a very prompt payment of the reward, and where possible verification of the associated data. Furthermore the sampler should be in possession of tag release data that can be exchanged with the fisherman. This may overcome any errors on behalf of the handlers and also ensure a high standard data submission associated with recoveries.

> If the fisherman, handlers and cannery workers see that the tag sampler is proactive and interested in the data, can cross check data with release information and apportion rewards immediately, then tags are likely to be returned promptly with the best possible data (Bayliff, 2003).

The PMU should keep all means at its disposal to communicate with the target fleets and feed them back information for the duration of the tag recovery programme. Nothing is likely to compromise any objectives in the whole system more than word getting out from just one fisher that he sent a tag in and never got a reply.

4.7.1.3 Costs

Publicity

Publicity campaigns and the costs of implementing them appear to vary drastically between programmes, as to be expected. The original IOTTP recommends 1% of the total budget for publicity. In the context of this study publicity costs have been identified separately underlying its importance.

Rewards

Within the vast majority of tagging programs rewards for the return of tags have consisted of either relatively small cash payments, T shirts, hats or some other small gift item of clothing with the logo of the tagging program embossed. These are recommended for inclusion into this study, as these types of gifts appear to be appreciated by fisherman, dockers and cannery workers in many developing countries.

The SPC with good reason considered the risks of non-reporting of recovered tags to be main hurdle to overcome. As mentioned previously this is exacerbated in large scale programmes such as these as recoveries could originate from such a large catchment area, and from such a diversity of fleets. The SPC, therefore reviewed their original proposed reward per tag from $20, and increased it to $50, in the form of cash returns and/or an annual lottery (SPC RTTP EC Proposal Document, 1988). Based on a 7% return rate from an annual release rate of 40,000 per year for two years, costs were originally proposed to be $224,000 or 6.4% of the overall budget.

It is possible that the reporting rate from the Indian Ocean as a result of the assumed high fishing activity and associated pressures is likely to be considerably higher, between 15-20%. However, until the programme is operational, this cannot be confirmed. Furthermore the absence of definitive tagging targets compromises obtaining a fixed cost for this item.

Reward costs, as detailed in the budget, for conventional tags have as such been calculated based on a slightly higher reporting rate of 25% (including some contingency for this item) for the entire project with a fixed cost per tag of $5 (based on a target of 150,000 for purposes of obtaining a budget for this item). Rewards for archival/pop-up tags that will be used in lower numbers are commonly between $500 and $1000 reflecting their rarity, higher cost and greater scientific value. At this time rewards for 200 tags at $500 have been included in the budget. As the project is underway annual lotteries (of approximately $1000) should be introduced also the construction of a 'reward scale' ($5 or cap for one tag, double the reward for one tag or a jacket for two and so on), for as these have proved to be very valuable tools within other larger scale tagging programmes.

Senior Managers in all large scale regional canning plants (Mauritius, Seychelles and Antsiranana) expressed concerns of having posters in the factories publicising monetary rewards, as this would be looked on as too much of a distraction for the workers. In such cases it may be advisable for the PMU to engage in further discussion with them regarding this, perhaps having a T shirt, cap or item of clothing as the reward.

Rewards distributed to longline (DWFN freezer vessels) reported tags are unlikely to be possible, as such should be reflected instead in a prompt reply of a certificate and tag release information.

Seeded tags (as mentioned in Section 4.6.4.3) will be rewarded the same as an ordinary tag recovered from a tagged fish, so as to avoid any financially driven false declarations.

4.8 Data Analysis

4.8.1 Catch and Effort Data

Due to the broad range of fisheries that exploit the principal tuna species and new statistical requirement that activities under the IOTTP bring, it is vital that data is accompanied and supported with Catch and

Effort data from all sectors including size sampling. These statistical needs are essential for achieving optimal efficiencies of data processing from tag recoveries.

New statistical requirements will be in relation to the traceability of fish through processing and marketing. In the present statistical system, only quantity declarations from each vessel trip are sourced. There is therefore a clear requirement within the IOTC framework for new information to accommodate the increased data handling requirements through the IOTTP.

While developing the system to these needs, it is advised that the following information should be recorded on a set by set basis, and fully integrated into all national databases:

- Whether the fish is landed locally to target a local cannery.
- Whether the fished is transhipped on a reefer
- If so, the final destination (port) of the reefer.

This information will be used in conjunction with tag reporting rates by fishermen and canneries, estimated for each port and landing site (using results obtained from tag seeding experiments as discussed).

In practical terms, this new information should be collected by the various national offices that are already collecting logbook data in landing ports and introduced into the logbook database, furthermore should be collected for every set and for all tuna transhipped or landed in the ports of Victoria, Antsiranana, Mombasa and Phuket.

In terms of databases, this additional information should be incorporated, set by set, in an improved logbook database (WINTUNA[22]). Size/market information should also be coded and integrated (for instance with a mixture of small tunas canned in Seychelles and large yellowfin sent to Italy). This new information as well as aiding this programme will be of interest at the national level in resource economics and rent studies. Such information should then be maintained in regional catch databases on completion of the IOTTP.

Such 'database development' is incorporated within the project budget detailed in Section 6.1 and Annex A V – Financing Plan.

For practical reasons of confidentiality, this detailed set by set information will not be submitted to the IOTC. However, this additional information should be fully operational and available to the IOTC experts, PMU and IOTC WG members involved with the processing and analysis tagging data. Development should therefore be instigated to allow full integration of these requirements.

Attention should also be directed to the isolation and analysis of data flow between COI states, EU MS's, and other regional states and how this impacts on the long term objectives of the study. It is well known that current data acquisition from small scale fisheries and particularly Flag of Convenience Asiatic longline fleets is extremely poor, although through the IOTC/OFCF sampling schemes considerable improvements are being towards statistics in some developing countries.

In the context of this study, both the IOTC and regional COI Member States should continually review their links with DWFN's, and make strenuous effort to bring the standard of data from all fleets up to the level of those from the semi-industrial fleets and EU purse seine fleet.

[22] Current system developed and used by IOTC

4.9 Integration with other studies

The funding of current small scale programmes by the IOTC is being obtained from recently released UNDP, IPTP funds, also an annual payment of €200,000 from EC DG FISH, also contributions from Japan and China. As more pilot and small scale studies are proposed and developed, the PMU must ensure coherence with this study, and given the significant expertise of the IOTC, this can be fully expected.

Outside of the IOTTP framework tagging proposals have also been submitted within European countries National Programme to DG FISH, in response to Common Fisheries Policy national submissions. Spain and France have submitted a joint proposal (proposal submitted by France, mutually signed by Spain), requesting up to €700,000 for tagging fish associated with floating objects in the Somalia basin entitled TAGFAD, investigating how FAD's may be influencing the behaviour and vulnerability of different sized Yellowfin and Bigeye. Scientists from IRD, IEO and AZTI will use predominantly archival and 'pop-up' tags, and hope to charter a purse seine supply vessel. Subject to financing the program is due to commence in September 2003 and run for approximately 3 months. As mentioned such objectives will therefore be scaled down within the framework of this study to avoid any study duplication and overlap (although objectives will be integrated into the overarching IOTTP framework).

Last year also saw the beginning of a research program involving tagging called FADIO, 'Fish Aggregation Devices as Instrumented Observatories of Pelagic Ecosystems', with field work initiated in the Central Pacific, with subsequent relocation to Seychelles and La Réunion. This is a joint research project between France, Spain, Greece, Belgium and the USA over a 3 year period. The bulk of the financing is from DG RESEARCH, European Commission, other donors include, University of Hawaii, as part of the Pelagic Fisheries Research Program. Tagging is a component of the study, and as such the PMU should coordinate closely with the teams when field studies commence in the WIO[23].

The proposed tagging project will be independent of FAO ACP FISH II[24], and at this stage is not proposed to be integrated within the only other potential large scale regional project; the GEF/World Bank financed 'South West Indian Ocean Fisheries Commission'.

4.10 Tagging in Recreational Fisheries

Tagging undertaken in recreational fisheries has brought some very encouraging results most significantly from large scale campaigns in the Eastern USA and Western Australia. The chart in Annex A I, Figure 15 displays YFT tag and recapture data from recreational campaigns in Eastern seaboard fisheries. It is clear that such recaptures have produced some good indicators outside of primary fishery areas. Furthermore, these have been implemented at a low cost.

Recreational fisheries exist and were visited by the team in the Seychelles, Mauritius and La Reunion. Indications suggest that there is clearly a potential for tagging in recreational fisheries in the Indian Ocean However, some limitations were identified that at this stage could limit its wide scale application and integration into this project at this stage, these include:

- Indian Ocean situation not similar to other successful sport tagging programs, e.g. Eastern USA and Western Australia
- High operational costs per tagged fish (e.g. high associated management coordination costs required and high fish reimbursement costs, as fish sales often subsidise operations in Recreational operations in the region)
- Range of tagging methodologies, potential high tag mortality and variable scientific results

[23] Coordination of the IOTTP objectives with both TAGFAD and FADIO should be facilitated, as project members participate on the IOTC WPT.

[24] An FAO project focusing on sustainable livelihood and fisheries management issues, primarily in Africa

§ Difficulty ensuring quality assurance, when apportioning funding and rewards
§ Range of development of sport fisheries in COI member states

It is therefore recommended that tagging from recreational platforms should be treated as 'Pilot studies', and be fully integrated into this project. Rather further evaluated and promoted where considered appropriate under the IOTTP framework. Limited tagging has been initiated in the WIO however the scale has been small and supporting publicity campaigns has been limited.

As detailed under the IOTTP Pilot/Small scale summary table (Annex A II, Table 11), a consultant[25] is being contracted by the IOTC to investigate more precisely the feasibility of tagging within selected areas in the Indian Ocean.

[25] Julian Pepperel

5 Project Management and Organisation

5.1.1 Organisation

The COI will be the Regional Authorizing Officer (RAO) or Supervisor (Maître d'oeuvre) for the project. The IOTC will act as the Contracting Authority (Maître d'ouvrage) and responsible through the formation of a Project Management Unit (PMU) for the implementation of the project (mise en oeuvre du project). While the EC Delegation will be the financial donor (Payeur Délégué) and endorser of payment request made by the RAO.

Annex A I, Figure 16 details the management arrangement of the PMU in relation to identified stakeholders.

5.1.1.1 PMU (Project Management Unit)

The PMU will be housed within the IOTC secretariat in Port Victoria in the Seychelles and will be responsible for all management, coordination and implementation of tagging activities. The SFA has however offered to provide and finance additional offices for the PMU or the IOTC secretariat.

The unit will be created and remain operational under the funding arrangements of this project, and for the anticipated duration of the project. However, beyond this, further funding would need to be secured if there is a need for the Unit to remain operational.

5.1.1.2 Financial management of project funds

The project funds will be held in an account in Mauritius, so avoiding any foreign exchange limitations that could arise from it having located in the Seychelles. The Chief Coordinator, IOTC Secretary and an IOC Representative will act as financial signatories[26]. All payment requests initiated by the signatories must then be submitted and endorsed by the EC Delegation (acting as Payeur Délégué).

A relatively small proportion of project funds (approximately €20,000) should also be kept in a foreign exchange account in the Seychelles; this will give the PMU access to smaller funds for the settling of day-to-day requirements.

Annex A I, Figure 17 displays the arrangement for the handling and management of project funds.

5.1.2 Operations

5.1.2.1 Personnel

Recruitment for all posts will be done following the EC guidelines and procedures; however personnel evaluations shall be carried out in close liaison with the IOTC and WPT personnel. Final recruitment and placement will only be finalized on agreement with the secretariat.

The PMU will be composed of the following members over the five year project duration (with the exception of the chief coordinator and financial administrator over three years):

[26] A minimum of two signatories are needed to access EDF project funds.

- Chief Coordinator - P5/EC equivalent
- Publicity Officer - P3/EC equivalent
- Financial Administrative Officer - P1/2/EC equivalent
- Secretary - locally sourced

In addition the project will require the recruitment and placement of four cruise leaders and two permanent chief tagging technicians. The cruise leaders will work on a 3 month on 3 month off system[27] over the period of vessel charter (30 months), with one onboard each of the tagging vessels at all times coordinating and managing tagging operations throughout the duration of the field operations. Outside of seagoing times cruise leaders will assist the PMU in shore based activities. One chief tagging technician will remain on each of the tagging vessels for the duration of the field studies (with relief).

A minimum of three 'tagging technicians' will be provided 'in kind' by each respective COI MS research organisation.

All additional vessel crew are to be provided under the chartering agreement. The crew's performance is instrumental to the capacity of the field work and it must be clearly stated in the tendering documents that both the vessel and the crew need to have a proven and a well founded experience in tropical tuna pole and lining.

Chief Coordinator

This post will strategize, organize and lead the IOTTP and require close liaison with all members of the unit, the IOTC and stakeholders. The post will requires a minimum staffing level of P5. The relevant key skills required for the post ranked by importance include: (all of which being at an advanced level)

1. Experience of tuna tagging experiments, both practically and at a management level
2. Understanding and experience of analysis, simulations and modeling of tag recapture data,
3. Knowledge of general tuna research, specifically stock assessment and modeling,
4. Knowledge of tuna fisheries management, and;
5. Knowledge of Indian Ocean tropical tuna fisheries.

It cannot be stressed enough the key pivotal role the chief coordinator will play in the study, and any shortfalls in such skills will seriously compromise the overarching objectives and results of the study.

The chief coordinator should also be directly involved with the recruitment of the remaining PMU staff and cruise leaders and also to coordinate and conduct the regional training programmes (Section 5.1.2.2).

Publicity Officer

Directly reportable to the Chief coordinator for strategic orientation and responsible for all aspects of publicity within the IOTTP, specifically preparing, consolidating and developing new and existing campaigns, and maintaining liaison with all National 'Tagging Representatives', IOTC/OFCF sampling programmes, shipowners associations, research institutions, vessels, and processing and downstream facilities etc. Furthermore, coordination of all rewards (including sending of certificates) both directly and through Tagging Reps and ensuring a 'quality assurance' for this aspect of the programme, so that sufficient feedback is maintained to people returning tags.

The relevant key skills required for the post ranked by importance include: (all of which being at an advanced level)

1. Knowledge of tuna tagging experiments,

[27] Ultimately depending on the specific length of each tagging cruise

2. Directly involved in tuna tagging publicity campaigns
3. Knowledge of tuna fisheries
4. Good working knowledge of accepted computer software (Word, Excel, PowerPoint, Access)

Financial/Administrative Officer

Responsible for addressing and carrying out the financial requirements and protocols of EDF funded projects. The person could be recruited locally as to avoid resettlement costs, however it is envisaged that the candidate should already be qualified in project accounting and trained in EC project accounting and auditing.

A suitable local candidate, without EC financial experience could however be trained in such skills by a series of workshops already provided by the EC.

Cruise Leaders

These are crucially important roles and contribute too many aspects of the successful implementation of field activities. The individuals recruited will need to be very proficient in the following:

1. Experience in overseeing and managing research cruises/tagging cruises
2. History of offshore sea-time
3. Experience of field tagging
4. Excellent and proven management experience
5. Advanced qualifications in fisheries science

Salaries and benefits for the PMU staff and cruise leaders, are included under the 'PMU management' item in the budget, as summarized in Section 6.1.

A breakdown of specific salaries and benefits are detailed in Annex A V – Financing Plan, salaries and benefits.

5.1.2.2 COI Regional tagging and training

Improved scientific assessments and reinforced management strategies of tropical tuna stocks in the WIO will obviously be of benefit to all coastal, SIDS and DWFN, not just COI MS's. Taking into account the proposed plans for pilot and small scale programmes and the larger scale aspect of this study, it is clear that there will be more of an immediate and directed benefit for the COI MS's, in the form of institutional strengthening and capacity building in the area of fisheries research and assessment.

For the proposed tagging to go ahead in the desired areas, it is proposed as described earlier, for teams of scientists and technicians in COI member states to receive training and instruction in both the techniques of tagging and the design of tagging studies, and more importantly, data analysis of the results. The latter can be complex but of considerably more value. With this increased knowledge and skills these national teams will then be well equipped to initiate small scale tagging studies, either in parallel or after the large scale operations, on fisheries of particular interest and value to their country while being coherent with the IOTTP framework.

As such, in parallel with the main tagging cruises and the large scale operations, as discussed two members will be sourced from each COI MS. Prior to the tagging cruises, it is then proposed that a series of training courses are arranged and executed by the PMU. These will be executed on land to avoid the high costs of utilising vessel charter time. The relevant research organisations in COI MS's are therefore called upon to present suitable candidates to the IOTC. Both the resources and materials required will be borne by the project and thus included in training and PMU costs.

5.1.2.3 Vessel specifications

Recommended minimum vessel specifications of a vessel are detailed in Annex A IV.

5.1.2.4 Equipment

The final plant and supplies dossier is detailed in Annex A V – Financing plan.

5.1.2.5 Project calendar

The proposed project calendar, detailing all aspect of project implementation including vessel cruises, PMU recruitment, publicity and training programmes is displayed in Annex A VI.

6 Financial and economic analysis

6.1 Financial and Economic Justification

The financial justification of the project will be the value for money and cost effectiveness of the tagging and tag recovery, data handling and analysis. As discussed previously in the report, the charter of the tagging vessel, with associated operational item costs (livebait, gear storage, cruise leaders (within PMU), and plants and supplies) is the costliest component, contributing over 60% of total costs.

Obtaining cost effectiveness within the limits of funding available has been to optimize the allocation of the funds in order to maximize the reduction of variance in the resultant scientific results, as discussed in Section 4.4.1. Including maximising strategies and the number of tags released from tagging operations on the vessel. As such in an effort to maximize objectives and potential benefits two vessels have been costed operating simultaneously over a two and a half year period. As discussed in 4.2.1 this will enable tagging of more than two cohorts over sequential years, and secondly this introduces a degree of redundancy in response to possible environmental, geographical and biological anomalies also discussed in Section 4.2.1. The project will be over 5 years.

The summary cost tables in addition with all other programme costs are shown in Annex A V – Financing Plan. The table below summarises the project costs by item. The total estimated costs include vessel charter, cruise teams, materials and equipment, and PMU and 10% contingencies.

Summary of Project Costs over 5 years (€)

Number of vessels	**2**

Length of field operations (vessel charter)	**2.5 years (500 tagging days)**

Cost Item	**€**
Vessel costs	8,580,000
Vessel storage facility	62,500
Archival tag costs	260,000
Conventional tag costs	150,000
Tagging equipment and supplies	423,110
Tag rewards - Archival	100,000
Tag rewards – Conventional	150,000
Publicity material	110,000
Project Management Unit	2,234,150
Consultants	90,000
Capacity building and training	**170,000**
Regional liaison	75,000
Project Monitoring and Evaluation	220,000
Sub Total	**12,624,760**
Contingencies (10%)	1,262476
Total	**13,887,236**

Although a 10% contingency has been applied to overall project costs over the 5 years, Both a 'tagging incentive' cost of 40% and a 10% 'other costs' has been included. This is thought to be absolutely vital to maintain both high tagging. Although vessel owners have applied additional costs for operating in a different ocean in this capacity it was also felt necessary to apply this cost, to maintain the 'attractiveness'

of the programme to potential vessel tenderers, clearly the most fundamental component of the programme.

Sensitivity analysis of total number of fish tagged together with the average daily tagging rates that would need to be achieved to meet these targets are presented in Annex VII. It is clearly not possible at this stage to predict the precise tagging rates and total number of fish tagged. That will depend on a number of factors, such as those discussed including successful spatial and temporal deployment of the tagging platforms, coordination of tagging teams and the identification of sources of live bait from natural and other sources.

In economic terms, it is not possible to apply classical social cost benefit analysis to tuna tagging programme in terms of the economic costs and benefits from the tuna tagging programme (i.e. the costs and benefits to the regional IOC economy as well as the economies of individual IOC member states). We therefore propose to compare in value terms, the costs of tuna tagging and data analysis over a project life of 5 years with assumed losses foregone in the absence of adequate data on tuna and yellowfin and bigeye stocks in particular. We have therefore made the following hypotheses:

- Assume declines in the value of tuna catches of 5 per cent over a 10 year project period. This based on a range of international prices for Yellowfin and Bigeye catches.
- Compare the costs of tuna tagging, data analysis and project management costs against the current value of YFT, BET and YFT catches.
- Compare the discounted cost of tuna tagging, data analysis and project management costs against the discounted value of losses foregone.

It is appreciated that such economic comparisons are crude, however they do place in context the costs of tuna tagging and management in the Western Indian Ocean against the value of nominal catches. There are dangers implicit in such comparisons, notably data on tuna catches for YFT, BET and YFT are approximate and in some cases unknown. Catch and the value of catch data are fraught with difficulties. These difficulties include:

- The impossibility of projecting tuna and species specific price trends over 10 years.
- The tremendous range in prices according to fish size, quality, product (e.g. frozen, fresh, sashimi, canned etc).

In economic terms, we have to assume that better data on tuna fisheries together with other accompanying measures (fishing management zones; MCS and VMS; application of international and national fisheries laws) will lead to better management of tuna resources at the regional level and beyond (across the Indian Ocean). To this end it is encouraging that under EU Fishing Agreements, investment in vessel monitoring systems (VMS) has taken place or is proposed for Madagascar, Seychelles and Mauritius and that the EU is also proposing to invest in a regional level fisheries MCS at the regional level for all member countries of the COI.

There are clearly important economic benefits that will be derived from the more sustainable management of the resource, including:

- The protection of nominal catches and their associated value.
- The protection of export earnings from frozen, fresh and canned tuna and tuna products.
- The maintenance of government revenues from taxation and licensing of fishing activities).
- Food security.
- Direct employment effects (fishing, fish processing)
- Indirect employment effects (port and harbour operations; boat building and maintenance; gear and equipment production and maintenance; other inputs for fishing and fish processing including fuel, supplies, packaging and canning).

It is evident that that scientific data from the tagging programme will contribute directly to the better management of tuna resources in the Western Indian Ocean and beyond. In the case of several IOC

states this will have direct economic and social benefits, notably in Seychelles (very high dependence on the fisheries sector in the absence of opportunities for economic diversification, apart from tourism), Madagascar (fishing communities and FA revenue, direct and indirect), Comoros (artisanal fisheries and revenues from FA's), Réunion (export earnings and recreational fisheries), Mayotte (export earnings and artisanal/recreational fisheries) and Mauritius (FA revenue, direct and indirect, export earnings, tuna processing and transhipment receipts).

The project envisages project costs of €4.3 million to be sourced from the 8th EDF and the remainder from the 9th EDF. Project costs will include the charter of the pole and line vessel, project management unit (PMU) costs, data processing and analysis, computer and other office supplies as well as travel, accommodation and benefits costs for key personnel in the management unit. Other costs will include allowances for the training of personnel in tuna tagging and data analysis as well as an allowances for regional liaison with other Indian Ocean tuna fishing nations and IOTC MS's including the Maldives, Kenya, Mozambique, Tanzania, Oman, Iran, India etc.

The total project costs will be dispersed over a period of 5 years, with the majority of the expenditure, including vessel charter and tags being in the first two years of the project. It will be clearly important that there will have to be decision points in the project as part of the project cycle. For example lower than projected tagging rates, the lack of adequate supplies of live bait will mean that the project implementation schedule will have to be reconsidered.

Against the project costs it is not feasible to estimate the direct benefits as noted above. While tuna tagging should in theory give more robust scientific data on which to base fisheries management strategies, it is clear that this **data alone will not ensure the sustainable exploitation of tuna**. It is therefore vital that other fisheries management initiatives for the region are implemented as rapidly as possible, including regional and national MCS programmes (the latter include Mauritius, Madagascar, Tanzania and Mozambique) which will receive EU funding. These initiatives should be integrated into the primary regional management framework already held by the IOTC (though consistent legislation and management measures etc) so that coherency and consistency are achieved.

One way of looking at the value for money or cost effectiveness of the proposed tuna tagging programme is to look at the projected tuna tagging costs against the value added for COI states which are linked to tuna fisheries and the value of the resource/nominal catches, notably for bigeye and yellowfin tuna. Data from COI member states suggest that the annual value added to the national economies which may be linked to tuna was around €108 million in 1999, if this value added is projected over a project life of 10 years, it is clear that the costs of the tuna tagging programme would be minimal as a proportion of value added over a 10 year period - under 1%. If one assumes that the value added linked to tuna fisheries declined by 20 per cent over 10 years, this would represent a loss in value added of €21 million for the IOC member states.

However the comparison between project costs and value added from is not in itself an adequate comparator. The other key factor is the value of the tuna resources which are extracted from the EEZ's of the IOC member states. In terms of the targeting of the tuna tagging programme, this means the valuation of nominal catches of bigeye and yellowfin tuna. Such a calculation is difficult because of:

- The difficulty on projecting prices where these depend on markets, quality, weight, etc.
- The fact that fishing vessels may mis declare their catches.
- The problems of IUU fishing in the EEZ's of COI countries as well as IUU fishing on the high seas of tuna which also migrate through EEZ's.
- The fact that catches may be landed outside the region or transhipped at sea.

6.2 Project Beneficiaries

The project will have both direct and indirect beneficiaries. The likely beneficiaries from the project are summarized in the table below. The table gives an indicative list of those institutions at the international, regional and national level that one would expect would benefit from the tuna tagging programme as well as an outline of the expected benefits.

Western Indian Ocean Tuna Tagging Programme – Project Beneficiaries

Project Beneficiaries	Examples	Benefits
International Regional Fisheries Organisations International Institutions	IOTC, other Tuna Commissions FAO, UNEP, WWF	Improved scientific data for the Western Indian Ocean which will have benefits for other parts of the Indian Ocean and other oceanic systems with significant tuna fisheries.
Regional Regional economic organisations	IOC, COMESA, SADC, IGAD, EAC	Improved scientific data on fisheries management and tuna fisheries; contribution to better management of tuna resources
National IOC member states (Comoros, Madagascar, Mauritius, Réunion, Seychelles). Other coastal states in the Western Indian Ocean (Kenya, Mozambique, Somalia, Tanzania) and beyond.	Ministries and departments concerned with fisheries management and the coastal and marine environments. Fisheries research organisations Fish/tuna processing companies	Improved scientific data for fisheries management; contribution to better management of tuna resources. Long term sustainable exploitation of tuna resources more likely with economic and social benefits at the macro and micro economic levels.
Fishing Communities	Fishing communities and fisher associations	Fishing communities should benefit from the more sustainable exploitation of their fisheries. This will protect incomes for artisanal and semi – industrial fishers

Clearly there will be a lag in the benefits accruing from tuna tagging, given the process of tagging recovery, data collection and analysis and the use of this data to strengthen the management of the regional tuna fisheries.

7 Assumptions and conditions for project viability

7.1 Political climate

The successful implementation of the tuna tagging programme will depend in part on the political commitment of the IOC states to the sustainable exploitation of their tuna resources in the future. This will include a political will to resource management and monitoring, control and surveillance (MCS).

7.2 Finance

While tuna tagging will provide valuable data on tuna migration, growth patterns and biological parameters, this data is only part of the equation for the sustainable exploitation of tuna resources. As important are the ability of the member states to implement a rational zonation of their EEZ's, application of fisheries and environmental law and implementation of MCS. As mentioned the IOTC has already constructed and implemented the primary management framework, however, parallel measures for tuna fisheries management will depend on adequate financial resources being made available by national states. In many cases, reliance will have to be made on finance by donors and international financial institutions, given the budgetary constraints within these countries. In addition, other possible sources of finance will include better financial conditions to be incorporated within EU, bilateral and private fishing agreements[28].

7.3 Commitment and capacity

The commitment and capacity of stakeholder countries and stakeholders to ensure the successful implementation of the tuna tagging programme will depend on a number of conditions. These include:

- Implementation of national and international fisheries and environmental law and conventions.
- Successful implementation of MCS.
- Adequate fisheries management measures and zonation for inshore waters as well as other parts of the EEZ.
- Adequate consultation with international, regional and national stakeholders, including the IOTC, FAO, SADC, the EU, World Bank, UNEP and other international institutions, fisheries departments, fisheries research institutes, producer and other representative groups for fishers.
- Careful liaison with individual countries engaged in tuna fishing including Japan, Korea, Taiwan.

INDIAN OCEAN COMMISSION COUNTRIES AND MAYOTTE – COMMITMENT TO AND CAPACITY ON TUNA TAGGING

Country	Commitment	Capacity
Comoros	Apparent commitment	Very limited financial and technical means. Issue of co – ordination between different island interests. Important to integrate approaches between the Comoros and the island of

[28] There are a number of initiatives under way. These include the finance and proposed finance by the EU of MCS at the regional level as well as other projects for Madagascar, Mozambique and Tanzania.

Country	Commitment	Capacity
		Mayotte.
Madagascar	Apparent commitment	Limited financial means. Some technical capacity
Mauritius	Committed to the project	Limited financial capacity; research capacity at AFRC and some experience of tuna tagging through PTR.
Mayotte	Committed to the project	Limited financial resources available for projects in the fisheries sector. Possible access to French Government + DG Fish finance. Capacity strengthened by good links with IRD and IFREMER
La Réunion	Committed to the project	Technical and financial capacity relatively strong. IRD and IFREMER plus local fisheries research organisation
Seychelles	Committed to the project	Experience of pilot programmes for tuna tagging, and extremely well place for future commitment and capacity

8 Project Risks

All programmes and projects have inherent risks; these include political, financial, technical and other types of risk, including logistics. Some of the risks will clearly be linked to the non achievement of the conditions set out in the previous section to this report. In particular the main risks for the success of the project may be summarised as follows:

- **Political risks:** collaboration between IOC member states and between IOC member states and other coastal states of the Indian Ocean with economic interests in tuna fisheries (e.g. Kenya, Mozambique, Tanzania, Oman, Iran, Maldives, India, Indonesia, Thailand, Taiwan, Japan etc). Political commitment to tuna tagging within the IOTC member states.
- **Other investments:** while tuna tagging will give valuable data on tuna behaviour, biology and stock structure, it is clear that other investments are necessary in VMS and in broader terms, MCS.
- **Project specific risks:** these centre on project delays, limited commitment to the secondment of technicians and other scientific staff from the fisheries research institutions of IOC member states low tagging rates and operational restrictions in tagging (such as availability of surface fish, environmental and mechanical)

Our overall assessment is that the project risks are relatively low, given the commitment of member states, existing and planned investments in MCS/VMS in member states of the COI and given the fact that the project will be managed by an experienced project management unit working within the existing IOTC structure at Victoria, Seychelles.

9 Coherence with Regional and EU Development Policy

9.1 The IOC Region

9.1.1 Introduction

The project with its concentration on resource management and the better management of tuna resources will benefit directly and indirectly to the macroeconomic environment of IOC member states. As has been shown earlier in this report, many of the IOC states and Mayotte have economic and social development linked to the fisheries sector in general and tuna and related species in particular. The MT's has functional policies for the fisheries sector which are included under the heading of the management of natural resources.

The project is welcomed by all the member states which we visited and it will be important that the project planning, work programme and objectives are constantly monitored to ensure that they are compatible with other initiatives on tuna management and tagging in the Indian Ocean. The project by its regional nature will contribute to regional cooperation in marine resource management in the Western Indian Ocean. While all the countries considered in this study are members of the Indian Ocean, with the exception of Mayotte, there are a number of moves to promote regional development and trade, including the activities of COMESA. (Common Market for Eastern and Southern Africa), SADC (Southern African Development Community). Of the IOCIOC member states, Mauritius and Seychelles are also members of SADC which has a regional policy and protocol for fisheries development. Comoros, Madagascar, Mauritius and the Seychelles are members of COMESA which has functional policies for the fisheries sector.

9.1.2 Coherence with the Macroeconomic Environment of the Member States of the IOC

All the member states of the IOC are island states which depend to a considerable extent on their marine resources and coastal environment. This is particularly the case with respect to Comoros, Seychelles and Mauritius (which has an important role as a transhipment centre for tuna and other species). In several cases, there is a high dependence on fish as a source of animal protein and this includes tuna. The tuna fisheries as we have already pointed out in this report make an important contribution to the economies of IOC countries in terms of:

- Foreign exchange earnings from tuna landings, transhipment, port fees and associated expenditure; the financial contribution from access agreements. These in turn contribute to national budgets.
- Food security and sources of animal protein.
- Direct, indirect and induced employment which is linked to tuna fisheries, including direct fishing activities in the semi – industrial and artisanal fishing sectors; indirect employment in fishing ports where tuna landings are made (notably Victoria in the Seychelles and Port Louis in Mauritius) as well as landing sites for artisanal fishers; indirect employment if fish processing and marketing and induced employment effects in industries linked to tuna fishing activities including gear and equipment, raw materials for processing etc.
- Trade development.

The protection of tuna stocks and their rational exploitation is one of the primary objectives of the proposed tuna tagging programme, and will, by making a contribution to the economic and social

development of IOC member states be coherent with their **main macroeconomic objectives**. These objectives include the following:

- Reduction of deficits on the balance of payments through the development of trade.
- Employment generation which will lead to poverty reduction and higher incomes.
- Food security and enhanced nutrition.

While in the longer term, the macroeconomic environment of IOC member states will depend on many factors, including macroeconomic stability, good budgetary management, the protection of a vital marine resource such as tuna and associated species is fundamental requirement of those countries with a heavy economic and social dependence on the fisheries sector. This is particularly the case with respect to lower income countries such as Comoros, Mayotte and the coastal regions of Madagascar.

9.1.3 Coherence with the Regional Economic Situation of the Fisheries Sector

We have demonstrated in this report the importance of the fisheries sector and the tuna sector in particular in the Western Indian Ocean. Analysis of the regional fisheries sector of the IOC countries and beyond indicates that non sustainable exploitation of tuna and related species would have a dramatic effect on:

- The revenues of the semi – industrial fleets which are targeting tuna (Réunion, Seychelles).
- The revenues of artisanal fleets which catch tuna (Comoros, Madagascar, Mayotte)
- Tourism revenues associated with recreational fisheries

The better management of tuna resources would therefore be entirely coherent with the regional economic situation of the fisheries sector and would make a valuable contribution to protecting the fisheries sector in the medium to long term.

9.2 Coherence with EU Development Policy

The proposed tuna tagging programme will be financed under EU funding. It is therefore incumbent that the project objectives are coherent with EU development policy.

The EU has active development cooperation with the IOC member states. There is within the Western Indian Ocean island states a considerable range of the levels of economic and social development. While Réunion, the Seychelles and Mauritius have relatively favourable levels of economic and social development, Comoros and Madagascar lie in the lowest 30 per cent of countries as measured by the Human Development Index (HDI) a composite index of GDP per head in purchasing power parity terms (PPP), life expectancy at birth and an education index based on adult literacy and pupil/student enrolment figures.

The Lomé IV was modified in Mauritius on 4 November 1995 (Lomé IV bis). Title III covers the development of fisheries. It is clear that the proposed tuna tagging project will contribute directly to the achievement of a number of Articles within Title III. In particular the project is relevant to and coherent with the following objectives:

- Improve knowledge of the fisheries environment and resources (Article. 59)
- Encourage the rational exploitation of the fishery resources of the ACP states and the resources of the high seas in which the ACP States and the Community share interests (Article. 59).
- Assistance from the Community for fisheries development shall include support to …'fisheries management and protection, including the assessment of fish stocks for a rational management of the fishery resources in their exclusive economic zones (Article. 60).

§ Article 62 states that 'special attention shall be given to enabling least – developed, landlocked and island ACP States to maximize their capabilities to manage their fishery resources.

The ACP – EU Partnership Agreement is contained in the **Cotonou Agreement (2000)**. There are a number of Articles in this agreement whose objectives will be furthered by the implementation of the tuna tagging programme. These include:

§ Regional cooperation on the environment (Article 30).
§ Building and/or strengthening the scientific and technical human and institutional capacity for environmental management for all environmental stakeholders (Article 32, 1 (b).
§ Cooperation on environmental protection and sustainable utilisation and management of natural resources shall aim at specific measures and schemes relating to current and future regional and international commitments concerning coastal, marine and fisheries resources (Article. 32 1 (c) (i).
§ With respect to economic sector development, Article 23 of the Cotonou Agreement says that 'cooperation shall support sustainable policy and institutional reforms… for equitable access to economic activities, particularly…sustainable development of water resources and fisheries as well as marine resources within the economic exclusive zones of the ACP States (Article. 23 (d).
§ Regional cooperation and integration form the basis of Articles 28 and 29 (Section 3 – Regional Cooperation and integration).

With respect to regional co – operation, the EU has prepared a Regional Indicative Programme for the period 2002 – 2007. The RIP emphasises investment in regional integration and trade, transport and communications and other programmes. It is clear that the proposed tuna tagging programme is coherent with the objectives as set out in Lome IV bis, the Cotonou Agreement and the EU Regional Indicative Programme for the Indian Ocean.

10 Project Cycle and Management

10.1 Introduction

We have developed the project using the guidelines produced by the Europe Aid Co-operation Office (Aid Co: 2002). This report includes the major components of project cycle management including:

- Project programming
- Project identification (which was developed by AidCo in collaboration with IOC and IOTC)
- Project Appraisal (financial and economic) evaluation
- Project Implementation (Monitoring and Evaluation are dealt with in Section 6.2)

10.2 Project Monitoring and Evaluation

The monitoring and evaluation of the project will be related to the log frame analysis which is presented in Annex A VIII. The monitoring and evaluation (M + E) of the project would be carried out by the PMU which would work in close collaboration with the IOTC and WPT members. The indicators that would use in carrying out the M + E functions would include the following:

- Tagging rates
- Tag recovery rates
- Production of cruise/activity reports
- Production of annual progress reports on the tagging programme.
- Entry, processing and analysis of data from tuna tagging (production of data analysis reports)
- Precision and reduction in variance in stock assessment models

External project monitoring, evaluation and annual audits will be carried out by consultants, and as such these are costed within the budget

10.3 Project Design and Management

The Logframe has been developed to address the issues in the project Terms of Reference and in relation to the diagnosis of what are the needs that the project must address with respect to tuna fisheries in the Western Indian Ocean which are displayed in the problem tree (Annex A I, Figure 13). The LFA contains the following main headings:

Global objective:

- Sustainable exploitation of Indian Ocean tuna stocks at all levels.

Specific Objectives:

- Improve the contribution that tuna make and will make to the economic and social development in the COI MS's

- Strengthen regional fisheries management in the Indian Ocean

Results:

- Estimates of the crucial parameters necessary for tuna stock assessments - age specific estimates of natural and fishing mortality:
  - Estimates of exploitation rates and differential vulnerability by areas and gear
  - Assessments of potential interactions between fisheries
  - Estimates of distribution range, stock structure, migration and movement
  - Estimates of growth and validation of age estimates
  - Assessments on the effects of FAD's and bathymetric environment on movement
  - A long term management plan for the sustainable exploitation of Indian ocean tuna fisheries
- Analytical capacity of the RFO increased
- Strengthened and well founded management for the sustainable exploitation of Indian ocean tuna fisheries

From the objectives of the tuna tagging programme, the expected results are presented against objective verifiable indicators and against assumptions.

11 Conclusions and Recommendations

The proposed tuna tagging project has been prepared to take account of technical, economic and social factors. The main conclusions are as follows:

§ Analysis presently done by the IOTC Scientific Committee have concluded that yellowfin, bigeye and skipjack stocks, particularly, yellowfin and bigeye tuna are already heavily fished and possibly under threat of over-exploitation.

§ It is clear and accepted that knowledge is poor in all areas, and as such under no circumstances will existing systems for collecting biological and statistical information both in the fisheries and throughout the species, resolve these problems in any timeframe that can be safely acted on, without the implementation of a large scale tagging programme.

§ The project would appear to be viable in terms of the potential contribution that it will make to marine resources and fisheries management in the Indian Ocean. This conclusion is based on a wide range of consultations in IOC member states, FAO, SPC and discussion with other experts.

§ The COI will be the Regional Authorizing Officer (RAO) or Supervisor for the project. The IOTC will act as the Contracting Authority and responsible through the formation of a Project Management Unit (PMU) for the implementation of the project. While the EC Delegation will be the financial donor and endorser of payment request made by the RAO.

§ The PMU will be housed within the IOTC secretariat in Port Victoria in the Seychelles and will be responsible for all management, coordination and implementation of tagging activities

§ The preferred platform for tagging in terms of technical capability and historical experience of pole and line tagging is the charter of two Spanish (from either Cantábria) dedicated pole and line vessels over a two and a half year period.

§ The vessel, in addition to the crew (included under the chartering arrangement) will be staffed by a Cruise Leader and tagging technicians. The cruise leaders and chief tagging technicians will be funded within the project, however the technicians (three from each COI country) will be provided 'in kind' from IOC and ACP Member states.

§ A series of pole and line cruises should therefore be planned by the PMU in the WIO, taking into account the specific autonomy and operational capacities of the chosen vessel(s). As the vessel moves between areas, base ports from which the vessel will then operate from, and trip lengths will vary. Both the PMU and the vessel must ensure that the overarching objectives being sought in each area must be adhered to maintain a coherent project cycle of implementation.

§ The main project risks are the attainment of daily tagging rates and tag recovery rates (the assumption of a recovery rate of 20 per cent has been made with other assumptions on tag recovery and tagging rates).

The risk of low tagging rates needs to be evaluated by further studies, instigated by the PMU. These will use environmental, oceanographic and operational data to evaluate on a case by case or area by area basis a more concise probability of tagging the targeted numbers as and when they are agreed. This will clearly be instrumental to the overall success of the field studies.

§ Publicity efforts should be concentrated and directed in the areas from where statistics and sampling is established.

- Project costs have been included for the preferred scenarios using Spanish pole and line vessels sourced from Cantábria.
- As well as vessel charter, we have included costs for tag rewards and tagging and other equipment, IT hardware, publicity and rewards and project management. In addition, we have made an allowance for 10% financial and physical contingencies.
- The vessel charter contract should well define the responsibility of each party (boat owner and captain on one side, the PMU and the scientist in charge on the other side).
- It is vital that pilot and small scale studies are further proposed developed and coordinated with the large scale aspects of this project to complement and ensure all the objectives of the IOTTP are met.

Technical Annexes

I Figures
II Tables
III Country profiles
IV Minimum vessel specifications
V Financial proposal
VI Project Calendar
VII Tagging rates sensitivity analysis
VIII Logframe analysis

Administrative Annexes

I Workplan and study itinerary
II Persons met
III Bibliography
IV Terms of Reference