Fisheries Operational Programme 2007-2013
Project part-financed by the European Union
European Fisheries Fund (EFF)
Co-financing rate: 75% EU Funds; 25% National Funds
Investing in sustainable fisheries

An aquaculture strategy for Malta

Preparatory study and recommendations prepared for the Ministry of Resource and Rural Affairs, Government of Malta

Final draft report

March 2012

Stirling Aquaculture
Institute of Aquaculture
University of Stirling
Stirling FK9 4LA
Tel: +44 (0)1786 467900
Fax: +44 (0)1786 451462
E-mail: aquaconsult@stir.ac.uk
Web: www.stirlingaqua.com

Programm Operattiv tas-Sajd 2007-2013
Proġett Parti Finanzjat mill-Unjoni Ewropea
Fond Ewropew għas-Sajd (FES)
Rata ta' Ko-Finanzjament: 75% Fondi UE; 25% Fondi Nazzjonali
Investment f'Sajd Sostenibbli

IMPORTANT NOTICE

This report has been prepared by the University of Stirling (acting through its consultancy arm, Stirling Aquaculture) and its appointed subcontractors (together referred to as "Stirling") for the Ministry of Resource and Rural Affairs (the "MRRA"), as part of our engagement under the terms of contract Ref. No. CT 3034/2010 signed on 28th March 2011 (the "Contract"). This report contains information obtained or derived from a variety of sources as indicated within the report. Stirling has not sought to establish the reliability of those sources or verified the information so provided. Accordingly no representation or warranty of any kind (whether express or implied) is given by Stirling to any person (except to the MRRA under the relevant terms of the Contract) as to the accuracy or completeness of the report. Moreover the report is not intended to form the basis of any investment decisions and does not absolve any third party from conducting its own due diligence in order to verify its contents. Stirling accepts no duty of care to any person (except to the MRRA under the relevant terms of the Contract) for the preparation of the report. Accordingly, regardless of the form of action, whether in contract, tort or otherwise, and to the extent permitted by applicable law, Stirling accepts no liability of any kind and disclaims all responsibility for the consequences of any person (other than the MRRA on the above basis) acting or refraining to act in reliance on the report or for any decisions made or not made which are based upon such report. In the event that, the MRRA is required to disclose any information contained in this report, it will notify Stirling promptly and consult with Stirling prior to disclosing such report. Stirling agrees to pay due regard to any representations which Stirling may make in connection with such disclosure. If, following consultation with Stirling, the MRRA discloses this report or any part thereof, it shall ensure that any disclaimer which Stirling has included or may subsequently wish to include in the information is reproduced in full in any copies disclosed.

Contents

Annexes

Acronyms

ABT	AquaBiotech Group
AFRD	Agriculture and Fisheries Regulation Department
AJD	AJD Tuna Ltd
APROMAR	Spanish Marine Aquaculture Producers Association
AZE	Allowed Zone of Effects
CCS	Closed Cycle Species
CFP	Common Fisheries Policy
COM	Common Organisation of the Markets
EATIP	European Aquaculture Technology and Innovation Platform
EC	European Commission
EFF	European Fisheries Fund
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EQS	Environmental Quality Standards
EU	European Union
F&F	Fish and Fish Ltd
FAO	Food and Agriculture Organisation
FEAP	Federation of European Aquaculture Producers
FFRC	Fish & Farming Regulation and Control division
FIFG	Financial Instrument for Fisheries Guidance
FMAP	Federation of Maltese Aquaculture Producers
FOPM	Fisheries Operational Programme for Malta
FTE	Full Time Equivalent
GEI	Gross Entrepreneurial Income
GFCM	General Fisheries Council for the Mediterranean
GFCM	General Fishery Commission for the Mediterranean
GIS	Geographical Information System
GMO	Genetically Modified Organism
GVA	Gross Value Added
HDPE	High Density Polyethylene
IBA	Important Bird Areas
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICZM	Integrated Coastal Zone Management
IMTA	Integrated Multi-Trophic Aquaculture
IUCN	International Union for Conservation of Nature
MARC	Malta Aquaculture Research Centre
MCA	Marine Conservation Area
MDC	Malta Development Corporation
MEPA	Malta Environment and Planning Authority
MFF	Malta Fish Farming Ltd
MMA	Malta Maritime Authority
MML	Malta Mariculture Ltd
MRRA	Ministry for Resources and Rural Affairs
MSP	Maritime Spatial Planning
NAC	National Aquaculture Centre
NGO	Non-Governmental Organisation
Nm	nautical mile
NSO	National Statistics Office
P2M	Pisciculture Marine de Malte Ltd
PDG	Policy and design guidelines - fish farming
PPP	Public Private Partnership
R&D	Research and Development
RTD	Research and Technology Development
SEA	Strategic Environmental Assessment
SMG	Strategy Management Group
STP	Sewage Treatment Plant
SWOT	Strengths Weaknesses Opportunities Threats
TOR	Terms of Reference
VNN	Viral Nervous necrosis
WCMP	Water Catchment Management Plan
WFD	Water Framework Directive

Executive summary

1 Introduction

This study was contracted by the Malta Aquaculture Research Centre (MARC), Ministry for Resources and Rural Affairs (MRRA) and took place over a 4 month period between February and June 2011. The purpose of the study is the preparation of an aquaculture strategy for Malta, with the overall objectives stated as:

- To lay down a structured path for sustainably developing aquaculture in Malta
- To identify the domains that are essential for a profitable and sustainable industry in Malta

The report contains sections on international context, the present status of the industry, key industry issues, future potential, and a strategy for the industry. The executive summary is based on key observations and conclusions, with key issues and possible solutions discussed under relevant headings.

2 International context

2.1 International policy and regulatory environment

As a member of the EU, Malta is required to adopt EC regulations into national law. This has implications for aquaculture health control, nature conservation, and environmental impact. In addition, it must abide by relevant aquaculture policy, such as the strategy for the development of a sustainable aquaculture industry in Europe, and other relevant FAO and IUCN initiatives.

The development of new approaches and technologies for production, such as those envisaged for Malta, are very much encouraged through flagship EU initiatives such as "A resource efficient Europe" and "Innovation Europe".

Regarding the development of EU policy in maritime spatial planning, work is underway to develop an Integrated Maritime Policy for the Mediterranean, to include the concepts of ICZM and Maritime Spatial Planning. As part of such initiatives, EU aquaculture strategy urges national authorities to ensure aquaculture has equal access with other potential users and encourages the establishment of aquaculture development zones in structural plans – this is of particular importance to Malta given the conflicts over the limited marine space available.

EU financial support for aquaculture in Malta comes in two forms: for commercial projects, European Fisheries Fund (EFF) grants (mainly for capital expenditure) are available for projects addressing key strategic objectives such as the diversification of cultivated species, reducing environmental impacts, and development of markets. For research and development, funding is available through RTD Framework Programmes, an example of which is the SELFDOTT project on bluefin tuna which involves Maltese partners. Both of these will be important to the further development of aquaculture in Malta.

The need for aquaculture to be environmentally sustainable is being supported by a number of FAO and IUCN initiatives regarding site selection, carrying capacity, good practice and sustainable development, all of which are particularly relevant to Malta.

2.2 Malta's position as an aquaculture producer in Europe

The Maltese aquaculture industry has two sectors: tuna penning, which relies on captured wild fish, and farming of "closed cycle species" (CCS) such as seabream and seabass, which are cultured from the egg. Production from tuna penning reached a peak of 7,000t in 2007, but is expected to fall to less than 1,000t in 2011 due to quota restrictions and reductions in the fishing fleet. At the industry peak, Malta was the largest producer in the Mediterranean, aided by its favourable position on tuna migratory routes and expertise in offshore aquaculture.

In contrast, Malta is only a minor producer of CCS, with production reaching 2,077t in 2009, compared with a regional production of around 250,000t. This sector is dominated by major industries in Greece, Turkey and Spain and is highly cyclical in nature and prone to overproduction.

Although Malta is close to its main market of Italy, it is constrained by lack of sites, lack of vertical integration and poor economies of scale. Competition with other industries will remain intense and limit expansion to what can be achieved through product differentiation. Development of new species is less constrained by immediate competition, but potentially by available resources to develop the market. Other potential constraints include apparent restrictions on sites for processing and packing plants, and only limited facilities for R&D.

3 Current status of the industry

Malta has a limited coastline, only part of which is suitable for cage culture, and competition for space with other legitimate users such as shipping, tourism and leisure is intense. With virtually no freshwater resources, all aquaculture activities in Malta are marine-based. The internal market for fish in Malta is limited and aquaculture products are thus mostly exported. In addition, because of the relatively small size of the industry in Malta, almost all equipment, feeds and juvenile fish supplies have been imported to date.

The industry has evolved to its present status over a period of around 20 years, and now has 6 farms operating at 9 sites, one farm producing only CCS, one both CCS and tuna, and the others only tuna. All farms have aspirations to develop their businesses especially if based on alternative species such as amberjack.

Over the period 1990 to 2000, production of CCS reached 2,000t from 4 farms but then declined to around 700t in 2005 due to low market prices and a change to tuna farming, which began in 2000. Production has since risen again reaching over 2,000t in 2009.

Most of the sites in Malta are very exposed, with an unlimited fetch in at least one direction, and the most exposed lying over 6 km from the shore. Because of this, Malta is a leader in the practice of offshore aquaculture. The only relatively sheltered sites are used for nursery production and/or holding broodstock.

Cage systems are now almost all circular HDPE plastic pipe as widely used elsewhere and have proved to be extremely robust and cost effective. Most losses that have occurred have been due to the impact of excessive currents on cage nets and moorings.

The production process for tuna consists of the capture of wild adult fish (typically over 70kg) in May/June mainly in the southern Mediterranean, transfer back to pens in Malta, and a fattening period of 6 months or more. The fish are fed on thawed wet baitfish which is imported frozen and put on about 30% bodyweight before harvest mostly in the autumn.

The production process for seabream consists of the hatchery production of fry which are stocked into sheltered nursery cages at 2-5g weight, later being transferred to more exposed cages for fattening over a period of 14-16 months before harvest at around 400g. Seabass follow a similar pattern but are grown to a weight of 2-3kg. Fish are fed on a dried pelletted diet.

Small quantities of meagre are now also produced and show good characteristics for aquaculture: fast growth, low mortality and good food conversion ratio. Market acceptability however is poor due to unfamiliarity to consumers and an unattractive appearance.

Almost all seabream and seabass produced in Malta are exported as a whole fresh ungutted product to Italy, and face strong competition especially from Greek producers. The frequency and reliability of the ferry link between Malta and Italy has been highlighted as a major concern to Maltese producers. No value-added processing or product diversification of any kind takes place in Malta prior to export. One company has however reported some success in exporting a frozen whole product to the Libyan market. Around 100t a year are sold locally, with portion size fish being a popular product in the tourist foodservice market.

The bulk of penned tuna production is exported to Japan as a frozen product, primarily for the lower-value supermarket sushi and sashimi trade. Annual consumption of bluefin tuna in Japan is around 50,000t, of which Mediterranean penned tuna make up around 20% and Malta 5-10%. Maltese operators are at the mercy of wholesale prices in Japan, and the Japanese economy as a whole. Prices have fluctuated markedly over the past

10 years and in 3 of those years have fallen below cost of production. Further uncertainties in the Japanese market are expected following the earthquake and tsunami of March 2011.

Research and development in aquaculture in Malta is carried out mainly at the Government run MARC at Fort St. Lucjan, Marsaxlokk. Research activity is focused on the development of 'new species' for aquaculture in Malta, with particular emphasis on the hatchery and cage rearing of amberjack and bluefin tuna. The Amberjack Project, a joint venture between MARC and MFF, operates a commercial hatchery for seabream and carries out research into alternative species. MARC also carries out water monitoring services for the industry and has an educational role, both for University-level biology students and to the general public. The University of Malta also plays a role in formal education and research in aquaculture.

During the period 2007-2008 the aquaculture industry in Malta directly employed 197 full-time equivalent (FTE) personnel, made up of 163 full-time employees and 73 part-timers. In addition to this, it was estimated that there were a further 767 indirect FTE positions in support and supply industries.

Almost all staff employed in the industry are Maltese nationals. Around 93% of aquaculture employees are currently men, around 60% of whom are aged 34 years or younger. Much of the workforce has a background in the fisheries sector, and is thus well suited to the nature of the work. There are currently no formal vocational training opportunities for aquaculture in Malta, and the provision of such training is considered highly desirable for the safe and efficient development of the aquaculture industry in Malta.

Divers are essential for routine maintenance, installation and various husbandry operations. There are no legal requirements for professional diving qualifications in Malta at present, but the introduction of legislation, based on that employed by most other EU member states, can be expected in the future.

The industry is represented by the Federation of Maltese Aquaculture Producers (FMAP), whose members include all 5 tuna farms, and which represents the interests of tuna farming in the media and with regard to regulatory matters. P2M, which only farms bass and bream, is not a member.

4 Aquaculture policy

A number of policy documents for the aquaculture industry have been produced since the industry began in the late 1980s, reflecting changes in that time, the most notable of which was the advent of tuna farming in 2000.

The first policy on aquaculture entitled "Policy and design guidelines - fish farming" (PDG) was issued in 1994. This set out production targets, guidance on site selection, environmental monitoring, fish health monitoring, and other issues. The PDG was amended in 2001, particularly with regard to site selection criteria. A new "National Policy on Aquaculture" was issued in 2004. This document sets out policy in very general terms, and gives only limited guidance on site selection. Further elements of policy are given in Malta's National Strategic Plan For Fisheries 2007-2013 and the draft Structure Plan 2006.

The most contentious issue in any of these policy documents is site location and conflicts with other users, and there are a number of discrepancies between them. There is clearly a need to define more accurately what species can be farmed where, and to differentiate between different types of production systems e.g. nursery and ongrowing facilities and their possible location. Furthermore, this should be clearly enshrined in National Policy, from which all other authorities including MEPA should take their guidance. At present it appears that MEPA is setting the policy for aquaculture locations rather than the MRRA.

A further observation on policy is that whilst there is reference to consultation between relevant Government departments and agencies, there appears to have been little or no consultation with the aquaculture industry itself.

5 Regulation

The basic legislation necessary for the regulation of the industry in Malta is essentially in place, but there are a number of regulatory issues that need to be addressed including licensing procedures, enforcement of operating conditions, the feeding of baitfish, and environmental monitoring.

The licensing process in Malta is lengthy and strongly influenced by MEPA, which is seen by the industry to be un-sympathetic to aquaculture. A further feature of the industry is the different operating conditions applying to different sites.

MRRA have in mind a concept whereby all existing and new installations are located in dedicated Aquaculture Zones (AZs), the permission and head lease for which has been granted to MRRA, which then issues concessions to individual operators, as is the principle behind the already established SE AZ. This addresses the need to give all operators a level playing field with equivalent operating terms and rents, and for new sites reduces the lead time for setting up an installation given overall permission has already been granted to MRRA. Only one application to MRRA would be necessary, thus creating the "one stop shop".

However, whilst such a system may work for new farms which in reality have little other choice, it would only be acceptable to existing farms providing they are not disadvantaged financially or operationally. In addition, it is crucial that concession terms are business friendly and encourage investment, particularly with regard to length of tenure. Given that requiring existing operators to move from their existing sites to new offshore zones outside the 50m/1nm limit is not considered feasible other than for tuna, and would seriously curtail if not completely rule out the prospects for CCS culture, it is suggested that the principle of zoning could be applied to existing sites providing that such concerns are taken into account.

With regard to what species can be cultured where in the available space, whether existing or new sites, the policy could essentially be as it appears to be now i.e. for most tuna farms to be located in more than 50m water depth and 1nm from shore, whilst CCS would mostly be in less than 50m water depth at varying distance from the shore. This would address the need for CCS to be grown on relatively sheltered sites, and to move tuna further offshore to reduce the impacts of baitfish feeding, where in any case they are better able to withstand the more exposed conditions. There would need to be flexibility in the application of this policy depending on individual permit conditions, carrying capacity, and what if any new sites are approved.

There is scope to streamline the administration of aquaculture within the MRRA through the rationalisation of Directorates, but given that some re-organisation has recently taken place, further rationalisation is likely to have to wait for the longer term.

Enforcement of operating consent conditions is currently considered to be inadequate, particularly with regard to the correct placement and maintenance of navigational markers. There is a need for the present process by which farms are monitored and enforcement instigated to be reviewed and if necessary additional resources made available.

At present there appear to be no specific obligations on tuna penning operators to minimise the impact of baitfish feeding i.e. smell and oil slicks. Appropriate conditions should therefore be considered, such conditions to be determined following a study of the nature, frequency and timing of the impacts in relation to individual farm locations.

A further way of improving operating standards within the industry would be the introduction of an industry Code of Good Practice (COGP), as envisaged in the Water Catchment Management Plan (WCMP) and other policy documents. The industry should ideally take the lead in the production of the Code to ensure industry acceptance. Such a Code could be one means of improving the public image of the industry and of backing up marketing initiatives.

MEPA has a key role to play in the regulation of the industry and as such it is important that it is seen to operate in a fair, timely and well informed manner. At present it is viewed by the industry as un-sympathetic to aquaculture. Measures to improve this include clearer policy direction from MRRA, the appointment of an aquaculture liaison officer, and the formation of a Working Group made up of representatives from the industry, MEPA and MRRA.

6 Environmental monitoring

The requirement for environmental monitoring of farms has been in place since the earliest days of the industry. Although such monitoring has no doubt been carried out with the best of intentions, there is a perception that it is unnecessarily complex and costly, and fails to provide any useful link between impacts and carrying capacity. There is a need therefore for a review of monitoring methodology in order to make it better “fit for purpose”. This is in line with the need to provide clear EQS by which adverse impacts can be judged, and an AZE over which such impacts are allowed.

7 Fish health control

Diseases of seabream and seabass are now mostly kept under control by good husbandry, and occasionally through appropriate medication. There are no so-called “notifiable diseases” of fish species currently cultured in Malta. The most serious disease the industry has faced was an outbreak of VNN virus in seabass in the 1990s originating from the import of infected fish. This outbreak spread rapidly between farms despite the relatively high separation distance between them and illustrates the need for strict control measures especially with regard to the source of stock.

Such problems have not affected tuna, which is less susceptible to disease. The fish are not usually kept much longer than 6 months and sites then lie fallow for a time before restocking, allowing any potential disease cycle to be broken.

With regard to health control within zones, the experience with VNN demonstrates that increased separation distance is unlikely to prevent the spread of disease. Measures should therefore be based on preventing the import of infected stock and good husbandry, reinforced by a COGP, and by Area Management Agreements (AMAs) between all the operators in a zone.

In addition, it is recommended that the MRRA should prepare a contingency plan for the control of potential emerging diseases of new species such as amberjack. A further requirement should production of CCS be increased over present levels is an improved fish disease diagnostic capability such as the one that used to be provided by the NAC.

8 Identification of sites and potential production scenarios

An assessment of marine sites has been carried out taking into account national policy, the suitability of different areas for different species, potentially conflicting marine uses, and conservation designations. Although it is likely that any new sites so identified will face challenges in terms of acceptance, they are considered to represent an upper resource limit in estimating any future production target.

The potential production capacity of the sites identified has been considered taking into account the sea space occupied by marine installations, suitability for different species, separation distances, and the possible environmental carrying capacity. The composition of CCS assumed for future production is 50% seabream and 50% amberjack. For both tuna and CCS, three different production scenarios are suggested (see table below).

Summary of production scenarios

	Scenario 1	Scenario 2	Scenario 3
Tuna	2,000t	4,500t	7,000t
CCS	2,500t	5,000t	10,000t

For tuna, the scenarios make certain assumptions regarding availability of stock, which is regarded as the most limiting factor. Potential capacity of existing sites based on ICCAT consents is 11,500t, and so is not considered limiting. With regard to CCS, production will be mainly dependent on which if any of the potential new sites/zones identified are approved, and the carrying capacity agreed for these and existing sites. In addition, there would need to be negotiations with existing operators to agree on the rationalisation of sites especially if site exchanges or modifications are proposed which are outside the terms of individual leases.

It should be emphasised that overall production of both tuna and CCS would depend on any combination of the scenarios for each species, given the different limitations for each.

With regard to timescales, 2025 has been suggested as a deadline for certain production targets to be achieved. For tuna, given the current strict regulatory environment, it is to be hoped that stocks recover sufficiently within the coming years to allow an increase in quotas, in which case production could return to 2007 levels of 7,000t p.a. or higher. For CCS, it is considered that a production of up to 10,000t could be achieved by 2025 providing that new sites are agreed and the industry is fully supported.

9 Socio-economic impacts

Gross industry output (both tuna and CCS) reached a peak of €130m in 2007 when tuna production reached 6,800t, with total gross value added (GVA) of €53m, and supported an estimated 964 FTE jobs (direct and indirect). This output was largely attributable to tuna penning. In the two following years however tuna penning made a loss due to increased costs, storm losses, foreign exchange differences, and (in 2009) low prices, and as a result total GVA for the industry as a whole was negative in 2008 and only €18m in 2009.

With regard to possible future outputs, analysis of economic impacts was made for three different scenarios for both tuna and CCS. The high production scenario for tuna of 7,000t p.a. (in line with 2007 volumes) indicates that the industry could generate a total GVA of €73m and support direct employment of 233 employees and indirect and induced employment of 804.

The analysis of the CCS scenarios including a new local hatchery illustrates that at the high production scenario of 10,000t p.a. and a hatchery producing 20 million juveniles p.a., the industry could generate a total GVA of €46m and support direct employment of 464 employees and indirect and induced employment of 442.

Whilst these two sectors could reach such production levels simultaneously and thus the overall impact could be an aggregate of the two, in practice it is likely that they will proceed at a different rate given they are influenced by different factors.

10 Marketing

The market for bluefin tuna is primarily in Japan, with Japanese companies purchasing direct from Maltese cages. As long as demand remains high in Japan there will be few incentives to develop alternatives. Should the production cycle be closed in both Japan and Europe, increased production will drive down prices and open new markets, placing tuna in a similar situation to other CCS.

For CCS Malta is a minor producer and must either accept whatever prices prevail in commodity markets or seek to differentiate products and target niche markets, for example through eco-labelling or certification. Premiums may be limited however, as compliance with approved standards will probably be increasingly necessary for market access.

The market for CCS is predominantly whole fresh fish, although the market for products from sea bream and sea bass is gradually developing, especially various presentations of sea bass fillets or ready to cook whole or head-off fish. These are opening up sales into more northern European countries. However, the relatively high production cost of sea bass and sea bream seriously limits opportunities for substantial market expansion in this way since the products are in competition with many others derived from cheaper white fish raw materials.

Greater opportunities exist for market expansion and value addition through the processing of meagre, which has a lower cost of production per unit of fillet and potentially a wider range of products. However it is still in competition with other whitefish and due to current unfamiliarity of consumers will require a substantial marketing effort to raise demand and maintain adequate prices.

The establishment of a high quality processing facility for farmed fish in Malta would open up new opportunities for the sector, but for more sophisticated products, greater throughput would be required to justify the investment necessary. At present it is estimated that a throughput of between 10 and 20 tonnes per day would be necessary to ensure financial viability. Further market research is required to identify specific opportunities for value-added products, considering the mix of product, target market and distribution logistics.

The potential introduction of amberjack offers a short-term market opportunity to Malta as it could be the leading producer until other countries catch up. As this fish sells very well into traditional fresh whole fish markets there is no immediate need for value adding processing or marketing activities. However, as competition increases, processing could help expand the market and further enhance the value for Maltese producers.

11 Alternative species

Malta has placed great emphasis in its vision for the industry on the production of new closed cycle species such as meagre, amberjack and bluefin tuna. Meagre is already in commercial production and can be produced at significantly lower cost than seabream and seabass, but market acceptance is poor due to unfamiliarity with consumers and an unattractive appearance. Closing the production cycle for bluefin tuna has already been achieved in Japan, and research efforts are underway in the Mediterranean. If the cycle can be closed and production difficulties overcome, the production of small fast growing tuna up to a size of 1-2kg for sale on the European market may offer an opportunity, as well as the further ongrowing of such fish to larger sizes. However, research progress is slow and it is likely to be some time before commercial production becomes a reality. The species with the most potential in the short to medium term is amberjack. It grows fast, has good market acceptance and has potential for processing at larger sizes. MARC, which is at the forefront in the breeding of the species, has succeeded in closing the lifecycle and has produced the first hatchery reared juveniles. Although significant further work needs to be done on refining the production process, particularly nutrition, the prospects look promising.

Plans are underway to establish a hatchery and spawning facility for seabream and other species including amberjack and bluefin tuna, and providing the site is approved this would provide a launch pad for the production of amberjack juveniles for the industry. The establishment of a full scale commercial hatchery in Malta is long overdue, and is essential if Malta is to realise its vision of developing alternative species.

Consideration has been given to opportunities for non-fish aquaculture. There is one company producing phytoplankton in Malta, and another testing land-based intensive shrimp farming. Integration of aquaculture with hydroponic horticulture is also receiving greater attention. Innovations such as these should be encouraged, but the commercial potential remains uncertain and no specific competitive technical advantage for locating in Malta has been identified.

12 R&D

The key areas for research are closely related to the needs of the industry and include commercialisation of amberjack culture, closing the cycle for bluefin tuna culture, research into other potential species, developing environmental carrying capacity criteria, development of offshore cage technology and better feeds and methods of feeding for penned tuna.

At present, the only R&D facilities are at the MARC and research work is carried out through a joint venture with MFF through the Amberjack Project. This appears to work well, although activities are restricted by difficulties with the management of Government staff and the limitations of the facilities available. Proposals are underway for the establishment of a large scale spawning and hatchery facility to be run as a Public Private Partnership (PPP) which would also include research facilities to replace those currently at the MARC. Providing the proposed site for the new hatchery is agreed and the PPP model successfully adopted, this should provide a good vehicle for undertaking applied R&D in Malta.

13 Improving the image of aquaculture

Aquaculture in Malta appears to have a poor public image in Malta, largely due to the problems associated with baitfish feeding of tuna. Measures to improve this image include demonstration of compliance with both statutory operating conditions and a publicly available COGP, and a Strategy Document which has been through a process of public consultation. Aquaculture has a good story to tell and there is much scope for educating the public through for example school visits to farms and farm open days.

14 Aquaculture strategy

Further to the findings of this study and the issues raised during the consultation exercise, four broad strategic objectives are proposed:

Strategic objective	Desired outcome
Improved regulation	Streamlined regulatory environment under one MRRA Directorate, with a clear policy on site locations, minimal conflict with other users, and standard conditions for all operators
Improved operation	Efficient, profitable farms operating according to the principles of best management practice, complying with their operating consents, causing no nuisance to other coastal users, and with a positive public image
Improved environmental monitoring	A system that recognises the link between biomass and impacts, specifies limits to what constitutes adverse impact (EQS), over what area such impacts are acceptable (AZE), and is proportionate, practical and cost effective
Better innovation	Facilities, funding and human resources to allow high quality applied research for the benefit of all industry operators

The realisation of these objectives and desired outcomes should be achieved by formulating specific action plans as part of an operational programme going forward. Required action plans are given in the table below. The timescale for individual action plans will depend on the relative priority and the resources available.

Action plans for inclusion in operational programme

Key issue	Action plans needed	Related recommendations (NB refer to list in Section 8.2)	Responsibility	Priority
Regulatory issues				
	Updating National Aquaculture Policy	4, 9,12, 16, 29	MRRA	H
	Improving relationship with MEPA (liaison officer, working group)	17, 18	MEPA, industry, MRRA	H
	Identifying and applying for new aquaculture sites/zones	8, 10	MRRA, industry	H
	Standardisation of concession conditions	11	MRRA, industry	M
	Preparation of AMAs	26	Industry	M
	Preparation of a disease contingency plan	27	MRRA	L
Operational issues				
	Hatchery development	6	MRRA, industry	H
	Baitfish feeding practices	1, 2, 14, 20	MRRA, industry	H
	Production of COGP	15, 34	Industry	M
	Enforcement of operating conditions inc. site marking	13	MRRA	M
	Improving the image of aquaculture	34, 35	Industry	M
	Market development	30, 31, 32, 33	Industry	M
	Review of tuna offal disposal	3	MRRA, industry	L
	Improved fish disease diagnostic capability	28	MRRA	L
	Vocational training forum	25	MCAST, MQA, industry	L
Environmental issues				
	Independent review of environmental monitoring system	24	MRRA, MEPA	H
	Develop EQS and AZE criteria	24	MRRA, industry	H
Innovation issues				
	Amberjack research	5	MRRA, industry	H
	Hatchery/R&D centre PPP model and business plan	6, 21, 22, 23	MRRA, industry	H
	Alternative tuna feeds	20		M
	Review of research priorities and funding	19	MRRA, industry	M

Priority: H=high M=medium L=low

Delivery of the desired outcomes and implementation of related action plans should be made the responsibility of a Strategy Management Group (SMG) representing key stakeholder interests and chaired at Ministerial level. Such an SMG should meet every 6 months and review, amend and agree action plans. Individual SMG members would be given specific responsibility for overseeing actions relating to the 4 key priority themes of regulation, operation, environment and innovation, reporting to the SMG every 6 months or as appropriate.

The tables below summarise the overall picture for both sectors in terms of potential production scenarios, assumptions, constraints, economic impacts, employment levels, and funding requirements.

The scenarios for penned tuna assume that penned tuna farming i.e. using wild caught stock, takes place mainly at sites outside the 1 nautical mile limit in 50m water depth or more, in line with current Government policy. The production targets and timeframes can be viewed as milestones by which certain levels might be achieved, or as stand alone outcomes. In reality, Malta has no control over the status of wild stocks or ICCAT quotas so it is impossible to predict what future production levels might be. Even if the cycle is closed for tuna and hatchery stock becomes available, it is likely that cage culture will mainly be of 1-2kg fish grown on inshore sites rather than on the offshore sites currently used for the much larger (70kg plus) wild caught tuna, although some growers may choose to ongrow some stock to larger sizes on offshore sites.

The scenarios for CCS assume that farms are mainly on sites within the 1 nautical mile limit in 50m water depth or less. Some sites further offshore in 50-60m depth and outside the 1nm limit may also be suitable for larger CCS e.g. large amberjack or hatchery produced tuna >6kg. The achievement of production targets within the suggested timeframes will be dependent mainly on the availability of sites and the carrying capacity agreed for those sites, and secondarily on the future viability of CCS culture generally.

It must be emphasised that the achievement of the 2020 and 2025 scenarios, especially for CCS, will only be achieved if the Government ensures that increased site capacity is made available.

Strategy summary table – the penned tuna sector

	Section reference				
Timeframe		**2010 (est.)**	**By 2015**	**By 2020**	**By 2025**
Production scenario	Table 17	Baseline	1	2	3
Production targets (t)		3,520	2,000	4,500	7,000
Main assumptions	6.5.1		Reduced quotas, minimum financially sustainable level	Stocks increase moderately, quotas increase	Stocks increase significantly, quotas and production return to 2007 levels
Environmental constraints	6.1.1		None expected	None expected	Some new sites overlap maerl beds and are also in proposed MPA
Other constraints	6.1.1		F&F/MFF site amendments would need change to bunkering area 4	As 1, plus NE Zone overlaps trawl zone, wind farm, bunkering area	As 2, plus potential navigational & other constraints for possible new sites
Impact of constraints on potential production level			None, providing flexibility in which sites are used	None, providing flexibility in which sites are used	None, providing flexibility in which sites are used
Economic impact	Tables 11, 20				
Total GVA (€'000)		36,667	20,833	46,875	72,917
Direct employment		117	67	150	233
Total employment		609	297	667	1,038
Total household income (€'000)		8,991	5,108	11,494	17,879
Composition of human resources required					
Managerial staff	Note 1		3	8	12
Manual workers			64	143	221
Funding requirements					
Ongrow & shorebase capex (€ million)	Note 2		8.26	18.59	28.91

Notes

1 Managerial staff 5% of direct employees

2 Capex assumes up-front cost not allowing for facilities already installed. Based on depreciation of €0.59/kg and 7 years average life, capex=€4130/t.

3 F&F= Fish and Fish, MFF=Malta Fish Farming, MPA=Marine Protected Area, GVA=Gross Value Added

Strategy summary table – the closed cycle species sector

	Section reference				
Timeframe		**2010 (est.)**	**By 2015**	**By 2020**	**By 2025**
Production scenario	6.5.2	Baseline	1	2	3
Production targets (t)		1,925	2,500	5,000	10,000
Main assumptions	6.5.1		Mostly existing sites, amendment of F&F/MFF sites to move tuna penning further offshore, CCS capacity 500t/site, P2M unchanged	As scen. 1, but NE Zone and associated rationalisation approved, CCS capacity 1000t/site, P2M unchanged	As scen. 2, but AJD SPB used for CCS, more new sites approved, P2M unchanged
Environmental constraints	6.1.1		None expected	NE Zone in proposed MPA, increased CCS site capacity needs to be verified	As 2, plus some new sites ovelap maerl beds and are also in proposed MPA
Other constraints	6.1.1		F&F/MFF site amendments would need change to bunkering area 4	As 1, plus NE Zone overlaps trawl zone, wind farm, bunkering area	As 2, plus potential navigational & other constraints for possible new sites
Economic impact	Tables 11, 27				
Total GVA (€'000)		3,068	16,653	26,555	46,359
Direct employment		71	168	266	464
Total employment		115	324	518	906
Total household income (€'000)		1,705	5,625	8,791	15,122
Composition of human resources required					
Managerial staff	Note 1		8	13	23
Manual workers			160	253	441
Funding requirements					
Hatchery - approx. capex (€ million)	Annex 14		8.50	8.50	8.50
Ongrow & shorebase capex (€ million)	Note 2		2.98	5.95	11.90

Notes

1 Managerial staff 5% of direct employees

2 Capex asssumes up front cost not allowing for facilities already installed. Based on depreciation of €0.17/kg and 7 years average life, capex=€1190/t.

3 AJD=AJD Tuna, CCS=closed cycle species, F&F= Fish and Fish, GVA=Gross Value Added, MFF=Malta Fish Farming, MPA=Marine Protected Area, SPB= St Paul's Bay

The scenarios presented above are seen as sequential milestones that could be realistically reached by the indicated date based on the assumptions given. However, there are clearly economic incentives for moving faster: the economic impact of increased output is cumulative, so the earlier targets are reached, the greater the total benefit for Malta over the next 15+ years. Alternatively, progress may be slower and if new sites are not authorised, development may be restricted to scenario 1 or 2. If the tuna penning industry does not show prospects for recovery within the next 5 years it may be desirable to place greater strategic focus on CCS and the potential use of offshore sites for the culture of larger amberjack for instance.

There are therefore many variables that affect the timetable for implementing the identified actions. An attempt to map the actions against time is shown in the tables below. However, in most cases, earlier action is desirable. The urgency of others (e.g. market development) will depend on the rate that production increases, or the competitive pressures faced by the producers.

The highest priorities for immediate action are the updating of the aquaculture policy and adoption of the aquaculture strategy and investment in better marine hatchery facilities and associated research and development.

Indicative roadmap of actions for the penned tuna sector

	2011	2012	2013	2014	2015
Regulatory Issues		Updating National Aquaculture Policy Improving relationship with MEPA	Identifying and Applying for New Aquaculture Sites / Zones		Standardisation of Concession Conditions Preparation of Area Management Agreements
Operational Issues		Baitfish Feeding Practices	Production of Codes of Good Practice Enforcement of Operating Conditions incl. Site Marking	Production of Codes of Good Practice Market Development	Improving the Image of Aquaculture Improved Fish Disease Diagnostic Capabilities
Environmental Issues		Independent Review of Environmental Monitoring Programme	Develop Environment Quality Standards and Allowed Zone of Effects Criteria		
Innovation Issues			Review of Research Priorities and Funding	Alternative Tuna Feeds	

	2016	2017	2018	2019	2020
Regulatory Issues		Preparation of a Disease Contingency Plan	Identifying and Applying for New Aquaculture Sites / Zones		
Operational Issues	Review of Tuna Offal Disposal Vocational Training Forum		Market development		
Environmental Issues					
Innovation Issues		Review of Research Priorities and Funding			

	2021	2022	2023	2024	2025
Regulatory Issues					
Operational Issues					
Environmental Issues					
Innovation Issues		Review of Research Priorities and Funding			

Indicative roadmap of actions for the closed cycle species sector

	2011	2012	2013	2014	2015
Regulatory Issues		Updating National Aquaculture Policy Improving relationship with MEPA	Identifying and Applying for New Aquaculture Sites / Zones		Standardisation of Concession Conditions Preparation of Area Management Agreements
Operational Issues		Hatchery Development	Hatchery Development	Hatchery Development	Hatchery Development
			Production of Codes of Good Practice	Production of Codes of Good Practice	Improving the Image of Aquaculture
			Enforcement of Operating Conditions incl. Site Marking	Market Development	Market Development
					Improved disease diagnostic facility
					Vocational Training Forum
Environmental Issues		Independent Review of Environmental Monitoring Programme	Develop Environment Quality Standards and Allowed Zone of Effects Criteria		
Innovation Issues		Amberjack Research	Amberjack Research	Amberjack Research	Amberjack Research
		Hatchery / R&D Centre PPP Model and Business Plan	Hatchery / R&D Centre PPP Model and Business Plan		
			Review of Research Priorities and Funding		

	2016	2017	2018	2019	2020
Regulatory Issues	Preparation of Area Management Agreements	Preparation of a Disease Contingency Plan	Identifying and Applying for New Aquaculture Sites / Zones		
Operational Issues	Hatchery Development				
	Vocational Training Forum				
	Market Development	Market Development	Market Development	Market Development	Market Development
Environmental Issues					
Innovation Issues	Amberjack Research	Review of Research Priorities and Funding			

	2021	2022	2023	2024	2025
Regulatory Issues		Identifying and Applying for New Aquaculture Sites / Zones			
Operational Issues					
Environmental Issues					
Innovation Issues		Review of Research Priorities and Funding			

1 Introduction

1.1 Background

This study was contracted by the Malta Aquaculture Research Centre (MARC), Ministry for Resources and Rural Affairs (MRRA) and took place over a 4 month period between February and June 2011. The Terms of Reference (TOR) for the study are given in Annex 1.

The aquaculture industry in Malta began in the late 1980s and in 2009 produced around 5,200t, of which 3,000t was Atlantic blue fin tuna (*Thunnus thynnus)* and 1,200t other species, predominantly seabream (*Sparus aurata)*. There are presently 6 companies operating from around 10 different sites, supported by the MARC, which also produces juveniles for one company. Most juveniles however have to be imported.

Tuna farming has reached a crossroads, having reached a peak of 7,000t in 2007, declining to around 3,000t in 2009, and expected to produce even less in 2011. This has been due to a reduction in the quotas for the capture of wild tuna on which the farms depend, in response to concerns over the status of stocks in the Mediterranean and East Atlantic. These concerns are likely to continue, despite some evidence that stock levels are improving.

The farming of seabream and other species, which depend on hatchery produced juveniles, so called "closed cycle species" (CCS) remains at a relatively low level compared with other Mediterranean countries, and is subject to the cyclical nature of the regional industry, characterised by periods of "boom and bust". Nevertheless, the Maltese product is well regarded in its main market of Italy, and Maltese growers have proved to be resilient throughout such periods.

In recent years, the MARC has made significant progress in the breeding of amberjack (*Seriola dumerili*), and is considered to be at the forefront of research into the species in the Mediterranean. Amberjack is considered to have excellent potential for aquaculture, and the foundations for the commercial production of this and other species are being laid with plans for a local hatchery. Research is also on-going with regard to closing the production cycle for blue fin tuna, but this is likely to be a longer term endeavour.

The way forward for Maltese aquaculture is thus seen to be to capitalise on such alternative species know-how, differentiating itself from the mass production of seabream and seabass found elsewhere, and national policy emphasises the need for such species diversification and technological innovation. At the same time, it is recognised that the development of the industry must give due consideration to environmental issues.

It is with this background that a strategy for aquaculture development in Malta is now required.

1.2 Study objectives

The TOR give the overall objectives of the study as:

- To lay down a structured path for sustainably developing aquaculture in Malta
- To identify the domains that are essential for a profitable and sustainable industry in Malta

Specific objectives and activities are defined in more detail under the following headings:

- Review of the present status of the aquaculture industry in Malta
- Establishing a production target
- Identification of sites or zones for aquaculture development
- Consultations
- Supporting research needs
- Identifying the financial sources for supporting research needs
- Streamlining of licensing and procedures
- Fish health control
- Diversification of fish products and improving marketability
- Non-finfish production potential

- Conformity with EU Directives and other international organisations' regulations

1.3 Scope of the work

The scope of the work as set out in the TOR emphasises the need for species diversification, suggesting planning for production of a new species every 5-10 years to allow market resilience and to encourage investment.

It envisages producing fish only in closed cycle to reduce the dependence on wild caught fish e.g. tuna and thus to improve sustainability. At the same time, it recognises that closing the cycle for tuna, as has already happened in Japan, will bring new challenges in terms of marketing given that Japan is presently the primary market.

The strategy must consider the potential of the industry, what is required to sustainably achieve that potential and the timescale (2011to 2025), taking into account environmental issues and financial viability.

1.4 Study approach

Our approach to the study has been to take into account the specific objectives given in the TOR, as well as to consider any other aspects necessary for the development of a sustainable industry.

Section 2, methodology, gives details of stakeholder consultations carried out, from which the main industry issues were identified.

Section 3, international context, considers relevant EU and other international aquaculture policy, and Malta's position as a producer in Europe, including a SWOT analysis.

Section 4, the present status of aquaculture in Malta, examines the history and evolution of the industry, national aquaculture policy, the regulation of the industry, fish health control, and existing socio-economic impacts.

Section 5 gives the results of the stakeholder consultations carried out during two visits to Malta, summarising the issues raised and discussing the findings and their implications for strategy.

Section 6 focuses on the future potential of the industry. Key to this is an assessment of both existing and potential new sites, given the extreme pressures on Malta's limited coastal resources. Further sub-sections cover technology appraisal, market opportunities, and research and development (R&D). Finally, taking the preceding sub-sections into account, future production scenarios are considered and their potential socio-economic impacts.

Section 7 summarises the main conclusions from the study. These provide the basis for recommendations which in turn feed into the action plans set out in the following section summarising the strategy for aquaculture in Malta.

Finally, under Section 8, the strategy for aquaculture in Malta is presented. Recommendations and proposals for policy positions are made, strategic objectives identified and associated action plans, roadmaps and timeframes proposed.

2 Methodology

2.1 Management and timing

The study team answered directly to Dr Robert Vassallo Agius, head of the Malta Aquaculture and Research Centre (MARC), who in turn responded directly to the Permanent Secretary of the Ministry for Resources and Rural Affairs (MRRA).

The study took place over a 4 month period between 16^{th} February and 16^{th} June 2011.

2.2 Study team

The Stirling Aquaculture study team and their responsibilities were as follows:

- John Bostock (project manager)
- David Scott (team leader and senior report author)
- Richard Corner (environment specialist)
- Trevor Meyer (marine fish specialist, fish health and local coordinator)

In addition, services were sub-contracted as follows:

- Tektraco Ltd (conservation and marine space issues)
- PwC (financial and economic analysis)

2.3 Secondary data analysis

Secondary data of relevance to the study was gathered from a variety of sources including the aquaculture media, scientific literature, industry reports, Food and Agriculture Organisation (FAO), Government of Malta statistics, the MEPA website, and market research reports. A full list of references is provided at the end of the report.

2.4 Stakeholder consultations

A list of industry stakeholders for consultation was drawn up in consultation with MRRA, which included relevant Government departments, producers, local councils, and NGOs. Stakeholders were approached by email and/or phone explaining the background to the study and inviting them to make contact with the study team to make their views known.

Face to face interviews were held with the majority of stakeholders contacted during two visits made by Stirling staff as follows:

15-19^{th} February 2011: David Scott, John Bostock, Trevor Meyer
13-19^{th} March 2011: David Scott, Richard Corner, Trevor Meyer

The interviews were carried out on a semi-structured basis working to a list of key issues relevant to the stakeholder in question. The meetings held were as follows:

15-19^{th} February 2011

- Dr. Grupetta, Director General, Agriculture and Fisheries Regulation
- Stefan Cachia, Director, EU Affairs
- Robert Aquilina, Chief Executive Officer (CEO), P2M Ltd
- Saviour Ellul, Managing Director (MD), Malta Fishfarming Ltd
- Dr Robert Vassallo Agius, Director, Malta Aquaculture Research Centre (MARC)
- Angus Sharman, Hatchery Manager, Malta Fishfarming Ltd
- Raymond Bugeja, Director, Ta' Mattew Fish Farms Ltd

13-19th March

- Dr Simeon Deguara, Malta Fishfarming Ltd
- Peter Portelli, Malta Tourism Authority
- Joe Borg, Director, Ecoserv Ltd
- Dr Ing. Tonio Sant, University of Malta (MRRA renewable energy)
- Charlie Azzopardi, MD, AJD Tuna Ltd
- Joe Caruana, Director, Fish & Fish Ltd
- Giovanni Cappitta, Director, Mare Blu Tuna Farm Ltd
- Dr John Refalo, Secretary, Federation of Maltese Aquaculture Producers
- Robert Aquilina, CEO, P2M
- Michael Sant, Unit Manager, Environmental Permitting and Industry Unit, Environment Protection Directorate, MEPA
- Claudine Cardona, Environmental Protection Officer, Unit E Water and Marine Policy, MEPA
- Mario Calleja, Mayor, Marsascala Local Council
- Manuel Borg, Director, Dive Med
- David Bugeja, Chief Officer, Ports and Yachting Directorate
- Vincent Attard, Executive President, Nature Trust
- Graziella Galea, Mayor, St Paul's Bay Local Council
- Robert Cutajar, Mayor, Mellieha Local Council

In addition to the above, Trevor Meyer attended the conference on the future of fisheries, held by 'Din l-Art Helwa' at the Intercontinental Hotel, St. Julians on 25 March 2011, and on 5 April 2011 had a further meeting with MEPA staff, accompanied by Robert Vassallo Agius of MARC, as follows:

- Dennis Kasap and Josianne Vassallo, Senior Environment Protection Officers, Environmental Assessment Unit
- Nadia Suda Lanzon, Senior Environment Protection Officer, Protected Areas, Ecosystem Management Unit

Robert Vassallo Agius also accompanied Stirling staff to many of these meetings. Aside from the key individuals mentioned, there were usually other staff present from the organisations concerned who also offered opinions. Shane Hunter of the AquaBioTech Group was interviewed by phone.

2.5 Reporting

An interim progress report was submitted half way through the study on 16th April 2011, setting out key issues raised during the meetings and provisional thoughts on some aspects of future development, including locations, species, regulation and socio-economic impacts.

The interim report was forwarded by Robert Vassallo Agius to the Permanent Secretary of MRRA, Dr Gruppetta as Director General of the AFRD, the Federation (FMAP) and P2M Ltd (not part of the federation). The feedback received has been taken into account in the final report.

The draft final report was submitted on 15th June 2011, with further drafts subsequently.

3 International context

3.1 International policy and regulatory environment

3.1.1 EU strategy for aquaculture

Aquaculture is broadly classed as a branch of fisheries within the European Commission and is included in the Common Fisheries Policy (CFP) and particularly the Common Organisation of the Markets (COM) in fishery and aquaculture products. However, to date, the CFP has few references to aquaculture production, site or capacity issues. The first specific strategy for the sustainable development of aquaculture in Europe was published by the European Commission in 2002 (COM (2002) 511 Final). This set out three overall objectives:

- Creating long term secure employment, in particular in fisheries dependent areas
- Assuring the availability to consumers of products that are healthy, safe and of good quality, as well as promoting high animal health and welfare standards
- Ensuring an environmentally sound industry

These were developed into 9 areas for action:

- Production
    - Refocus priorities for public aid through the FIFG
    - Promote research on new species and strains, as well as on alternative protein sources for fish feed
    - Create specific common definitions and norms for organic and "environment friendly" aquaculture
- Competition for space
    - Develop closed water recirculating systems, offshore fish cage technology, mollusc offshore rafts and long lines
    - Incorporate future aquaculture development in Integrated Zone Strategies and Management Plans
- Market development, marketing and information
    - Increase use of official quality marks
    - Improve the image of the industry, and develop promotional campaigns
    - Develop new tools to gather statistical information on production and markets
    - Further develop farmers' partnerships
- Training
    - Adapt training programmes to aquaculture needs
    - Recognise the role of women
    - Recognise aquaculture in rural development and reversing the decline in coastal communities
- Governance
    - Stakeholder participation must be further developed
    - The industry should make more use of self-regulation and voluntary agreements
- Safety of aquaculture products
    - Recast of the Community legislation on food hygiene
    - Provisions for dioxin and antibiotic residues
    - More research on and control of toxic algal blooms and aquatic animal diseases
    - Regular updating and simplifying of aquatic animal health legislation
    - Modification of the veterinary pharmaceutical legislation
- Animal welfare
    - Initiatives to improve farmed fish welfare
- Environmental aspects
    - Mitigate the impact of wastes
    - Manage the demand for wild fish for on-growing

- Develop instruments to tackle the impact of escapees, alien species and GMOs
  - Integrated pollution prevention and control
  - Specific criteria and guidelines for aquaculture Environmental Impact Assessments
  - Recognise and strengthen the positive impact of extensive culture and re-stocking
  - Find solutions for the predation from protected wild species
- Research
  - Extending the opportunities of financing research and technological development
  - Identifying research priorities

A key target for the 1992 strategy was growth in production of around 4% per year. By 2008 it was clear that this target had not been achieved, indeed there was virtually zero growth at the EU level and the output of some species had declined. The Commission therefore issued a follow-up communication in 2009 (COM(2009) 162/3) entitled "Building a sustainable future for aquaculture: A new impetus for the Strategy for the Sustainable Development of European Aquaculture". This reinforced the earlier strategy whilst identifying specific further actions to help with strengthening it. These actions were detailed under the following headings:

- A vision for the future of EU aquaculture
  - Current challenges and outlook
  - Building the future of the EU aquaculture industry
- Promoting competitiveness of EU aquaculture production
  - Research and technological development
  - Equal competitor in terms of space
  - Enabling the aquaculture business to cope with market demands
  - The international dimension
- Establishing conditions for sustainable growth of aquaculture
  - Ensuring compatibility between aquaculture and the environment
  - Shaping a high-performance aquatic animal-farming industry
  - Ensuring consumer health protection and recognising the health benefits of aquatic food
- Improving the sector's image and governance
  - Better implementation of EU legislation
  - Reducing the administrative burden
  - Ensuring proper stakeholder participation and appropriate information to the public
  - Ensuring an adequate monitoring of the aquaculture sector

Particular emphasis is placed on improving competitiveness through streamlining regulation and taking broader account of global trends and opportunities. The renewed emphasis on supporting sustainable aquaculture development has been supported by the European Parliament with additional recommendations (Committee on Fisheries A7-0150/210, "Report on a new impetus for the Strategy for the Sustainable Development of European Aquaculture (2009/2107(INI))").

3.1.2 Aquaculture and the development of EU policy in maritime spatial planning

The issue of making sites available for coastal aquaculture is recognised as problematic due to conflicts of interest and concerns over environmental impacts, and both of the aquaculture strategy documents urge National and Regional authorities to ensure aquaculture has equal access with other potential users and encourages the establishment of aquaculture development zones in structural plans. However, broader initiatives on Maritime Spatial Planning (http://ec.europa.eu/maritimeaffairs/spatial_planning_en.html) and Integrated Coastal Zone Management (http://ec.europa.eu/environment/iczm/home.htm) are underway, in which aquaculture is expected to be recognised. Policy development in this area is currently open for public consultation by the Commission on Maritime Spatial Planning and Integrated Coastal Zone Management and is expected to result in an EC policy by 2013 (http://ec.europa.eu/fisheries/partners/consultations/msp/index_en.htm). This work is part of the wider programme to develop an Integrated Maritime Policy for the EU (http://ec.europa.eu/maritimeaffairs/mp_dev_en.html) of which an Integrated maritime policy in the Mediterranean (http://ec.europa.eu/maritimeaffairs/mediterranean_en.html) would be an integral part. The Commission vision for this policy is:

- The permeation of an integrated approach to maritime affairs at the appropriate levels will continue to be encouraged, together with further cooperation and dialogue with non-EU Mediterranean coastal States in this respect.
- Structured and effective dialogue amongst coastal States on governance of the marine space will be stimulated at the appropriate fora.
- Stakeholder platforms will be encouraged to regularly address the Mediterranean Sea and its specificities, and working towards basin-wide stakeholder dialogue, inclusive of stakeholders from non-EU Mediterranean coastal States.
- The necessary efforts need to be employed by Mediterranean Member States in the definition of integrative "Marine Strategies", in line with the obligations arising from the Marine Strategy Framework Directive.
- The potential of engaging in Maritime Spatial Planning in specific sub-regions or sea-areas in the Mediterranean should be fully explored.
- The concretisation of Integrated Coastal Zone Management in coastal areas and islands needs to be strengthened, particularly coherence between onshore and offshore planning.
- The development of marine knowledge and integration between marine and maritime research efforts need to be fully pursued, this being at the basis of an ecosystem-based approach to the management of activities at sea.
- The integration of surveillance of maritime activities and operations in the Mediterranean will be furthered, with the objective of making the Mediterranean Sea a safer and secure maritime space.

3.1.3 Aquaculture and developing EU policy on food security

The issue of food security is rising up the political agenda as a number of studies[1] have highlighted the dual problems of rapidly growing world population and increased vulnerability of agriculture due to climate change. Europe is particularly vulnerable with respect to fish supplies as 60% (€15.5 billion) is now imported[2]. However, the EC does not yet have a specific or integrated policy on food security. Nevertheless, aquaculture can be considered to be a significant activity within the "Knowledge Based Bio-Economy" and as such, can be a means by which Europe meets the strategic objectives of Europe 2020 (http://ec.europa.eu/europe2020/index_en.htm). The development of new approaches and technologies for production are very much encouraged through flagship initiatives such as "A resource efficient Europe" (http://ec.europa.eu/resource-efficient-europe/index_en.htm) and "Innovation Europe" (http://ec.europa.eu/research/innovation-union/index_en.cfm).

3.1.4 Common Fisheries Policy

A reformed Common Fisheries Policy (CFP) is under development for implementation by 2012. This is expected to contain greater reference to the role of aquaculture, especially as aquaculture products increasingly interact with capture fishery products in the marketplace, or utilise products and by-products from capture fisheries.

In a recent publication (EC, 2011), the European Commission "highlights once again the importance of developing a sustainable and top-notch European aquaculture industry. Its aim is to have Member States agree to abolish barriers to the development of this sector. The Commission therefore asks the States to develop their aquaculture strategy without delay and calls on the sector to organise in order to make its voice stronger."

The reform of the CFP gives measures for aquaculture which are in line with the strategy 'Building a sustainable future for European aquaculture', adopted in 2009. Such measures include the intention to ask each Member State to draw up a multiannual strategic plan by 2014 to encourage the development of aquaculture activities on their territories. Economic development, sustainability, food security and job creation are key elements of such plans, with the emphasis on administrative simplification, improved access to water and

[1] E.g. http://webarchive.nationalarchives.gov.uk/+/http://www.bis.gov.uk/foresight/our-work/projects/current-projects/global-food-and-farming-futures, http://www.quae.com/en/livre/?GCOI=27380100796800 and http://www.fao.org/wsfs/forum2050/wsfs-forum/en/
[2] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/fisheries/statistics/

space, the development of environmental, economic and sustainability indicators, and the study of the environmental impact of further development of aquaculture.

A further measure proposed is the creation of an Aquaculture Advisory Council, made up of relevant stakeholders, which will provide advice to the Commission on policy matters and current issues.

3.1.5 FAO and IUCN initiatives to support sustainable aquaculture

At the national planning level, the natural resource requirements of aquaculture and potential environmental impacts have come under greatest scrutiny as there have been a number of campaigns against aquaculture by environmental lobby groups. However, it is widely recognised that aquaculture can be carried out in a sustainable manner with minimal environmental impacts. The Food and Agriculture Organisation of the United Nations has an extensive programme of support for aquaculture development in this respect. A key element of current activity is the theme "An Ecosystem Approach to Aquaculture" (http://www.fao.org/fishery/topic/16035/en) with parallel and linked attention to theme "An Ecosystem Approach to Fisheries". The conceptual basis for an ecosystem approach to aquaculture was set out at a conference in Spain in 2007 (http://www.fao.org/docrep/011/i0339e/i0339e00.htm). Consideration is being given to environmental interactions of both near shore and offshore aquaculture and further reports are expected to be published through GESAMP (http://gesamp.org/ e.g. see http://www.gesamp.org/data/gesamp/files/media/Publications/Reports_and_studies_76/gallery_1041/object_1041_large.pdf)

Specific to the Mediterranean is the FAO organised "General Fisheries Commission for the Mediterranean Committee on Aquaculture" (GFCM-CAQ) which has two research activities in support of policy development for cage aquaculture:

- InDAM - Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean (http://www.faosipam.org/?pag=content/_ShowPortal&Portal=InDAM)
- SHoCMed - Project in support to the GFCM CAQ Working Group on Site Selection and Carrying Capacity (WGSC) (http://www.faosipam.org/?pag=content/_ShowPortal&Portal=SHOCMED)

The International Union for Conservation of Nature (IUCN) has also taken an interest in the environmental interactions of aquaculture in the Mediterranean and issues of site selection and responsible practices with three reports:

- Interactions between Aquaculture and the Environment: http://cmsdata.iucn.org/downloads/acua_en_final.pdf
- Site Selection and Site Management: http://data.iucn.org/dbtw-wpd/edocs/2009-032.pdf
- Aquaculture Responsible Practices and Certification: http://data.iucn.org/dbtw-wpd/edocs/2009-032.pdf

3.1.6 European legislation

As a member of the European Union, Malta is required to adopt EC regulations into law. Some of the specific laws affecting aquaculture are considered later in this report. The key areas of legislation are summarised in the following table.

Table 1. Summary of key aquaculture legislation

Regulatory area	Comments	Key EU Documents
Licensing of aquaculture operations	No EU legislation - wide variety of national and regional provisions	
Access to sites	No EU legislation, although could be introduced in the future for marine aquaculture through initiatives on maritime spatial planning and integrated coastal zone management. National and	

	Regional schemes for planning permission and site leasing.	
Animal health and welfare	EU directives are in place and further development is expected to help control serious aquatic animal diseases and promote good husbandry	Council Directive 2006/88/EC as amended by Directive 2008/53/EC
Veterinary medicines	EU regulations are in place controlling the marketing of veterinary medicines for fish. These are considered to be too restrictive my most of the industry and may be revised once new rules on setting maximum residue limits have been established	Council Directive 2001/82/EC as amended by Directive 2004/28/EC
Food safety and standards	This is a more highly regulated aspect of aquaculture involving a large number of regulations and directives covering hygiene, feed, additive, product labelling and inspection procedures	Regulation (EC) No 178/2002, Regulation (EC) No 136/2004, Regulation (EC) No 882/2004, Regulation (EC) No 183/2005, Commission Regulation (EC) No 2074/2005, Commission Regulation (EC) No 2074/2005, Regulation (EC) No 2074/2005 , Commission Regulation (EC) No. 1666/2006, Regulation (EC) No 2076/2005, Regulation (EC) No 853/2004, (EC) No 854/2004 and (EC) No 882/2004, Regulation (EC) No 852/2004, Regulation (EC) No 853/2004, Regulation (EC) No 854/2004, Commission Regulation (EC) No 2073/2005, Commission Regulation (EC) No 1662/2006, Regulation (EC) No. 853/2004, Council Directive 96/23/EC, Directives 85/358/EEC and 86/469/EEC and Decisions 89/187/EEC and 91/664/EEC, Directive 2002/32/EC, Decision 2002/657/EC, Council Directive 96/23/EC, Decision 2003/181/EC, Decision 2002/657/EC, Decision 2004/25/EC, Decision 2002/657/EC, Commission Decision 2005/34/EC, Regulation (EC) No 396/2005, Commission Regulation (EC) No 1881/2006, Regulation 2377/90 and amending Directive 2001/82/EC and 726/2004, Commission Regulation (EU) No 37/2010, Council Regulation (EC) No 104/2000, Directive 2000/13/EC, Commission Regulation (EC) No 2065/2001, Council Regulation (EC) No 104/2000, Regulation (EC) No 1829/2003, Regulation (EC) No 1830/2003, Directive 2001/18/EC, Regulation (EC) No 1831/2003, Regulation (EC) No 1935/2004, Directives 80/590/EEC and 89/109/EEC
Nature conservation	Regulation of aquaculture sites and management is required to take account of nature conservation issues under EU directives on conservation and biodiversity. This has particular implications for the control of predatory wildlife on aquaculture sites	Directives 97/409/EEC, 92/43/EC,
Environmental impacts	Under a gradual process of transition, the environmental aspects of aquaculture are coming under the Water Framework Directive (fresh and coastal waters) and potentially the Marine Strategy Framework Directive (marine waters). The delays in implementing the Water Framework Directive has created uncertainty which has affected aquaculture development	Directive 2000/60/EC and Directive 2008/56/EC other regulations include Directive 2006/113/EC, Directive 2006/11/EC, Directive 2008/105/EC, 76/464/EEC, Regulation (EC) No. 708/2007
Environmental impact	Environmental Impact Assessments are now required under EC directives for	Directive 85/337/EEC as amended by Directives 97/11/EC and 2003/35/EC

assessment	most new aquaculture developments	
Strategic environmental assessment	EC Directives require an environmental assessment of government plans and programmes likely to have significant effects on the environment, including aquaculture.	Council Directive 2001/42/EC
Trade rules	International trade is primarily governed through the World Trade Organisation with a system of import tariffs and various bilateral free trade agreements. Sanitary and phytosanitary measures are incorporated into these, together with anti-dumping safeguards. Specific EU regulations have been introduced in some circumstances, e.g. against Norwegian salmon (EC 1890/97 and EC 1891/97 which were repealed in Regulation 930/2003)	EC No 384/66, EC 2026/97
Data collection	New provisions have been introduced for the collection of data on aquaculture operations and economic performance	Regulation (EC) No 2008/199, Regulation (EC) No 665/2008

3.1.7 EC Support for aquaculture development

Direct support to the aquaculture sector is mainly provided through the European Fisheries Fund, which also covers capture fisheries, processing and marketing. The scheme is administered through national government agencies who are also responsible for part-funding the grants that are made. Each country administers the scheme in accordance with a National Strategic Plan and grants are intended to cover only part of the investment cost made by the private sector. Projects eligible for funding in Malta need to address key strategic objectives such as:

- To close the production cycle of existing aquaculture production and achieve the diversification of cultivated species
- Reduce the negative impact of existing operations on the environment
- Develop markets through investment in processing and packing facilities and promotional campaigns

Support for research and technological development is currently provided through the 7th RTD Framework Programme (FP7) which encompasses a wide range of funding mechanisms. Most of these require collaborative research between organisations in two or more EU Member or Associated States. Examples of such funding are the REPRODOTT and SELFDOTT[3] projects on bluefin tuna breeding and larval rearing. The latter has a budget of €3 million and 14 partners including Malta Fish Farming Ltd and the Malta Centre for Fisheries Sciences.

In terms of future strategy for aquaculture research, the European Commission is currently developing policy for the 8th Framework Programme which is due to commence in 2014. This may adopt a more strategic "investment" approach and is likely to be significantly influenced by the Technology Platforms that have been encouraged during FP7. These platforms are industry led and funded with the objective of setting out agreed priorities and recommending research strategies. The European Aquaculture Technology and Innovation Platform[4] (EATIP) is currently developing a strategic research and innovation agenda covering the following areas:

- Product quality, consumer safety and health
- Technology and systems
- Managing the biological lifecycle

[3] http://sites.google.com/site/selfdottpublic/
[4] http://www.eatip.eu/

- Sustainable feed production
- Integration with the environment
- Knowledge management
- Aquatic animal health and welfare

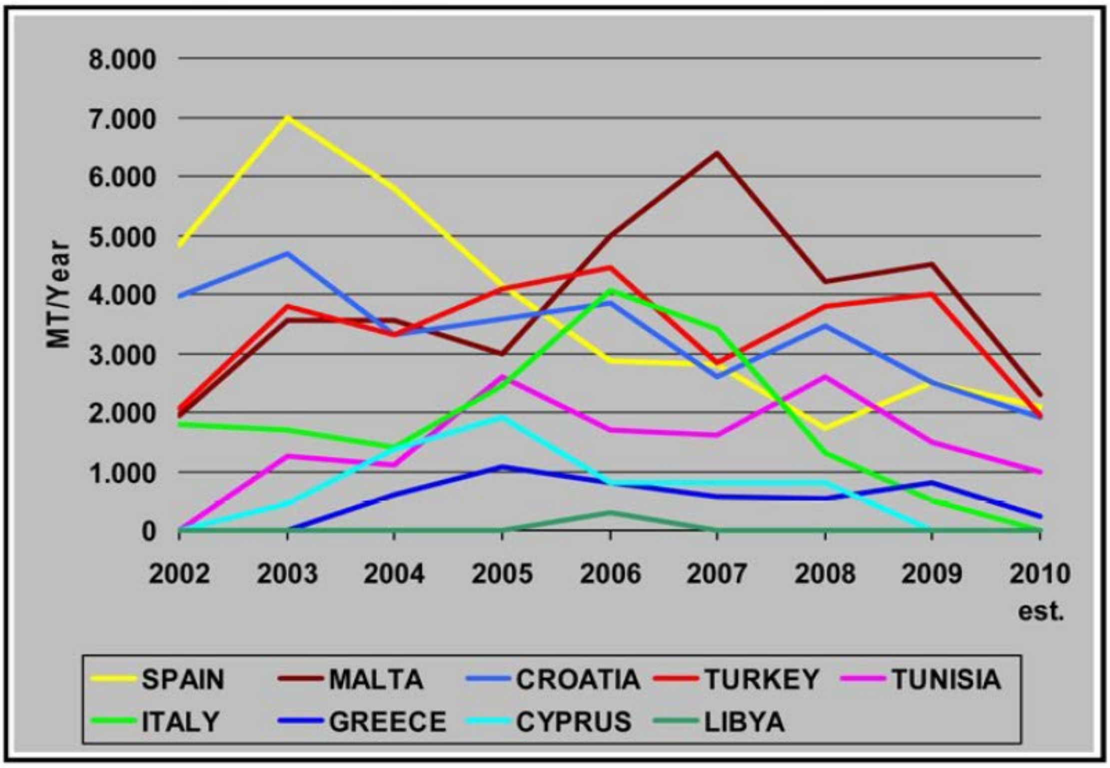
Whilst there is no obligation for the Commission to fund the programmes recommended by EATIP, they are likely to have significant influence on Commission RTD funding programmes for aquaculture.

3.2 Malta's position as an aquaculture producer in Europe

3.2.1 Competitive environment

The Maltese aquaculture sector is entirely based on marine finfish production from cages, but is segmented into tuna penning operations and "closed cycle" aquaculture species, predominantly sea bream and sea bass. Over recent years the tuna segment has been more important economically, but it has become increasingly constrained by decreasing bluefin tuna catch limits. Initially the bluefin tuna penning added value to existing Maltese catches of that species. However, the purchase of tuna from Libyan, French and Spanish purse seiners increased production volumes and the value generated. This peaked in 2007 with the production of 6,800 tonnes at a value of €96.8m (NSO data), making it the leading Mediterranean producer by some margin (see Figure 1). Production in 2009 was substantially lower at 3000 tonnes, representing 18.5% of total Mediterranean production by quantity and 30% by value. In the tuna sector therefore, Malta has achieved a very significant position and high market value. A key strength of Malta in the tuna sector is its proximity to migratory routes and thus to potential stock, limiting the distance over which captured tuna have to be transferred back to Malta for fattening. In addition, Malta has unrivalled expertise in offshore aquaculture, given it has never had an alternative.

Figure 1. Production of penned bluefin tuna in the Mediterranean.



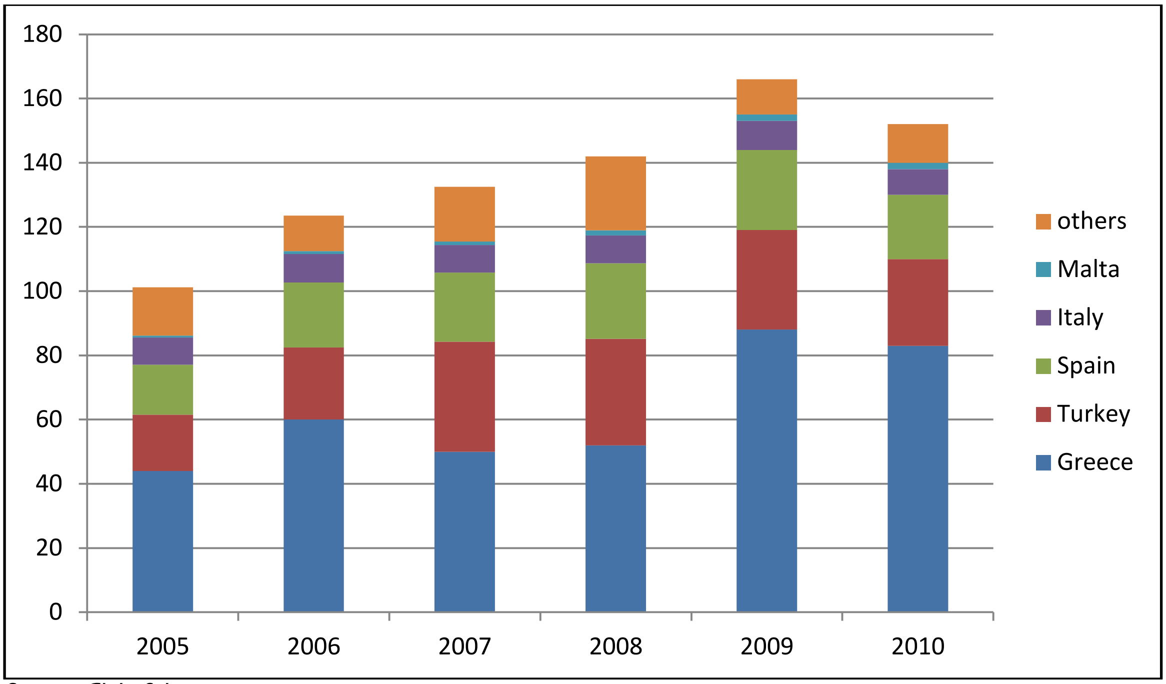
Source: FMAP

As a producer of seabass and bream (and more recently meagre and some other species), Malta is far less significant in the Mediterranean region. Total production of sea bass and sea bream in 2009 was 2,077 tonnes with a value of €7.3 million, compared with a regional production of 250,629 tonnes valued at €1,013 million (around 0.7% by value).

Figure 2 shows the annual production of seabream for the period 2005 to 2010. This indicates that the annual production per country has been relatively stable over this 5 year period save for a marked increase by Greek producers during 2009 and 2010. The graph also emphasises the small relative contribution to the global supply of seabream by Maltese producers. Total production of seabream declined in 2010 following a steady increase over the period 2005-2009. The Maltese contribution to global seabass production is negligible.

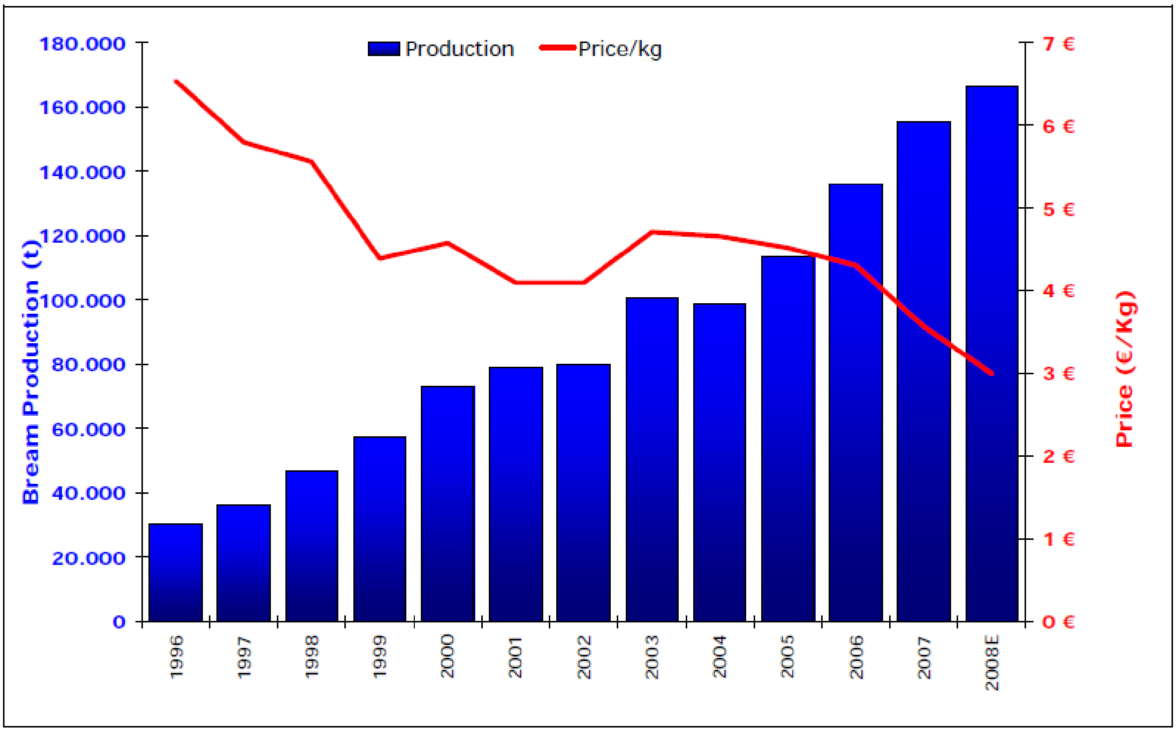
Increases in production have generally been accompanies by decreases in sales value, which has increased competition (see Figure 3 andFigure **4**). Maltese producers must take prices from the wider European commodity market for these species, or seek to differentiate into niche markets e.g. through species diversification, organic or novel value added products or geographic specialisation. For instance there has been significant production of larger sized bass (up to 2 kg) which can command higher prices per kilo on some markets.

Figure 2. Annual seabream production by country for the period 2005-2010. Figures in '000's of tonnes.



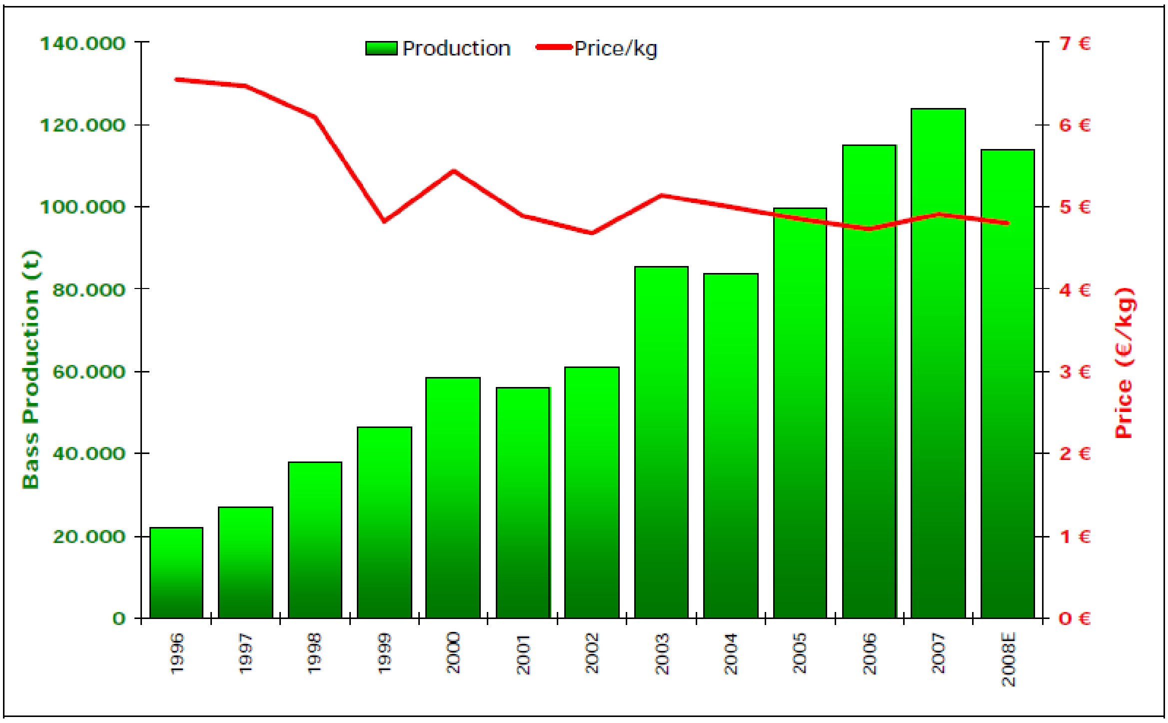
Source: Globefish

Figure 3. Evolution of production and price for European gilthead sea bream



Source: Barazi-Yeroulanos, 2010

Figure 4. Evolution of production and price for European sea bass



Source: Barazi-Yeroulanos, 2010

In terms of production costs, Barazi-Yeroulanos (2010) found there were few economies of scale for farms below 1000t production per year, which suggests larger Greek, Turkish and Spanish producers may have some advantage here. It can be seen from the salmon industry that significant up-scaling, the introduction of automation and mechanisation can have a substantial impact on production costs.

The ratio of fixed to variable costs was reported to be lower in Malta than in some other countries with similar sized farms (e.g. Cyprus, Italy, Algeria and Albania). However, the total cost of production was reported to be higher in Malta due to the need for imported seed and feed (average €4.04/kg compared with the lowest value of €3.40/kg in Croatia).

3.2.2 Internal and external constraints on growth

In many respects, Malta is very well positioned with good access to high quality seawater and marine sites and ready access to the largest single market for seafood in the world. It is also a market that is growing, and which will require greater supply from aquaculture in the future as global population increases and competition for capture fisheries resources intensifies. However, it is relatively small even in European terms (and the European aquaculture sector is less than 5% of global aquaculture) and somewhat fragmented, especially with respect to investment in hatchery production, product and market development.

The Maltese aquaculture industry is focused on higher than average valued products for which the market is naturally more limited. Growth in sales of higher value fish is likely to be constrained in the near future due to the economic crisis which started in 2008. Competition with other producing countries for sea bass and bream will remain intense and limit expansion to what can be achieved through differentiation (e.g. on size or service etc). Development of new species is less constrained by immediate competition, but potentially by available resources to develop the market. The tuna industry is clearly constrained to some extent by market and competition, but particularly through quotas for capture of wild fish for ongrowing.

Limitation on aquaculture sites is a common issue throughout Europe and also a major issue for Malta. A successful aquaculture industry will require policy support and reasonable allocation of marine resources. The lack of a hatchery is a particular constraint, especially in light of the potential for Malta to be a leader in new species development and exploitation.

Whilst the Industry does now have a representative body in the Federation of Maltese Aquaculture Producers (FMAP), this is focused on tuna and has not brought any coherence to the development or marketing of other species such as that achieved by the Spanish Marine Aquaculture Producers Association (APROMAR) which has an extensive programme of cooperative promotional and marketing activities, and which led to the formation of Doradas y Lubinas de Canarias (DYLCAN) – a marketing cooperative of eight aquaculture companies in the Canary Islands. With processing and value addition expected to be increasingly important in the developing European seafood market, the difficulties experienced by at least one Maltese company in securing a site for basic packing operations suggests that sites for processing and perhaps feed manufacture could also be a future constraint.

Malta has a well established centre for aquaculture research (MARC), but it has limited facilities and relatively little access to facilities and expertise at the University of Malta. It is however active in European networks and collaborations for marine aquaculture research. Specialist fish health expertise however is almost limited to one key individual in the private sector, and there is no longer any dedicated Government backed diagnostic service. Limited capacity for research and access to technical expertise is likely to be a constraint, especially for strategies involving pioneering new species or closing the reproductive cycle for bluefin tuna.

3.2.3 SWOT analysis

A consideration of the strengths, weaknesses, opportunities and threats for the Maltese aquaculture industry, taking into account regional competitors, is shown below.

SWOT analysis for the Maltese aquaculture industry in the Mediterranean context

Strengths	Weaknesses
Experienced offshore sector with scope for expansion and greater economies of scale Relative proximity to Italian market Leader in the development of amberjack for aquaculture Well established international research links for mariculture Geographical position: on migratory route for tuna Fisher versatility – adaptable and competent workforce Good water quality Good water temperatures for growth Well flushed offshore sites Farms not burdened by debt	Geographical position results in increased cost of imported inputs and makes exports more expensive and less competitive Small domestic market Lack of domestic marine fish hatchery Lack of domestic feed producer Limited influence on international markets Very limited coastal space for aquaculture Competition for such space from shipping, tourism and other uses Poor perception of the sector by public, mainly due to tuna penning Limited cooperation between companies in marketing Limited uptake of quality management and certification schemes Limited economies of scale for CCS
Opportunities	**Threats**
Develop a leading position in the culture, processing and marketing of amberjack Continue to play a major role in the bluefin tuna industry if the reproductive cycle can be closed and full cycle farming becomes feasible Development of premium value added products based on new species Introduce quality control schemes, branding and greater cooperation in market development Become a leading centre for offshore aquaculture development	Industry could become unviable due to competition from other countries if not allowed to expand and develop greater economies of scale Industry will fail to develop if a suitable commercial scale marine hatchery is not established. Industry will find it harder to sell to European supermarkets and other buyers without robust quality management schemes that incorporate animal welfare, environmental and social responsibility Declining quotas for tuna due to over fishing Uncertainty regarding tenure of sites

4 Present status of aquaculture in Malta

4.1 Status of the industry

4.1.1 Introduction

Malta is a small island state, with a land area of only 320km^2. Consequently the total length of its coastline and total shelf area are limited. For example, its coastline length of 140km is only 1.3% that of the UK, and its ocean shelf area of 13,000km^2 is only 2.7% that of the UK. The limited coastline length in particular represents a significant constraint to all stakeholders of coastal waters, particularly aquaculture, and has resulted in strong competition for space and resources. In addition, the limited number of suitable locations providing shelter from the prevailing north-westerly winds represents an additional constraint to the development of inshore aquaculture operations. Heightened environmental awareness in recent years, mostly concerning the protection of sea-grass beds and other fragile ecosystems, has further restricted the availability of potential sites for aquaculture production.

Malta represents a poor market for fish and the products of aquaculture. The total annual consumption of fish and seafood products in Malta amounted to only 2,651 tonnes in 2004, equivalent to a per capita consumption of only 6.58kg per year (FAO, 2011). This compares to a global per capita consumption of 17kg (in 2007) and an annual European consumption of 22.2kg. Consequently, all aquaculture investments in Malta have been directed towards the production of fish for export. In addition, because of the relatively small size of the aquaculture industry in Malta, almost all equipment, feeds and juvenile fish supplies have been imported to date.

With virtually no freshwater resources, all aquaculture activities in Malta are marine-based.

4.1.2 Evolution of the industry

Initial interest in aquaculture in Malta stemmed from the activities of Professor Carmelo Agius. As Chief Consultant on Fisheries and Aquaculture to the Minister of Agriculture and Fisheries, Malta during the late 1980's and early 1990's, Professor Agius worked towards the development of an aquaculture industry in Malta, both through research carried out at the newly established National Aquaculture Centre (NAC) at Fort St. Lucjan, Marsaxlokk and through attempts to attract foreign investors in aquaculture.

Initial research work at the NAC focused on the development of rearing techniques for various species and hybrids of tilapia in seawater, in particular *Oreochromis spilurus* and hybrids of *Oreochromis mossambicus* x *Oreochromis niloticus.* This work was largely unsuccessful, however, due to poor market acceptance of the tilapia product and poor growth and survival at high salinities and low winter water temperatures.

Large-scale commercial aquaculture in Malta commenced through an investment from the Monaco-based producer Pisciculture Marine de Monaco (P2M) in 1990. P2M were looking for a suitable location for the cage culture of their hatchery produce, and were attracted to invest in Malta mainly due to its proximity to the Italian market, the availability of suitable inshore production sites and the high quality of Maltese inshore waters (with no freshwater run-off and limited industrial developments in the country). There was also considered to be a competitive advantage with respect to the main producers in Greece as the winter seawater temperatures in Malta are several degrees higher than those experienced in most Greek waters thus allowing improved growth rates in Maltese waters.

European seabass (*Dicentrarchus labrax)* and gilthead seabream (*Sparus aurata)* juveniles were shipped over to Malta from the hatchery in Monaco and stocked into plastic 'jet-float' cages moored in the sheltered waters of Mistra Bay, in St. Paul's Bay (see Figure 5). Grow-out was then carried out at a semi-exposed site further out in St. Paul's Bay, immediately south of St. Paul's Island (Gzejjer Selmunett), which is sheltered from the prevailing westerly and north-westerly winds. An additional cage site was then established in Mellieha Bay, south of the Armier headland and thus also protected from prevailing north-westerlies. At this time it was considered that, by being the first aquaculture cage operator to invest in Malta, P2M had secured the best inshore sites available in Malta.

The cage design used by P2M was based on the use of floating oil hoses connected to form a ring, and fitted with custom-made stanchions and hose clamps. These cages have proved exceptionally robust, and remain in service to this day, after over 20 years of constant use. However, these cages are now in the process of being replaced by Fusion Marine HDPE plastic cages, which avoid the need for regular maintenance of the steel work used in the stanchion assemblies.

Figure 5. Satellite image of Malta showing location of existing aquaculture production units (not to scale)

Source: Google Earth

Initial plans allowed for the production of roughly equal volumes of both seabass and seabream, to be exported to the Italian fresh fish market. Production rapidly increased from 200 tonnes in 1991 to around 900 tonnes per annum by 1994/1995 (FAO, 2005-2011). Fish juveniles were originally obtained from the parent company's hatchery in Monaco, but moved on to other sources when the Monaco facility ceased production.

In 1992 a pilot marine fish hatchery was installed at the NAC, in an attempt to produce at least some of the seabass and seabream juveniles required by the new aquaculture industry in Malta. Although the scale of potential production was limited by the space available at the Centre, a production of 400,000 2g juveniles was achieved by 1994. With further improvements in technology and management, production reached a peak of 1.5 million juveniles during the period 1995-1998, all of which was sold to Maltese cage operators. However, the bulk of seabass and seabream juveniles continued to be imported from mostly European hatcheries. For example, P2M alone required in excess of 3 million juveniles per annum during the mid-1990s.

In addition to a juvenile fish production capability, the NAC also developed a fish health diagnostic laboratory to provide fish health technical support to the rapidly expanding aquaculture industry.

During 1993 a second major commercial operator started production in Malta. This company, Malta Mariculture Ltd (MML), was a collaborative venture between local investors, the Commonwealth Development Corporation and the University of Stirling, and operated a site established in the Comino Channel between the islands of Malta and Comino. This site was considered as challenging, with a significant exposure to the south-west and north-east, and occasional strong currents through the channel. For this reason Dunlop Tempest II rubber hose cages were installed at the site, in two rafts, scaled for the production of 500 tonnes of gilthead seabream. By the end of the first year of production 160 tonnes of seabream were produced, and the target tonnage of 500 tonnes was reached by 1996.

The success of these two major operators quickly attracted the attention of other investors. Two companies, Fish & Fish Ltd (F&F)(an Italian investment) and Malta Fishfarming Ltd (MFF)(a subsidiary of the Maltese construction company Elbros Ltd) were established, installing cages at two very exposed offshore sites off the south-east coast of Malta. F&F rapidly encountered financial problems before any fish production could be realised and changed hands to Maltese investors by early 1995, coinciding with the replacement of the cages with a single raft of Dunlop Tempest II cages. MFF successfully operated Farmocean offshore cages for the production of mostly seabream, and used the inshore cage facilities of the NAC in Marsaxlokk Bay for nursery production.

With 4 major fish farm operators now under operation, a total annual Maltese production of just over 2000 tonnes of seabream and seabass was realised by 1999.

However, a number of serious issues had emerged over the period 1995-1999 which had significantly affected the profitability of most of the producers.

In 1996 all producers of seabass were affected by an outbreak of viral nervous necrosis (VNN), caused by a Nodavirus. Before this time this disease was unknown in the Mediterranean, and was thought to have been introduced to Maltese waters through the importation of seabass juveniles from a hatchery in Italy. Mortalities were high, amounting to 30-50% of the entire stock of seabass that year, and all size classes were affected. The risk of further losses caused most producers to concentrate more on the production of gilthead seabream, which is unaffected by this disease.

By the late 1990's all aquaculture producers were being affected by low market prices caused by over-production in Europe, particularly by the rapidly expanding Greek producers. This was compounded by the fact that Italian and other European buyers were liable to pay an import duty of 15% on all fresh fish purchases from Malta, since Malta was at that time not an EU member state. Because of this problem a number of Maltese aquaculture producers were struggling to maintain production at a profitable level and one, MML, sold its operations to a group of Maltese investors. Malta acceded to the European Union in 2004, and was granted a concession in 2002 allowing it to export fresh fish to the EU without the import duty. This improved the profitability of those aquaculture operators still producing seabream and seabass at this time.

By the end of the 1990's advances in cage technology had produced exceptionally robust cages made from welded high-density polyethylene (HDPE) pipes which made offshore aquaculture a realistic and cost effective proposition. These cages made possible the long-distance towing and offshore holding of bluefin tuna, and tuna ranching operations became established in both South Australia and the Mediterranean. Azzopardi Fisheries, a major fish trader in Malta, was quick to take advantage of this potentially lucrative but high-risk industry, and in 2000 established an offshore tuna ranching operation off the coast of St. Paul's Bay. He then consolidated his position by purchasing MML in 2002 and switching this site to the production of tuna.

Several Maltese aquaculture producers, particularly those located in the exposed waters off the south-east coast of Malta, quickly saw the potential of this industry and, having offshore sites suited to tuna ranching activities, switched production to blue-fin tuna. Both Fish & Fish Ltd and Malta Fishfarming Ltd moved their cage operations slightly offshore and started tuna ranching during 2001/2002, whilst continuing to produce sea bream in smaller numbers. At this time, the Maltese government received a number of licensing requests from other investors, both overseas and Maltese, keen to take advantage of this rapidly expanding sector of the aquaculture industry. In order to accommodate these requests, and partly as a response to concerns over the effects of tuna ranching activities on water quality at highly touristic bathing areas, an offshore aquaculture zone was identified 6km off the south-east coast of Malta where in principle all subsequent tuna ranching operations were to be obliged to set up their operations. The zone was established by 2006 and two companies, Ta' Mattew Fish Farms Ltd (a Maltese and Korean joint venture) and Mare Blu (an investment made by the Spanish tuna ranching operations of Ricardo Fuentes Group) received production licenses for three cage sites. Because of the extreme offshore conditions prevalent at this offshore site, both operators experienced total losses between 2007 and 2009 from storm damage but continue to operate.

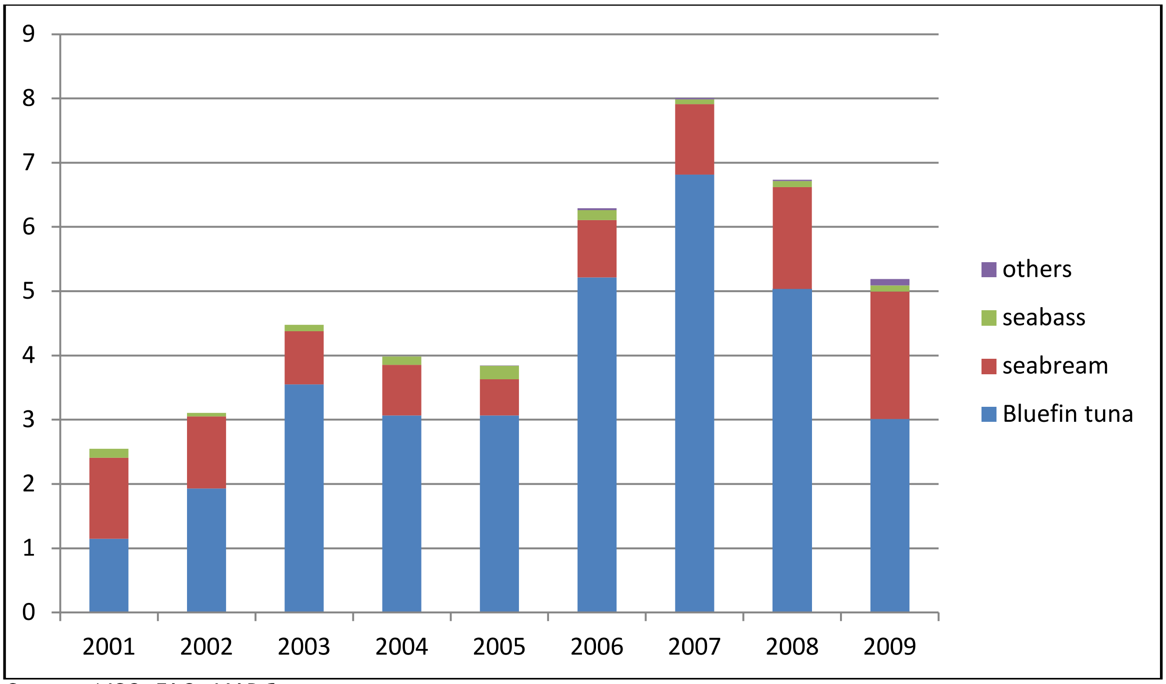
The long-term future of the tuna ranching industry is now in some doubt. Concerns over the health of remaining stocks of the eastern Atlantic bluefin tuna have led to a reduction in catch quotas from 29,500 tonnes in 2007 to only 12,900 tonnes in 2011, and a reduction in the duration of the purse seiner fishing season to only 30 days, between mid-May and mid-June. This has reduced the opportunity to catch tuna for ranching purposes. In addition, extreme environmentalist organisations have resorted to efforts to prevent tuna ranching operations from collecting and transporting tuna to their cage facilities, and unsuccessful attempts were made during 2010 to ban all international trade in the eastern Atlantic stocks of bluefin tuna through CITES legislation. Other constraints to the long-term future of the industry are concerns over the use of large quantities of wild-caught pelagic fish for feeding purposes, the water pollution caused by the use of this feedstuff and by the dumping of processing by-products at sea, and price fluctuations of bluefin tuna in the Japanese market, with additional uncertainties caused by the earthquake and tsunami in March 2011.

The long-term future of the conventional finfish aquaculture industry is likely to remain heavily dependent on the production of gilthead seabream. The cost of production of seabass is higher, and so various production strategies are being employed to maximise profits, such as the production of 2-3kg fish for a specialist market. Most aquaculture operators are keen on the development of 'new species' and several now produce meagre (*Argyrosomus regius)* in small quantities.

4.1.3 Recent trends in aquaculture production in Malta

The most recent year for which aquaculture production statistics have been published by the National Statistics Office of Malta is for 2009. Total aquaculture production by Malta in 2009 amounted to 5,188 tonnes (see Figure 6) with a total stock value of €76,400,000. 3,011 tonnes of this stock, or 58% of total production, consisted of bluefin tuna sales, with 1,984 tonnes (38%) consisting of gilthead seabream and 93 tonnes (1.8%) of European seabass. The remaining 101 tonnes (1.9%) consisted of other species, mostly meagre.

Figure 6. Aquaculture production in Malta, 2001-2009. Figures in thousands of tonnes.

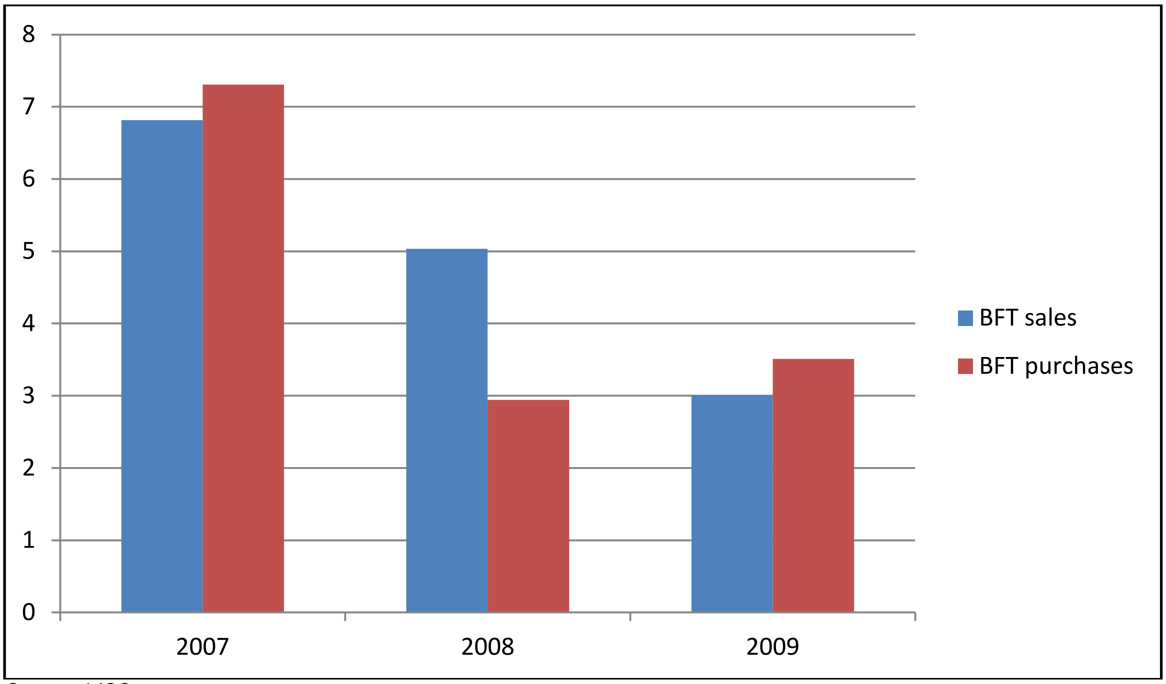


Sources: NSO, FAO, MARC.

The NSO provides data on bluefin tuna sales and purchases, which are graphically represented in Figure 7. This illustrates the relatively high biomass of adult fish purchased and the relatively low biomass added by feeding compared with CCS. Whilst most tuna purchased in any one year is fattened and sold the same year, stock is often held over and sold the following year depending on market conditions.

Sales of bluefin tuna from Maltese penning operations dropped by 56% between 2007 and 2009 from 6,813 tonnes to 3,011 tonnes, representing a 61% drop in value from €96.8 million to €37.5 million, primarily due to low market prices in Japan forcing producers to hold onto stock and also partly due to a reduction in catch quota imposed by ICCAT. In 2009 3,509 tonnes of bluefin tuna were purchased from purse seiners and stocked into cages, whilst only 3,011 tonnes of tuna were sold, implying that some tuna stocks purchased in 2009 were held over until 2010.

Figure 7. Bluefin tuna sales and purchases from Maltese penning operations for 2007-2009, thousands of tonnes.

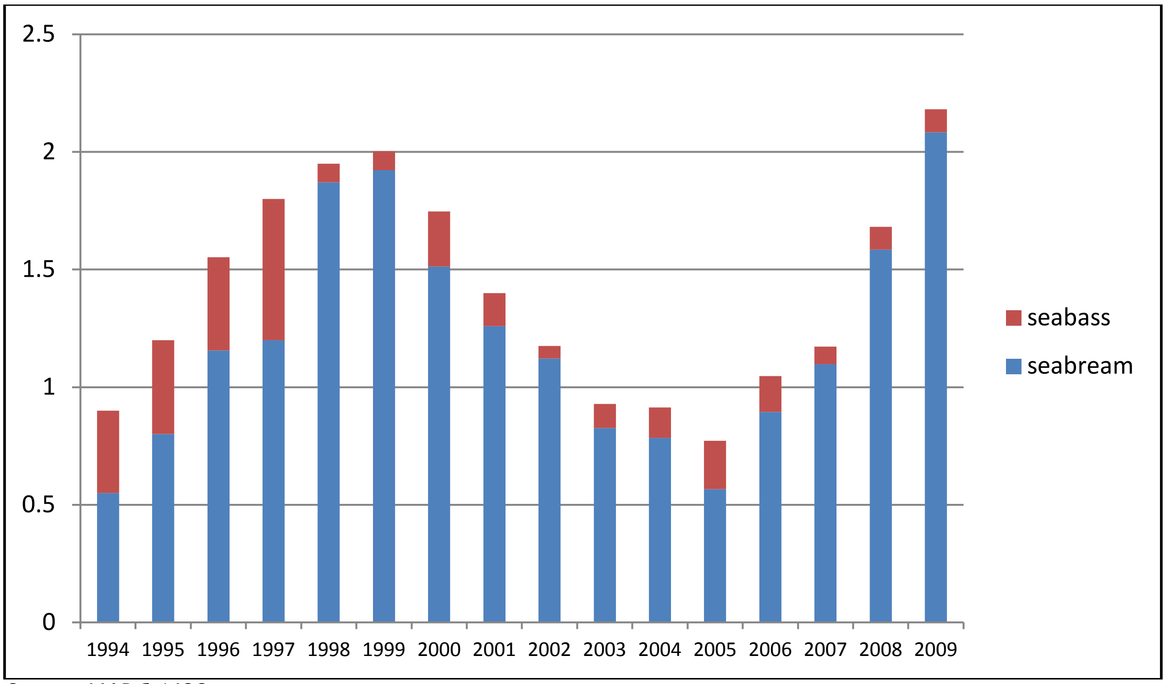


Source: NSO

Provisional figures for 2010 from interviews suggest that production of bluefin tuna from Maltese penning operations was around 3,500 tonnes, whilst early indications for 2011 suggest production may fall to below 1000t.

Seabream export sales (see Figure 8) grew from 665t in 2005 to over 2,000t in 2009, an increasing trend following EU accession in 2004. Seabass production has remained low, varying between 75 and 97 tonnes per annum between 2007 and 2009.

Figure 8. Annual production of seabream and seabass from Maltese farms, in thousands of tonnes.



Source: MARC, NSO

4.1.4 Production constraints and future aspirations of existing operators

There are presently six commercial farms operating in Malta, all leasing sites from the Government of Malta on varying terms depending on when they began operating. In this section, the site constraints of different farms are given and their aspirations for future production, as expressed during interviews, are indicated. More details of the location of each company's sites and their facilities are given in Figure 5 and Annex 2.

The only other cage site in Malta is that operated by MARC for research and development activity.

4.1.4.1 P2M

P2M has sites at Mistra Bay, St.Paul's Bay and Mellieha Bay. The conditions of the production permit for P2M are limited to the use of a specific area of seabed for a period of 46 years, and there is no maximum production tonnage limit. Since 2002, however, production capacity has effectively been limited since any expansion of the existing seabed area, or any movement or changes to cages within the existing concession, has been ruled out by MEPA due to the perceived environmental sensitivity of the areas concerned.

P2M currently has no plans for any significant expansion, and considers the existing production level of approximately 1000 tonnes per annum as being optimal for the present scale of operations. The company has shown interest in the development and production of new finfish species in the past and is currently the largest producer of meagre in Malta, and the only producer of seabass.

4.1.4.2 F&F

F&F has a site located off the Delimara peninsula in south-east Malta. F&F currently has a MEPA permit for the production of up to 300 tonnes of seabass and seabream, and up to 1200 tonnes of bluefin tuna. The ICCAT allowance for this facility is 1500 tonnes of bluefin tuna. F&F have expressed an interest in increasing the number of cages employed at their production site, but a recent proposal was turned down by MEPA.

Future production plans look forward to an increase in the number of tuna pens to allow an increase in tuna penning production to the permitted level of 1200 tonnes per annum. Fish & Fish also hope to develop and increase the production of seabream and other closed cycle species such as amberjack.

4.1.4.3 MFF

MFF also has a site located off the Delimara peninsula in south-east Malta, lying around 1km north of F&F. Current permits granted by MEPA allow for the total production of 500 tonnes of finfish, comprising 350 tonnes of bluefin tuna and 150 tonnes of seabream. The tuna penning operation has an ICCAT production consent of up to 1500 tonnes of bluefin tuna. Tuna production is presently modest, but MFF is the only other significant producer of seabream in Malta apart from P2M.

MFF have shown a strong interest in species diversity, and were the first aquaculture facility to experiment in the cage production of wild-caught amberjack back in 1995. Together with MARC, MFF have been closely involved in the development of amberjack culture in Malta, and hope to produce this species in large volumes once production techniques have become established. The company also hopes to increase the production of seabream significantly in the future. There are no plans to produce seabass at present. Plans for tuna penning activities are under review, but are not expected to expand beyond present levels for the foreseeable future.

4.1.4.4 AJD Tuna Ltd

AJD is the largest grower of tuna in Malta and has a site off St. Paul's Bay with an ICCAT consent for the production of 2,500 tonnes. A further site in the S Comino Channel has a MEPA permit for the production of 350t tuna and 150t bass and bream p.a., and an ICCAT consent for 800t tuna.

Although at present AJD does not produce seabream, despite the possession of a permit to do so, they are optimistic about the introduction of amberjack culture to Malta and have expressed an interest in the cage production of this species. Bluefin tuna production is expected to continue at existing levels for the foreseeable future, with a general desire to increase production over the coming years.

4.1.4.5 Ta' Mattew Fish Farms Ltd

Ta' Mattew Fish Farms Ltd has a site in the offshore aquaculture zone with a MEPA permit consent for 1500 tonnes, matching its ICCAT production allowance. It suffered a total loss of stock and cages in 2009 due to bad weather. Production in 2010 was only just sufficient to remain viable. The main constraint on future production is the lack of fish for stocking due to low ICCAT quotas. Ta' Mattew see much potential in the cage production of amberjack, and expect to shift some production to amberjack in the future.

4.1.4.6 Mare Blue Tuna Farm Ltd

Mare Blue Tuna Farm Ltd also has a site in the offshore aquaculture zone with a MEPA permit capacity of 1500 tonnes, matching its ICCAT production allowance. It also suffered a total loss of stock and cages due to bad weather, this time in 2007. The company decided not to stock fish during 2010, but intends to restock during 2011. Mare Blu are open to the production of other species of finfish, but recognise that the extreme conditions prevailing at the offshore aquaculture zone limit their potential.

A further site for 1500t in the zone held in the name of Deep Sea Ltd is also leased by the same group but is not presently used.

4.1.4.7 MARC

The MARC carries out experimental work at a cage facility in Marsaxlokk Bay, directly in front of the MARC facility at Fort St. Lucjan, Marsaxlokk. It is currently used primarily for the rearing of amberjack broodstock and has an amberjack nursery site, in support of current research and development activities devoted to the establishment of rearing techniques for amberjack in Malta. It is proposed to keep this site for continuing research work and holding broodstock.

4.1.5 Production systems in use

All current aquaculture operations in Malta employ floating cages for fish production. During the 1990's a range of cage types were employed, including wooden 7.5m square Kames cages, cages constructed from 'Jet floats', consisting of square plastic air-filled cubes bolted together with plastic pins, cages made from rubber oil hoses bolted together to form a floating ring, Dunlop 'Tempest II' square rubber-hose cages, 'Floatex' plastic circular cages and 'Farmocean' semi-submersible cages. The choice of cage system and design was dictated by the exposure of the farm site, so that the Kames cages, Jet floats and 'Floatex' cages were used in sheltered, inshore sites for the juvenile stages of production whilst the rubber hose, Dunlop and Farmocean designs were more suited to offshore conditions.

By the end of the 1990's high-strength plastic circular cages became widely available on the market. This design of cage consists of high density polyethylene pipes welded together into a ring, usually with moulded plastic stanchions fitted to provide additional strength and support the cage net. HDPE cages of this type have a number of advantages over other cage types. Most importantly they are significantly cheaper than other cage designs, their cost consisting of the HDPE pipe, the pre-moulded stanchions and cage assembly. Being made of HDPE plastic, these cages are resistant to corrosion, a major problem with metal cage designs. They are also free of moving parts. These two points minimise maintenance requirements drastically. The HDPE plastic pipes are also flexible, which means that the cage flexes with the wave action, thus providing additional strength to the design. Lastly, since the HDPE pipe can be cut and welded with comparative ease, this cage design is extremely adaptable – cages of any size can be assembled at any suitable land location close to the cage site and simply towed to the mooring system for installation. Damaged cages can also be repaired with comparative ease by the replacement and re-welding of damaged parts.

Very high strength HDPE cages are the only cage designs suited to long-distance towing operations in open ocean conditions, and are also the only cage design suited to holding large production volumes of fish moored in very exposed offshore conditions. Consequently they have been adopted by the tuna penning industry throughout the world.

Since 2000, most existing aquaculture producers in Malta have replaced their older cage designs with HDPE plastic circular cages, or are in the process of doing so. All operators who have moved over to tuna penning, and newly-established tuna penning operations, all use high-strength HDPE cage designs.

A number of companies now specialise in the manufacture of high strength HDPE cage designs, including Fusion Marine (UK), Polarcirkel (Norway) and Corelsa (Spain). In addition, with appropriate expertise, cages can be made by the aquaculture producers themselves, by purchasing suitable HDPE pipe and, where necessary, pre-formed stanchions, and assembling the cages themselves, and a number of aquaculture operators in Malta now follow this strategy.

Typical cage sizes currently employed for seabass and seabream ongrowing are 50-90m circumference circles (16-28m diameter), with net depths typically of 8-10m. This will provide a net holding volume of between 1500 and 6000 m^3 per cage. Tuna penning operations normally use far larger cages - 160m circles (equivalent to a diameter of 50m) are commonly employed. With a typical net depth of 24m at the side and as much as 38m to the centre of the net floor, these nets have a holding volume of between 45,000 and 55,000m^3.

4.1.6 Production processes – closed cycle aquaculture

Commercial-scale aquaculture operations in Malta started with the production of gilthead seabream and European seabass. The production processes employed for both species are virtually identical, although the performance indicators for these species do differ somewhat. Both species are produced by way of closed-cycle aquaculture i.e. production is based on the supply of hatchery-reared juveniles, with no reliance on wild stocks.

Juvenile seabass and seabream are purchased from overseas hatcheries, although a small quantity are produced by the commercial hatchery operations of MARC. The main hatcheries used for juvenile purchases at present are the following:

- Ferme Marine de Douhet, Ile d'Oleron, France
- Valle Ca Zuliani, Rovigo and Monfalcone, Italy
- Panittica Pugliese, Bari, Italy
- Acqua Azzurra, Pachino, Sicily.

Juvenile seabream and seabass are normally purchased at a size of between 1g and 3g, and are delivered by truck to Malta, with a typical delivery time of 2-4 days. Specialized live fish transportation trucks are used for shipment, and transport-related mortalities are generally very low, amounting to a few percent. Typical purchase price for juvenile seabream of 2-3g average weight is €0.20-€0.22 per juvenile. On arrival in Malta, the juveniles are discharged into small transport cages and then towed out to the nursery cage site.

Because of the small size of the juveniles, and the small mesh size of the holding nets required for their initial culture (typically employing a mesh size of 6mm), the production of seabass and seabream requires that the initial growth stages be carried out at sheltered inshore locations. In Malta only two nursery sites are currently employed – those at Mistra Bay, a sheltered inlet in St. Paul's Bay, and the MARC cage facility in Marsaxlokk Bay. Some operators without access to sheltered nursery sites can produce seabream, but are restricted to stocking juveniles in offshore waters only between the months of June and September when weather conditions permit.

At a size of 30-50g the seabass or seabream can then be transferred to semi-exposed offshore sites for on-growing to the usual market size of 300-500g. Existing sites for seabass and seabream on-growing consist of St. Paul's Bay and Mellieha Bay, both operated by P2M, which are sheltered from all directions except the north-east, and the exposed sites off the south-east coast of Malta operated by Malta Fishfarming and Fish & Fish, which are exposed to the south, south-east, east, north-east and north. Net mesh sizes employed for grow-out typically range between 10mm and 25mm.

Seabass and seabream are fed on proprietary pelleted and extruded feeds, formulated specifically for these species. Typical feed formulations include a protein content of 40-50% and an oil content of 15-20%. The bulk of the protein and oil components consist of fish meal and fish oil, although much research work is being carried out by feed companies to replace these components with vegetable-based products such as soya meal and soyabean oil in order to reduce costs and to reduce reliance on marine-based products. The feed companies presently employed for seabream and seabass production in Malta consist of Skretting (imported from their production plant in Spain), Biomar (produced in both France and Spain) and Coppens (produced in the Netherlands), and feed is imported by way of containers, with a typical delivery time between ordering and delivery of around 3 weeks. Pellet sizes employed range between 1mm starter feeds and 7mm grow-out feeds. Feed prices currently amount to a little over €1.00/kg and there is a constant upward pressure on prices due to the limited world supply of fish meal and fish oil.

Some producers routinely grade their fish stocks, primarily to assist in marketing a uniform-sized product. Whereas seabream are relatively resistant to handling operations, seabass are very sensitive and are not normally handled beyond an average weight of 50-100g.

The bulk of seabream and seabass produced in Malta is exported by truck fresh, on ice, to Italy, primarily to the wholesale market at Rome. Seabream are sold as whole portion-sized fish, of 300-400g average weight, packed in 6kg polystyrene boxes. Because of higher mortality rates and a vulnerability to the viral disease VNN, the cost of production of seabass is higher than that of seabream. Consequently seabass production has dropped significantly since 1997, and most is currently grown to a size of 2-3kg for a specialist export market for large fish.

Seabream production is now highly efficient. Fish are grown at a maximum stocking density of 17kg/m^3 over a 13-15 month period with a typical mortality rate of around 5-10% over a growth cycle. Average food conversion ratio is currently around 1.85, and the cost of production is probably close to €3.50/kg. This is thought to be lower than that achieved by Malta's main competitor, Greece, who, partly because of low winter water temperatures and partly to greater costs of debt, are thought to produce seabream at a cost of closer to €4.00/kg.

A number of seabream producers have shown some interest in the production of meagre, *Argyrosomus regius,* over recent years, following the availability of juveniles of this species from commercial hatcheries. Production methods and systems are identical to those used for seabass and seabream, and so bass and bream producers can grow this species without the need for dedicated production systems. Growth rates are impressive, with fish reaching an average weight of 1.2kg within 12 months at a food conversion ratio of only 1.25, and survival rates are good. The main constraint to the expansion in the production of this species is poor market demand, however, and production volumes are expected to remain low.

4.1.7 Production processes – capture-based aquaculture

The tuna penning industry in Malta is capture-based aquaculture. It aims to capture stocks of bluefin tuna during their spawning migration through the Mediterranean Sea, when post-spawning fish have a low flesh quality and market prices are minimal. The tuna are then fed heavily on oily pelagic fish to boost the flesh quality and oil content, and are sold during October to December to Japan, specifically for the Japanese sushi and sashimi market. Ideally all fish will be sold by December, so that the cages can remain empty during the winter and spring months to minimise stock losses caused by winter storms.

Adult bluefin tuna, *Thunnus thynnus,* are caught in the open sea by purse seiners during their annual spawning migration through the Mediterranean Sea during May and June. The fish are transferred to transport cages which are then towed across the sea to offshore cage farms, where the fish are stocked. Fish may be towed over a considerable distance, and Maltese tuna pens have received fish from as far away Cyprus in the past. Most tuna penning operations now obtain their tuna from international waters, caught by Libyan, French and Spanish purse seiners. The collection and towing process for bluefin tuna incurs a considerable expense in fuel, tugboat rental and personnel costs.

In Malta the tuna cage facilities are located in exposed waters, typically between 1 and 6km offshore, at depths of 50-80m. Existing production sites are located off St. Paul's Bay (AJD Tuna), off the southern coast of Comino (AJD Tuna), 1km off the south-east coast of Malta (Malta Fishfarming and Fish & Fish) and in an aquaculture zone 6km off the east coast of Malta (Ta' Mattew and Mare Blu). Large 50-90m diameter HDPE circular cages are employed, usually moored independently by way of radial moorings but sometimes moored in a submerged grid system. The cages may be single, twin or three-pipe designs, with or without plastic moulded stanchions. Manufacturers include Fusion Marine (UK), Corelsa (Spain), with some cages assembled by the cage operators themselves, using HDPE pipe. Nets with a depth of up to 40m are employed, with a mesh size of around 140mm.

The tuna caught are adult spawning stock, varying in size between 70kg and 600kg. They are typically purchased from the purse seiner for €6-10/kg, although there is a premium for fish in excess of 100kg, which therefore command a slightly higher price. The tuna are then maintained in the holding cages and fed on frozen mackerel, herring and sardines, purchased in bulk from such countries as the Netherlands and

Morocco. Feed costs are increasing, but averaged around €0.60/kg during 2010. Since this form of aquaculture involves the conditioning of post-spawning fish as opposed to growth, food conversion ratios are extremely high, typically varying between 1:12 and 1:30 depending on fish size and the length of time held in the cages. However, this involves the use of whole wet fish as opposed to dry pellets and so the water content of the feed needs to be taken into account when making comparisons with pelleted feeds.

The frozen bait fish is either partially or completely thawed prior to feeding. The feed is normally lowered into a small feeding pen situated inside the holding cage, where it is given time to thaw. The feed is then released from this pen by diver, and allowed to float down through the cage where it is consumed by the tuna. One farm uses a system whereby thawed bait fish are flushed from a well in the boat into the centre of the cage via a pipe. Well-managed operations carefully monitor the feeding, so that losses of feed through the cage net are minimised.

Bluefin tuna are harvested with the aid of spear guns equipped with an explosive charge. Individual fish are killed by divers, usually instantly, by a shot to the head. They are then hauled to the water surface and transferred directly from the cage to the processing ship, where the fish is gutted, de-headed and transferred to the hold where it is blast-frozen. The frozen tuna are then shipped to market by sea. Very occasionally fish are sold as a fresh product by air-freight. All fish are sold to East Asia, primarily Japan, for the sushi and sashimi market.

Over a 4 month cycle, the tuna will typically increase in weight by around 30%. Tuna are very susceptible to physical damage to the eye and skin from contact with the holding net, and careful husbandry practices are therefore required during transfer and towing operations to avoid damaging the tuna. Stocking densities are kept very low, typically less than 4kg/m3. Once in the holding cage mortalities are negligible, and to date there are no known disease or health problems associated with tuna penning.

The cost of production may vary considerably, particularly according to the length of time the fish are maintained in the cages, but averages €12-14/kg including feed costs. Feeding costs again vary, but are around €3-4/kg of fish sold. The minimum scale of operation considered to sustain a viable tuna penning operation in Malta is said to be 300-500 tonnes.

The tuna penning industry is strictly controlled by the International Convention on the Conservation of Atlantic Tunas (ICCAT). All fish movements, including purchases and transfers from the purse seiners and all fish harvests and sales, are monitored by international fisheries observers who are required to be present on-site during each fish movement, and all stocks and stock transfers are carefully recorded.

4.1.8 Markets and marketing practices

4.1.8.1 The domestic market

According to FAO 2011, the total supply of fish for direct human consumption in Malta in 2004 was 2,651t, based on production of 1,936t, imports of 1,853t and exports of 1,138t. With regard to production, supply from the wild fishery was around 1000t p.a. and aquaculture 900t. Given a population at that time of around 400,000, consumption per capita was 6.58kg, significantly below the European average. These figures exclude penned tuna, all of which is exported.

Although the production of fish from aquaculture (predominantly seabass and seabream) has more than doubled since 2004, overall consumption is thought to be much the same given that all but around 100t of these species is exported. There is potential in the future to reduce the volume of imports and indeed increase consumption especially if the range of locally cultured species can be increased to provide greater choice in the local marketplace.

4.1.8.2 Seabass and seabream

Almost all seabream and seabass farm production in Malta is exported to Italy, where it is purchased as a whole fresh product primarily by large fish wholesale companies and supermarket chains. Competition with other European suppliers of seabream and seabass on the Italian market, particularly from those operating in Greece and Turkey, is fierce, and the competitive advantage of a higher growth rate of the Maltese product is partly negated by lower shipping costs for Greek exporters.

Both of the major seabream and seabass producers in Malta operate their own fish packing facilities, which are licensed for the handling and sale of fresh fish products within the EU according to the necessary EU legislation. Seabream and seabass are packed in 6kg polystyrene boxes and exported by truck to the main Italian markets. The frequency and reliability of the ferry link between Malta and Italy has been highlighted as a major concern to Maltese seabream and seabass producers, since they are totally dependent on road freight for the export of their product.

There are no serious attempts to brand Maltese seabream and seabass products on the Maltese markets, and no value-added processing or product diversification of any kind takes place in Malta prior to export. One company has however reported some success in exporting a frozen whole product to the Libyan market.

A small percentage of the seabream and seabass production is sold to the local market together with some meagre. Local consumption is thought to amount to around 100 tonnes per annum, and bass and bream are now established food items in Malta. These species are a preferred commodity amongst local fish retailers since their availability is consistent (not dependant on the weather, for example), the harvest size of 250-400g is consistent with a portion-sized product, and quality is high with a long shelf life. Retail prices for seabream in Malta averaged €5.00-6.00 per kg in 2010, whilst seabass reached a higher price, averaging around €8.00 to 8.50 per kg. These prices compare with other locally-available fresh fish products as shown in Table 2.

Table 2. Comparison of retail fish prices in Malta, 2010.

Common name	Species	Retail price €/kg	Comments
Dolphinfish	*Coryphaena hippurus*	2.50	Seasonal, local, fresh
Gilthead seabream	*Sparus aurata*	5-6.00	Local, farmed
European seabass	*Dicentrarchus labrax*	8-8.50	Local, farmed
Octopus	*Octopus vulgaris*	8.00	Local, fresh
Catfish fillets	*Pangasius spp.*	8.00	Imported as fresh fillets
Atlantic salmon	*Salmo salar*	9.50	Imported whole, fresh
Meagre	*Argyrosomus regius*	9.50	Local, farmed
Nile perch	*Lates niloticus*	10.50	Imported as fresh fillets
Swordfish	*Xiphias gladius*	14.00	Locally caught, steaks
Squid	*Loligo vulgaris*	15.00	Locally caught, fresh
Grouper	*Epinephelus spp.*	18.00 – 20.00	Local, whole fish
Seabreams	*Pagellus & Pagrus spp.*	18.00 – 20.00	Local, whole fish

Source: prices obtained from local fish retailers, Sliema

Table 2 shows that farmed seabream and seabass are of relatively low value in Malta compared to wild-caught species which, with the exception of dolphinfish which floods the local market between September and October, are typically a very high-priced product. However, despite the lower cost of seabass and seabream it appears unlikely that volumes will increase significantly in the near future.

A small quantity of farm-raised meagre is sold on the local market, although local demand appears to be constrained by the fact that it is an unfamiliar species in Malta, is considered by some to have an unattractive black colouration, and is marketed too large to sell as a portion-sized product.

4.1.8.3 Bluefin tuna

The bulk of penned tuna production from Malta is exported to Japan as a frozen product, primarily for the lower-value supermarket sushi and sashimi trade. The higher end of this market is supplied by fresh and frozen wild-caught tuna. Japan consumes approximately 50,000 tonnes of bluefin tuna on an annual basis, of which 30,000 to 35,000 tonnes is a frozen product. This compares to an annual consumption of 4,000 tonnes in the USA and 3,000 tonnes in Europe. 25,000 to 30,000 tonnes of this demand is currently supplied by tuna penning operations, 90% of which is consumed by the Japanese market.

Total Mediterranean production of bluefin tuna from penning operations is expected to drop to below 10,000 tonnes for 2010, with Maltese operations currently representing around 25% of that production according to provisional production figures for 2010 (FMAP). Other Mediterranean tuna penning nations include Spain, Tunisia, Croatia, Cyprus and Italy. Other suppliers of penned tuna to the Japanese market include Japan (approximately 10,000 tonnes of Pacific bluefin), Australia (approximately 7,000 tonnes of southern bluefin) and Mexico (producing just over 1000 tonnes of Pacific bluefin). As well as such other suppliers of penned tuna, Maltese production also has to compete with wild caught fish. Being a frozen product, the tuna product of the Maltese tuna penning industry may be stored for long periods of time in Japanese cold-stores, which can affect the market considerably.

Because Malta produces approximately 5-10% of total Japanese bluefin tuna consumption, and around 10-20% of farmed bluefin tuna consumption, Maltese tuna pen operators are at the mercy of wholesale tuna prices in Japan, and the Japanese economy as a whole. Prices have fluctuated markedly over the past 10 years and have dropped so low in some years as to require tuna pen operators to hold their tuna stock over the winter and sell the following year. Further uncertainties in the Japanese market are expected following the earthquake and tsunami of March 2011.

4.1.9 Research and development

Research and development in aquaculture in Malta is carried out mainly at the Malta Aquaculture Research Centre (MARC) at Fort St. Lucjan, Marsaxlokk. This facility was established in 1988 as the National Aquaculture Centre, and was then renamed the Malta Centre for Fisheries Sciences in 2001 before becoming the MARC. These changes in name reflect changes in the main functions of the facility between the aquaculture and capture fishery industries over the past 25 years, which in turn has mainly been dictated by the availability of expertise with respect to management of the facility.

The research and development activities of the MARC focus on the development of 'new species' for aquaculture in Malta, with particular emphasis on the hatchery and cage rearing of amberjack, *Seriola dumerili* and bluefin tuna, *Thunnus thynnus.* The operation of a commercial-scale marine fish hatchery is central to this research capability. The hatchery is scaled for the production of up to 1.5 million seabream juveniles per annum at a commercial level, and also has the capacity for research into new species development, nutrition and growth trials and fish vaccine testing. Hatchery operations are currently funded by the Amberjack Project, a public-private partnership between the MARC and Malta Fishfarming (MFF).

The bulk of marine fish production is currently devoted to gilthead seabream, which is produced under a collaborative agreement between the MARC and MFF. These seabream juveniles are then supplied to MFF for commercial production in offshore cages, according to a Joint Venture Agreement. The production of seabream juveniles at a commercial level allows research to be carried out into the optimisation of mass culture techniques for this and other closely related species.

MARC also plays a role in the rehabilitation and release of sea turtles. It carries out water monitoring services for the aquaculture industry and has an educational role, both for University-level biology students and to the general public.

The University of Malta plays a role in formal education and research in aquaculture. The Department of Biology offers an honours degree (BSc) and postgraduate courses (both MSc and PhD) in biological sciences and offers expertise in marine sciences, including fisheries biology, marine aquaculture and marine pollution and environmental studies. The BSc course in Biology offers 4th year study units in agriculture, fisheries and the management of biological resources, and marine biology.

Senior academic staff specialise in marine ecotoxicology (Professor Victor Axiak, Head of Department), aquaculture (Professor Carmelo Agius), marine benthic ecology (Professor Patrick Schembri) and marine ecological assessment and monitoring (Dr. Joseph Borg). The number of Maltese students carrying out postgraduate research in aquaculture is low, however.

4.1.10 Human resources

Whereas in the early years of the aquaculture industry in Malta there was a heavy reliance of expatriate personnel, particularly for farm management positions, almost all management and operations staff employed in the industry are now Maltese nationals. A number of aquaculture producers do, however, employ some nationals from developing countries as seamen.

As is typical of the fisheries production industry, the Maltese aquaculture industry employs mostly young men. Around 93% of aquaculture employees are currently men, around 60% of whom are aged 34 years or younger.

80% of these employees possess a secondary education, which probably reflects the state of the education system in Malta as opposed to any deliberate selection of employees on the part of the aquaculture producers.

The National Strategic Plan for Fisheries 2007-2013 quotes "fisher versatility" as a key strength of the sector: "Maltese fishers are highly versatile. In the past they have been able to cope with new challenges and conditions such as those offered by aquaculture and many participate actively in this sector. This bodes well for the future of the sector which will have to face many new challenges especially those associated with the poor states of Mediterranean stocks and which will necessitate fishers to look for alternative opportunities."

There are currently no formal vocational training opportunities for aquaculture in Malta, and most production employees receive informal on-the-job training. Some basic seamanship skills are, however, considered necessary for all sea-based work.

Divers are essential for routine maintenance, installation and various husbandry operations. At present, most divers employed have amateur diving qualifications (mostly through PADI) but a high level of experience and skill is required, particularly for the tuna penning industry. There are no legal requirements for professional diving qualifications in Malta at present, but the introduction of such legislation, based on that employed by most other EU member states, can be expected in the future.

The provision of formal vocational training in aquaculture, to include such areas as health & safety and safety at sea, is considered highly desirable for the safe and efficient development of the aquaculture industry in Malta. Some foresight for the training of diving staff to a professional level might also be prudent, since relevant legislation is almost certainly to be introduced in the future and, at present, no professional dive training is available in Malta.

During the period 2007-2008 the aquaculture industry in Malta directly employed 197 full-time equivalent (FTE) personnel, made up of 163 full-time employees and 73 part-timers (Applied Economics Consulting Ltd, 2009). In addition to this, it was estimated that there were a further 767 indirect FTE positions in support and supply industries including the retail, wholesale, transport, communications, financial and manufacturing sectors.

4.1.11 Industry representation

The industry is represented in Malta by the Federation of Maltese Aquaculture Producers (FMAP). FMAP was established in 2008 in response to increasing pressures on the bluefin tuna farming industry, and all 5 tuna farms are members. P2M, which only farms bass and bream, is not a member. FMAP plays a key role in representing the interests of tuna farming in the media and with regard to regulatory matters in Malta.

FMAP is a member association of the Federation of European Aquaculture Producers (FEAP), an international organisation of national aquaculture associations of European countries, whose basic aims are to develop and establish a common policy on questions relating to the production and commercialisation of aquaculture species and to make known to the appropriate authorities the common policies envisaged. FEAP offers an international forum where issues that affect aquaculture producers in Malta can be discussed with other European aquaculture producers.

4.1.12 Support services to the aquaculture industry in Malta

Apart from the active producers already mentioned in Malta, there are a number of other companies and individuals providing support to the industry e.g. fish health specialists, diving companies and consultants.

Environmental monitoring services are provided by Ecoserv Ltd, whose principals are based at the University of Malta, and which has carried out monitoring of all the tuna farms in Malta for more than 10 years, in addition to other monitoring work for the industry. The MARC also carries out water quality monitoring for farms.

Another company based in Mosta, the AquaBiotech Group (ABT), offers a wide range of services to the global aquaculture industry, including aquaculture consultancy and technical support for cage aquaculture and hatcheries, the design and development of recirculated aquaculture systems, ornamental fish production, water and waste-water treatment, fishery development projects, marine surveying activities and market research studies. ABT has a turnover of around €2 million and employs around 15 staff. The company possesses a small research hatchery facility which is capable of carrying out a range of trials and product development activities, and has received grants from the Malta Council of Science and Technology and the EU for research relating to recirculation systems.

ABT are primarily involved in overseas projects and services, and have not provided any major consultancy or support services to the Maltese aquaculture industry to date. However, the company clearly represents a potential provider of services and is a potential stakeholder in the future development of the aquaculture industry.

4.2 Aquaculture policy

4.2.1 Introduction

A number of policy documents for the aquaculture industry have been produced since the industry began in the late 1980s, reflecting changes in that time, the most notable of which was the advent of tuna farming in 2000. This section reviews such documents and seeks to arrive at a conclusion as to what actually constitutes policy at the present time, especially with regard to the siting of aquaculture installations, as policy in this area often appears contradictory. Such a conclusion is important as no assessment of potential new sites can be attempted without clarifying this point.

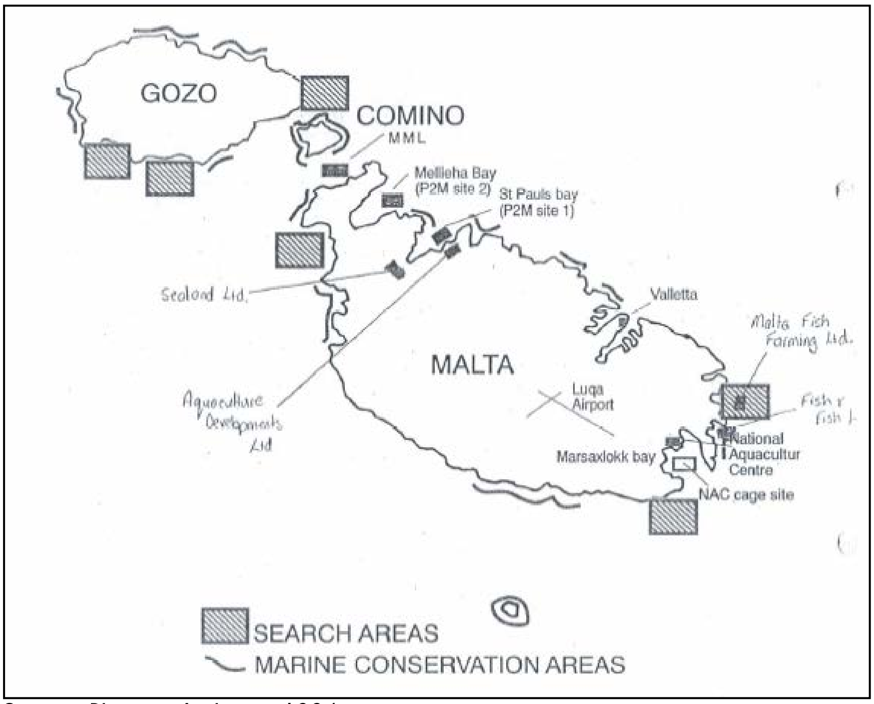
4.2.2 1994 policy and design guidelines - fish farming

Aquaculture in Malta began in the late 1980s but it was not until 1994 that the first policy on aquaculture was issued by the then Planning Authority entitled "Policy and design guidelines - fish farming" (PDG). This document was issued after the establishment of P2M and MML and as other investors were also showing interest. At this time, production focussed on seabream and seabass, in common with other Mediterranean countries. The PDG was based on reports by the then Director of the NAC, Professor Carmelo Agius, and on the Structure Plan.

Key elements of the PDG included:

- 2 land based hatcheries, each with a capacity of 5 million juveniles p.a., in addition to the experimental hatchery at the NAC
- A maximum of 12 sea based production units, each with a capacity of 400-500t p.a., to be established over the following 10 year period, with an eventual production of 5-7,000t p.a.
- 6 possible search areas were identified as potential locations for such units, based mainly on shelter from the prevailing winds (see Figure 9)

Figure 9. Fish farm search areas and marine conservation areas.



Source: Planning Authority, 1994

- The location of farms within the search areas was to be dependent on an EIS, with a recommendation that units should be located well offshore in around 40m water depth and/or where currents were strong enough to remove wastes. In addition, they were to be located well clear of sea grass communities and so as to minimise conflicts with other maritime and recreational activities.

- The location of farms within a Marine Conservation Area (MCA) was deemed unacceptable unless a beneficial impact could be demonstrated.

- The area occupied by a unit was to be limited to 50,000m^2 sea area for the buoyed perimeter line and 200,000m^2 seabed area for the moorings.

- A limited number of small scale land based units each producing less than 150t p.a. for species which could not be cultured in offshore cages, located close to shore but no more than 10m above sea level.

- A further option for integrated freshwater aquaculture was envisaged, for units producing less than 50t p.a. and using no more than 2,500m2 of ground, located in existing agricultural buildings inland.

- Guidance on visual impacts, environmental monitoring, management, licensing, restoration, inspection and maintenance of cages, fish health monitoring, predation, feeding, staffing.

- Reference to a number of Structure Plan policies likely to affect the location of farms.

- In addition to the above, detailed requirements were laid down for monitoring programmes to assess the environmental impacts of farms.

This policy served the industry over the following six years and elements of it continue to be in use today. However, by 2000 it was becoming clear that amendments would be required, partly as a result of the advent of tuna farming.

4.2.3 Amendment to the 1994 policy and design guidelines

In May 2001, the Planning Authority approved Supplementary Guidance entitled "Policy & Design Guidance on Fishfarming - Search area policy (Amendment), 2001", and this was endorsed by the Minister in August 2001.

The main recommendation of the amendment was to delete the previously proposed search areas for reasons including the following:

- The search areas were proposed primarily according to shelter from prevailing winds, pending results of impact monitoring, and were now deemed inappropriate
- A number of farms were said to have defaulted on their environmental monitoring obligations
- There was a need to cater for new developments including new species
- An EIS for a tuna penning application in the Ta 'Cenc search area (south west of Gozo) had revealed a potentially negative impact on internationally important seabird colonies in the area
- The Malta Maritime Authority (MMA) had indicated a number of search areas were unacceptable from a shipping point of view, and recommended no development in the search areas off Marsascala, Mellieha, and Benghajsa, other than existing operations/applications
- The search area off Ras il-Qala (south east of Gozo) was considered unsuitable due to rock blasting activities in the area, and potential impacts on a local bay.

In view of the above, the Environmental Management Unit of the Planning Authority, in agreement with the Department of Fisheries and the MMA, recommended that, in addition to the deletion of the search areas:

(i) A National Policy on Aquaculture be prepared in collaboration with all relevant Government departments, to be finalised by February 2002
(ii) Apart from existing applications being proposed, no further applications to be accepted for farms less than 1 nautical mile from the shore or in less than 50m water depth until the new Policy was formulated
(iii) Further action was to be taken to ensure existing farms complied with their permits.

4.2.4 National Policy on Aquaculture

Despite intentions to prepare the new Policy by 2002, it was to be March 2004 before it was finally published. Although the Policy has been endorsed by MEPA, it has still to be formally approved by Government. A copy of the Policy document is given in Annex 3.

The preamble to the document states:

"The objective of this document is to formalise the Government's policy with respect to this emerging industry, and provide a holistic national strategy with respect to aquaculture development in Malta."

Key elements of the document include:

Background considerations, including:

- A history of the industry indicating the recent emergence of tuna penning, as well as continuing bass and bream farming. The importance of aquaculture to the Maltese economy
- The need for a competitive and sustainable industry, taking into account improved operational standards, species diversification, new production technologies, improved quality of produce, environmental sustainability, and investment in R&D.
- The requirements of the industry in terms of land area needed for different operations and the sea area needed for sea based farms. With regard to the latter, it states: "The sea depth and location required is dependent on the type of species cultured. Inshore and sheltered sites may also be required, for the rearing of smaller sized fish species or juveniles or any other species of plants or animals that may require inshore areas for their proper growth."

- With regard to environmental considerations, it is stated that the requirements in Malta for EIA and monitoring are amongst the most rigourous in the Mediterranean, nevertheless pointing out a need for further refinement of such monitoring. Analysis of monitoring data to date showed that impacts were closely linked to site-specific circumstances, operating practices and species cultured. All development permits issued lay down conditions for environmental monitoring for which operators must pay.

A section on "National policy on aquaculture development", including content on:

- Legislation governing aquaculture in Malta and the associated regulatory authorities

- The need for Malta to abide by any relevant international commitments, particularly with regard to biodiversity, and for aquaculture operations to participate in the development and adoption of relevant international codes of practice.

- With regard to environmental considerations, the need for aquaculture operations to undergo EIA prior to development and on-going monitoring, and to comply with all necessary regulations regarding the use of therapeutants and other chemicals. In addition they should comply with international systems regarding conservation of species, and support research and development in to the culture of endangered stocks.

- With regard to conduct of aquaculture operations, reference is made to quality assurance of feeds and fish products, health control, containment of farmed fish, and data collection.

- With regard to socio-economic aspects, aquaculture must not negatively affect the livelihoods of local communities, and a reasonable balance must be found regarding the use of resources shared with other activities. At the same time, areas used for aquaculture operations, whether land or sea based, require property rights.

Finally, a section on "Strategy" includes the following points:

- The relevant authorities to endeavour to fulfil the policy on aquaculture

- The Ministry for Rural Affairs and the Environment to review and make recommendations on the National Policy after five years.

- Requests for aquaculture development to be administered by the Fisheries Conservation and Control Division, which should liaise as appropriate with other regulatory authorities.

With regard to the location of aquaculture developments, the strategy states:

> **"Strategy for the Development and Management of Marine Installations**
>
> (i) Marine installations occupying large areas used for the culture of large fish shall be located in designated areas, located as far out from the coast as the species cultured and available technology allows.
>
> (ii) Marine installations occupying limited areas involving small fish that necessitate sheltered waters shall be located to avoid significant visual impact as much as possible, and the best use of available areas.
>
> (iii) Marine installations involving filtrating marine resources, algae and invertebrates shall be given priority on the use of inshore available areas.
>
> **Strategy for the Management of Land Developments**
>
> (i) Land bases related to marine installations shall be restricted to industrial areas and other appropriate sites.
>
> (ii) Land installation involving complete cycles / on-growing:

(a) Making use of completely closed systems shall be restricted to industrial areas, former quarries etc. These could be located in the countryside on the same basis as new agricultural buildings.

(b) Making use of open systems shall be restricted to areas outside the water protection zone or in areas where their effluent can be properly managed."

4.2.5 Fisheries Operational Programme for Malta (2007-2013)

The Fisheries Operational Programme for Malta 2007-2013 (FOPM) was prepared in accordance with Council (EC) Regulation No. 1198/2006 regarding the European Fisheries Fund (EFF) in July 2006, the purpose of the programme being to identify priorities for the development of Maltese fisheries, aquaculture and processing in accordance with the objectives of the Common Fisheries Policy (CFP).

The FOPM is based on Malta's National Strategic Plan For Fisheries 2007-2013, which gives its objectives for the development of aquaculture as "To stabilise existing aquaculture production, increase product diversification and improve the value added of the sector". Specific actions include:

- To close the production cycle of existing aquaculture production and to achieve the diversification of cultivated species
- Reducing the negative impact of existing operations on the environment

The establishment of a hatchery to provide juveniles of both existing and new species for the local industry is given as a priority, and a possible location for such a hatchery is given. Reference is made to the development of new aquaculture zones to the NE and SE of Malta for the fattening of tuna, whilst existing inshore sites currently used for tuna are to be used for other species. Mention is also made of the possible use of modern "low-consumption" recycling systems on land for nursery stages.

The FOPM reflects the National Strategic Plan, providing an analysis of the fisheries and aquaculture sector at the time, setting out objectives for development, and describing priority axes and related support measures. Further information on financial support measures is given in Annex 4.

With regard to fishing, it is acknowledged that GFCM priority species such as tuna, swordfish and dolphin fish are under increasing pressure, and that "a shift towards less threatened species as well as aquaculture species will need to take place over the coming years".

In 2006, the value of capture fisheries was around €2.4m, whilst that of aquaculture was approaching €25m (of which bass and bream €2.4m and tuna €22.4m). In the analysis, aquaculture is thus seen as an opportunity for Malta, stating "Malta is currently undertaking to relocate its aquaculture installations further outwards to around 3 km from the shore. This will allow the number of fish farms to increase and it is estimated that production of farmed fish will increase to 15,000 Tonnes. This should permit the diversification of species away from the traditional sea bass and sea bream production and which should permit the tapping of new markets."

At the same time, the potential environmental impact of aquaculture is acknowledged, and the benefits of moving further offshore with regard to dispersion of wastes and reducing conflicts with other coastal users is highlighted. Reference is made to relocating farms close to the coast to sites 6km from the coast in 80m water depth, whilst acknowledging that the establishment of such sites requires further development of cage technology.

A final reference to locations in the analysis states "it is the intention of the authorities to move all aquaculture operations considerably off shore and at the south of the Island."

There is acknowledgement of the need for a land based hatchery, and investment in such a facility is to be supported under the FOP.

4.2.6 Other initiatives

Other initiatives taking their lead from national policy include the Water Catchment Management Plan (WCMP), which provides a summary of how the EU Water Framework Directive (WFD) will be implemented in Malta, and Integrated Coastal Zone Management (ICZM). With regard to the WCMP, the key measure relating to aquaculture is to "define and implement operational guidance for aquaculture activities" and is to be lead by the MRRA, with the involvement of relevant stakeholders. The purpose of such guidance is to build on existing good practice and address malpractice.

With regard to ICZM, a Coastal Strategy Topic Paper was produced in 2002 to provide evidence for the Structure Plan Review. An assessment of aquaculture is made in the paper and recommendations given on the location of sites.

4.2.7 Observations regarding national policy

In many respects, the original 1994 PDG was more explicit than the 2004 Policy. For example, the PDG set out production targets, numbers of farms, preferred site characteristics and search areas, whilst the 2004 Policy gives only general guidance on such issues as well as referring to the need to comply for example with international guidelines and policies.

Whilst the FOPM is not policy as such but is based on the National Strategic Plan for Fisheries, the declining importance of fisheries and the growing potential of aquaculture is made evident, and the proposed support measures largely reflect this. Reference is made to a production target of 15,000t, based on the location or relocation of farms further offshore, although there are conflicting statements regarding distances from shore, with both 3 and 6km being mentioned. Emphasis is on diversification of species, and support for capture based aquaculture e.g. tuna penning appears to be ruled out.

The most contentious issue in any of these policy documents is clearly that of site location and conflicts with other users. It is evident that the PDG in defining search areas had not fully taken into account potentially conflicting activities, but this only came to light once new operations had applied for sites in such areas. The deletion of such search areas in the 2001 Amendment to the PDG is thus not surprising. However, although the Amendment restricted applications for new farms to locations with more than 50m water depth and at least 1 nautical mile from shore, no reference to this specific requirement is made in the 2004 Policy, which instead gives guidance on the location of sea based farms as stated in the "Strategy for the Development and Management of Marine Installations" (points (i) to (iii) in section 4.2.4 above).

In this and other respects, there appears to be a discrepancy between the 2004 Policy and the draft Structure Plan 2006. "Policy FIN 2 – Aquaculture" of the Plan appears to use elements of the PDG, the PDG Amendment, and the 2004 Policy.

In particular, with regard to location of sites, it states:

"MEPA designates an offshore aquaculture zone as shown on Map 1 to accommodate new and relocated existing marine installations rearing large fish species. Additional offshore aquaculture zones may be designated provided the zones are at least 1 nautical mile from the coast; beyond the 50 m depth contour; do not conflict with strategic marine uses; and where the activities within them are not likely to create adverse environmental impacts.

MEPA will not permit marine installations rearing small fish species and/or filtrating marine species, algae and invertebrates, within Tourism Hubs, and shallow inlets and bays, in or close to areas which are protected or merit protection; and where they would have significant adverse environmental or visual impacts. MEPA will only permit land bases for marine installations within the Industrial Hubs identified in Policy EMP 6.

MEPA will revise the Supplementary Guidance *Policy and Design Guidance: Fishfarming*1994; amended 2001) according to the provisions of this policy."

Further to the above statement on locations, it goes on:

"Monitoring Measure: – F2, F3

1.6.8 In recent years, a new interest in farming Blue-Fin tuna has emerged. The Blue-Fin tuna to stock the cages are caught in international waters by purse seining during their migration period within the Mediterranean and purchased by the farm operators. Once towed to Malta the fish are reared on the farm for a period of nine months. Such large species require extensive areas (in the order of 1,600 square metres per cage) for their rearing.

1.6.9 This policy guides existing and new farms rearing large species such as Blue-Fin tuna towards designated zones away from the coast to minimise the impacts on water quality, habitats, recreation and landscape. When designating these zones, conflicts with existing strategic marine uses such as Harbour Approach Routes, spoil grounds and bunkering sites (shown on the Map 2) should be avoided whilst the fish farms themselves should not cause any adverse environmental impacts particularly on benthic habitats.

1.6.10 Small species aquaculture development is directed to areas away from Tourism Hubs and shallow inlets and bays; firstly to ensure that they are in open waters where good water circulation prevails thus ensuring that water quality and benthic habitats are not affected negatively by fish waste, and secondly to minimise conflicts with other legitimate coastal uses.

1.6.11 Land-based facilities associated with marine installations are allowed only in Industrial Hubs to ensure that, whilst their operational requirements are catered for, they do not take up space for legitimate coastal uses, since these operations are industrial in nature and do not need to be located on the coast."

From this it is assumed that current overall policy regarding sea based farms is as follows:

- Large species farms e.g. for tuna occupying large areas to be located in designated aquaculture zones such as the new SE Aquaculture Zone, or other new zones out with the 1 nautical mile limit and 50m contour; existing tuna farms to be relocated to such zones

- Small species farms e.g. for bass and bream occupying small areas and requiring sheltered waters not to be permitted within Tourism Hubs, shallow inlets and bays, in or close to areas which are protected or merit protection, or where they would have significant adverse environmental or visual impacts

From the latter, it is assumed therefore that small species farms are permitted within the 1nautical mile/50m contour limit providing that they comply with the other requirements. Despite this, there seems to be a general perception that ALL aquaculture, whatever the species or size of fish, should be located offshore and outwith the 50m contour, although the distance offshore differs markedly between sources.

There is clearly a need to define more accurately what species can be farmed where, and to differentiate between different types of production systems e.g. nursery and ongrowing facilities and their possible location.

A further observation on policy is that whilst there is reference to consultation between relevant Government departments and agencies, there appears to have been little or no consultation with the aquaculture industry itself. This is contrary to EU policy, which emphasises the need for proper stakeholder consultation.

4.3 Regulation of the industry

4.3.1 General aquaculture legislation

Since accession to the European Union in 2004, Malta has been obliged to implement all current EU directives concerning aquaculture regulation (seeTable 1). A summary of all potential legislation relating to aquaculture in Malta is given in Annex 5. Other legislation relating more specifically to aquaculture is explained further below.

The commercial aquaculture industry in Malta commenced in 1990 with the establishment of P2M. Since it was apparent that legislation was required specific to the aquaculture industry, an Aquaculture Regulations Act was introduced in May 1990, which laid down basic regulations concerning the licensing of aquaculture operations. These provisions established the basic requirements of an aquaculture industry, such as the requirement for an operator to hold a licence to rear or fatten fish, and a requirement for any fish farm site to possess a licence for the rearing or fattening of fish. The licences in these cases were provided by the Director of Agriculture and Fisheries. Any licence would require a list of conditions to be adhered to, and could be revoked in the event of the said conditions not being met. The licences in this case were valid for 1 year, and renewable on a yearly basis.

Following the establishment of P2M and growing interest in aquaculture developments in Malta, a provision of the Fishery Regulations Act of 1993 allowed for the Director of Fisheries to 'reserve specified areas in the territorial waters of Malta for the cultivation of mussels and oysters and other fish, including finfish, molluscs and crustaceans, and may grant a concession for this purpose for a specified period on such terms as he may establish'.

The current basis for aquaculture legislation in Malta is the Fisheries Conservation and Management Act of 2001. This act includes the requirement of a permit for the installation or operation of an aquaculture establishment, granted by the Director responsible for fisheries management subject to a list of conditions established with the consultation of the Chairman of the Malta Maritime Authority (MMA) and the Chairman of MEPA with regard to the allocation of 'an appropriate site for the aquaculture establishment'. This act, therefore, formally lays out a requirement for consultation between the Director of Fisheries, the Malta Maritime Authority and the Malta Environment and Planning Authority for the granting of an aquaculture permit. The fact that no specific conditions or requirements are listed for these issues suggests that individual aquaculture permits may vary with respect to the list of conditions required for operation, and may vary over time according to government policy and approved development plans and planning policies.

In particular, the aquaculture permit allows exclusive rights to harvest the products of the aquaculture establishment within a specific area of land or sea as specified in the permit, subject to 'such conditions as appear to the Director to be necessary or expedient for the regulation of aquaculture, the management of fisheries and the economic benefit of Malta'. This act also allows for the Minister responsible for fisheries and aquaculture to impose regulations over 'the promotion and control of the cultivation of fish including the issue by the Director of a code of practice for the maintenance and operation of aquaculture establishments'.

4.3.2 Planning legislation

The Development Planning Act, 1992 (Chapter 356) established the Malta Environment and Planning Authority (MEPA) to provide for planning and development in Malta. The remit of MEPA is 'to promote the proper planning and sustainable development of land and at sea, both public and private' and 'the control of such development in accordance with national development plans and planning policies'. All aquaculture developments subsequent to the enactment of this act required the approval of MEPA. A number of amendments have been carried out to this act, most particularly by Acts XXI of 1992, XVI and XXIII of 1997, XXIII of 2000 and VI and XXI of 2001, which have strengthened the role of MEPA and increased its influence on the approval of development permits for aquaculture operations in Malta.

The Development Planning Act of 1992 has now largely been replaced by the Environment and Development Planning Act, 2010 (Chapter 504), and emphasises the duty of every person and the government to protect the environment. In particular it obliges government to: give due consideration to environmental concerns in decisions on socio-economic and other policies; to address and abate pollution and other environmental degradation; to collaborate with other governments and global entities in the protection of the global environment; to apply scientific and technical knowledge and resources in determining matters that affect the environment; to safeguard biological diversity; and to combat all forms of pollution. The planning and development policies of MEPA are designed to promote sustainable development, protect and manage the environment and sustainably manage natural resources.

4.3.3 Fish health legislation

In addition to general animal health legislation (Chapter 36: Prevention of Disease Ordinance and Chapter 437: Veterinary Services Act, 2002) the following legislation applies directly to fish health in Malta:

The first legislation concerning aquaculture activities in Malta, the 'Aquaculture Regulations act of 1990, includes certain provisions to guard against the spread of disease. In particular paragraph 7 allows for the Director of Agriculture and Fisheries to revoke a licence if, in his opinion, there is a risk of the spread of disease. In addition, a minimum distance between fish farms of 1km was set. Any movements of live fish stock from a licensed place would require the written permission of the Director of Agriculture and Fisheries. Any importation of live fish stock would also require the written permission of the Department of Agriculture and Fisheries, and a health certificate from the point of origin.

The Fisheries Conservation and Management Act, 2001, updated the existing aquaculture legislation and established conditions concerning the 'health condition' of the fish stocks, measures for the prevention of escape of fish stocks and measures for the prevention of disease transmission to wild fish stocks. It also allows for the Director of Fisheries to enact regulations concerning the regulation of importation of live fish stocks and some control over the operation of fish farming activities through the issuing of a code of practice for the maintenance and operation of aquaculture establishments.

Following accession to the EU in 2004, 'Measures for the Control of Fish Diseases Rules, 2005' was enacted, which implemented European Council Directive 93/53/EEC by defining the minimum measures to be carried out in Malta for the control of fish diseases referred to in Schedule A, list I and II, attached to EU Council Directive 91/67/EEC. All aquaculture operations producing fish susceptible to these diseases are obliged to be registered with the appropriate authority and any suspicion of the presence of any disease listed in list I and II notified to the Department of Fisheries. However, no susceptible fish species to the diseases listed in this directive (Infectious Salmon Anaemia (ISA) in list I and Viral Haemorrhagic Septicaemia (VHS) and Infectious Haematopoietic Anaemia (IHA) in list II) are currently farmed in Malta and only a single susceptible fish species, turbot, has any potential at all for aquaculture in the Maltese environment, making this legislation largely irrelevant to existing or potential aquaculture activities in Malta.

Similar legislation for the control of disease in molluscs was set out in 'Bivalve Molluscs (Minimum Measures for the Control of Diseases) Rules, 2005 which established the minimum measures to be applied in the control of diseases affecting bivalve molluscs. This required any bivalve farm to be registered with the Department of Fisheries and to keep detailed records of all stock movements. In addition, a monitoring and sampling programme needed to be implemented and measures laid down to be taken in the event of suspected disease outbreaks.

The Residues in Meat Regulations of 1998 prohibited the sale or use of the antimicrobial chloramphenicol for farmed animals, including fish, and prohibited the unregulated use of thyrostatic, oestrogenic, androgenic or gestagenic drugs on farmed fish stocks. However it does allow for the controlled and licensed use of veterinary medicinal products having an oestrogenic, androgenic or gestagenic action on fish stocks for zootechnical purposes, thus allowing the use of hormone manipulation techniques to promote the spawning of such fish species as amberjack and bluefin tuna. There is also provision for the use of sex inversion techniques in juvenile fish (less than 3 months old) using drugs with an androgenous action.

Existing fish disease legislation in Malta is based on 'Animal Health Requirements for Aquaculture Animals and Products thereof, and on the Prevention and Control of Certain Diseases in Aquatic Animals Rules, 2009' of the Veterinary Services Act of 2009. This implements European Union Council Directives 2006/88/EC and 2008/53/EC and repeals and replaces both 'Measures for the Control of Fish Diseases Rules, 2005' and 'Bivalve Molluscs (Minimum Measures for the Control of Diseases) Rules, 2005'.

4.3.4 Other legislation concerning aquaculture in Malta

Legislation concerning shellfish in Maltese waters is covered by the Quality Required of Shellfish Waters Regulations, 2001(part of The Environmental Protection Act of 2001), which designates waters requiring protection in order to support shellfish life and sets parameters for the required level of water quality. There is also a provision to establish pollution reduction programmes with an aim of conforming to the stated water quality parameters with six years of site designation, by way of regular sampling operations. Although this act does not distinguish between wild and cultured shellfish stocks it does establish the availability of areas of seabed suited to shellfish culture in Malta.

Legislation concerning the quality of fish feeds for aquaculture use is covered by The Undesirable Substances in Animal Feeds Rules, 2009, which implements Directive 2008/76/EC of the European Commission which amends the first schedule to Directive 2002/32/EC. This act regulates the level of undesirable substances in fish feed products used in the Maltese aquaculture industry. This act is supplemented by the Undesirable Substances in Animal Feeds (Amendment) Rules of 2010.

In 1997 legislation was introduced to regulate the harvesting or cultivation of marine plants through the requirement of a licence issued by the Fisheries Dept. (Marine Vegetation Licence Regulations), to address interest in the production and harvesting of *Padina padonica* by a pharmaceutical company in Malta.

4.3.5 Key agencies involved in regulation of the industry

4.3.5.1 Agriculture and Fisheries Regulation Department, Ministry for Resources and Rural Affairs

This Department comprises Directorates for Veterinary Regulation, Fisheries Control and Plant Health, and is managed by the Director General for Agriculture and Fisheries Regulation, Dr. Anthony Gruppetta.

The Fisheries Control Directorate of MRRA regulates and administers the aquaculture industry in Malta and has direct responsibility for the issuing of aquaculture operating permits.

The Agriculture and Fisheries Regulation Dept. also regulates all veterinary aspects of aquaculture production including fish health, processing and packing activities. The mission statement for the Department states that the regulation of the aquaculture industry is aimed to ensure sustainability.

4.3.5.2 Department of Rural Development and Aquaculture, Ministry for Resources and Rural Affairs

This Department comprises Directorates for Agriculture, Animal Welfare, Wholesale Markets and Fishing Fleet Facilities, Parks, and the MARC. The MARC is thus part of an entirely separate ministry department to the Fisheries Control Directorate.

4.3.5.3 Malta Environment and Planning Authority (MEPA)

MEPA is the national agency responsible for land use, planning and environmental regulation in Malta.

MEPA has considerable power in implementing policy, and is entitled to make a plan or policy on any matter relating to the environment and development planning at its own instigation, and review any existing plan or policy at its own instigation, provided consultation is carried out with the relevant Minister.

MEPA planning policy is contained in a Structure Plan, the last one of which was published in 1990, and a replacement for which is currently being drafted. More specific environmental or development planning policy is set out in 'subject plans',' local plans', 'management plans' and 'action plans'.

No development, including aquaculture developments, may be carried out without development permission from MEPA, and MEPA has the power to grant or refuse such development permission. If permission is granted, then MEPA has the power to levy a charge for that permission, known as a 'Development Permission Fee', in accordance with an existing schedule of charges.

MEPA itself is divided into three directorates:

- Environmental Protection Directorate – advises government on environmental standards and policies, draws up plans and provides a licensing regime to safeguard and monitor the environment and controls the activities having environmental impact.
- Planning Directorate – processes development applications, responsible for enforcement, policy development and plan making.
- Directorate for Corporate Services – responsible for human resources, information technology, mapping and land surveying, support services and finance.

4.3.6 Steps necessary for obtaining development permission for aquaculture projects

The process flow for the application for full development permission for aquaculture setups is published on the Fish and Farming Regulation and Control page in the Veterinary section of the Ministry for Resources and Rural Affairs website (see Figure 10). The process flow diagram is outdated, and refers to the names of government departments no longer in use due to subsequent reorganisation, but it does show key steps.

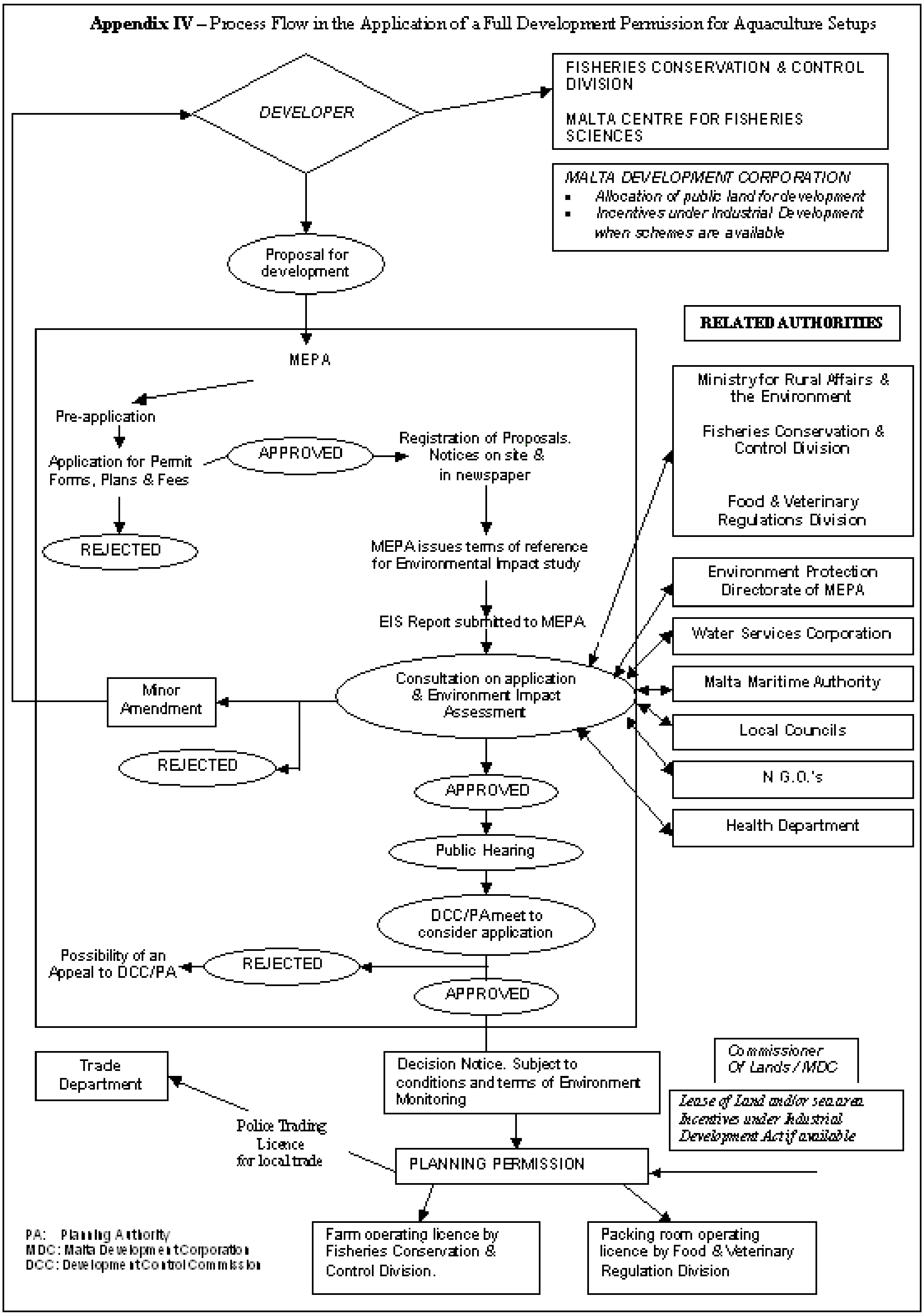
At present, the prospective aquaculture developer first approaches the Fisheries Control Directorate of the Agriculture and Fisheries Regulation Dept. at the MRRA with details of his proposed development and for the formal application of a licence to operate an aquaculture facility. Assuming the development proposal is viable and consistent with existing laws, policy and guidelines, it is then passed to MEPA's Planning Directorate for consideration. It then passes through a pre-application process where it is assessed for compliance with existing laws and MEPA policies and guidelines. If it is deemed to conflict with any of these laws, policies and guidelines or is not considered a viable proposal for any other reason the developer would normally be informed of the reasons and a recommendation to either withdraw or amend the application be given.

If the development proposal is approved during the pre-application process, it is then registered as a formal development proposal and published in the MEPA website and the local press to give any person the opportunity to object to the development proposal, in writing, to MEPA. It is then passed to the Environmental Assessment Unit to screen the proposal to assess any requirement for an Environmental Impact Assessment (EIA) or a Strategic Environmental Assessment (SEA), and construct the terms of reference for any such assessment.

Once the EIA or SEA is submitted the development application is then assessed by MEPA. It is at this stage that other stakeholders are consulted with respect to the development application. The main stakeholders consulted for aquaculture development proposals are the following:

- Fisheries Control Directorate, Agriculture and Fisheries Regulation Dept., MRRA
- Veterinary Regulation Directorate, Agriculture and Fisheries Regulation Dept., MRRA
- Environmental Protection Directorate, MEPA
- Water Services Corporation
- Transport Malta (previously Malta Maritime Authority)
- Local government councils
- NGOs
  Health Dept.

Figure 10. Process flow for the application of full development permission for an aquaculture setup



Source: MRRA website, June 2011

The results of this appraisal process will either result in approval, an approval subject to minor amendments or a rejection. Assuming approval, the development proposal will then be subject to a public hearing and is then reviewed by the MEPA board for final approval or rejection. If approved at this stage, a decision notice is delivered to the developer detailing any conditions and terms of environmental monitoring. This then leads to formal planning permission. Under new legislation, a decision must be made by MEPA on an application within 52 weeks of submission of the application or an EIA.

Once planning permission is obtained, the developer will need to obtain permission from either the Lands Dept. (for government-owned land) or the Planning Area Permits Board (for privately-owned land) for the development of any land-based facilities, subject to a land use permit granted by MEPA.

The aquaculture development would then normally be granted an operating licence and, if necessary, a packing room operating licence by the Agriculture and Fisheries Regulation Dept. of the MRRA.

4.3.7 Compliance with and enforcement of planning permit conditions

Planning permission is granted to aquaculture developments under various conditions outlined in an operational permit, which are designed to ensure that the development conforms to the environmental standards as defined in existing environmental regulations. MEPA employs an enforcement procedure which obliges an Enforcement Officer to monitor developments in his area. If any development is found not to be carried out in accordance with the permit or any conditions attached to that permit, that development may then be held to represent an infringement of the relevant planning control.

Where an infringement has been detected, the enforcement officer may issue a stop notice or stop & enforcement notice, requiring the developer to take any necessary actions to regularise his position within a time frame as specified in the enforcement notice. MEPA also employs a procedure for the investigation of complaints, and may verify any such complaints to assess if a breach in permit conditions has occurred.

The document 'Notes on the Situation Regarding the Proposed Fish Farm Search Areas in the Policy and Design Guidance for Fish Farming (1994)' written by the Environmental Management Unit at MEPA in 2002 stated that various fish farms had defaulted on their environmental monitoring programmes, an issue that was being discussed with the Legal Office and the National Aquaculture Centre at that time. However, no action appears to have been taken on this matter, either through enforcement procedures or through the conditions for such circumstances included in the planning permission conditions. Furthermore, planning permission for the replacement of existing finfish production licences with tuna penning licences and farm relocations continued to be granted during the period 2001-2004, despite the fact that environmental monitoring records were presumably reviewed and assessed prior to the granting of these permits.

Interviews with various stakeholders of coastal and marine resources in Malta reveal a widespread perception that some aquaculture producers are occasionally in breach of their permitting conditions. For example, Malta Transport, responsible for all shipping activities in Malta, has reported poor maintenance of marker buoys used to demarcate some aquaculture operations, resulting in faulty lights and even buoys breaking free from their moorings. There is also a perception that suspected infringements are often not formally investigated and therefore rarely result in action being taken. This perception regarding lack of enforcement applies to many activities in Malta, and is thought to be a consequence of an understaffed police environmental enforcement unit.

In addition, there is a widespread view amongst coastal resource stakeholders that some tuna penning operations in Malta are responsible for a range of adverse effects on the marine environment, including the appearance of a foul-smelling slick of fish oil on the water surface at certain times, particularly noticeable during the summer months on recreational beaches, that appears to be blamed for the development of skin rashes in some bathers, and the occasional washing-up of tuna processing waste on the shore-line. Such slicks have also been the subject of complaints to the Harbour Master at Malta Transport. Interestingly these complaints appear to vary according to the location. They are very prevalent off the south-east coast of Malta, particularly around the Delimara peninsula and the coast of Marsascala, where waters are generally pristine and used mostly by local tourists. There are several tuna penning operations in this area presumably responsible for these problems. However, the St. Paul's Bay local council reported no issues and no significant complaints from locals of that vicinity of water pollution issues of this kind, despite the close presence of AJD Tuna Ltd., the largest tuna penning operator in Malta.

It is clear that some of these issues at least are the result of feeding and harvesting practices employed by tuna penning operations. The feeding of large quantities of frozen and thawed fish to the tuna stock does often result in the release of large quantities of fish oil once the fish is placed in the tuna pens. Since oils disperse widely over the water surface, although representing a relatively small quantity of fish oil overall, these slicks may have a significant visual and olfactory impact and are presumably very unpleasant to swim through. If feeding takes place during periods of strong onshore winds, then the slicks may approach recreational beaches downwind of the tuna penning facilities. The presence of tuna processing waste on beaches and inshore waters is presumably due to the dumping of such waste at sea. Although aquaculture operators are obliged to pass this offal through a mincing machine and dispose of it beyond the 12 mile limits, strong onshore winds may be able to blow floating tuna processing debris into inshore waters and onto recreational beaches.

In the defence of the tuna penning industry, neither of these issues is necessarily due to the deliberate non-compliance of the tuna penning operators to the planning permit conditions. The issue of fish oil slicks following feeding was never addressed in either the Environmental Impact Statements or the permit conditions, presumably due to ignorance over this issue by all parties upon the early development of the tuna penning industry. The dumping of minced tuna processing waste (consisting of viscera, fish heads and tails) at sea, beyond the 12 mile limit, was a condition set by all planning permits *in lieu* of the establishment of a land-based disposal facility at the civil abattoir and so was explicitly endorsed by MEPA.

All tuna penning operators are aware of these issues and have made attempts to rectify the problem. For example, the frozen fish used as a feedstuff for the tuna can be partially thawed ashore and drained of a significant quantity of fish oil prior to feeding, and several operators employ a variety of methods to avoid excessive release of fish oil. Efforts have also been made to prevent the accidental release of tuna processing waste in inshore waters and to move the processing ships further offshore during processing operations.

A number of conditions could be imposed on aquaculture producers to minimise the effect of these issues either in planning permit conditions or through required codes of good practice. For example, efforts could be made to remove much of the fish oil from the frozen or thawed fish feedstuff prior to its placing into the water and regulations could be introduced to restrict the feeding of tuna during periods of inshore winds. The issue of tuna processing waste will be addressed when the on-shore disposal facility at the civil abattoir is operational.

It is no secret that the tuna penning industry is controversial, and receives bad press on a regular basis, despite the fact that it is now highly regulated and subject to significant restrictions to protect wild tuna stocks. It is difficult to escape the conclusion that many of the objections to the tuna penning operations are based on this general level of disapproval as opposed to any specific breach of conditions or husbandry best practices on the part of the tuna penning operations. A clear statement on the part of the national government of Malta on support for the tuna penning industry, or lack of it, would be welcome in order that regulators such as MEPA are in a position to judge planning permits concerning tuna penning operations objectively.

Some apparent breaches of permitting conditions are caused by events unforeseen during the permitting process which the aquaculture operators find impossible to resolve in a realistic way. For example, if marketing conditions or any *force majeure* obliges an aquaculture operator to hold stock during a period when permitting conditions demand that the farm be emptied and lay fallow, that operator will be in breach but not in a position to resolve the problem quickly and efficiently. To resolve these issues, control obligations on the developers should be designed to recognise any areas where breaches might occur through no fault or malicious breach on the part of the developer, and to contain a mechanism whereby aquaculture operators can inform MEPA of any unavoidable breaches of conditions in advance and reach a mutually acceptable formula to resolve that breach. This would encourage more openness on the parts of the aquaculture operators to more fully abide by the conditions of their planning permits and allow better regulation of the industry on the part of MEPA.

4.3.8 Planning permission issues with respect to aquaculture zones

The proposed aquaculture zone off the east coast of Malta was created to satisfy the demand for permit applications for tuna penning operations, taking into account the high degree of competition between coastal resource stakeholders in Malta and environmental issues apparent from existing tuna penning operations. The application for the zone was made by the Agriculture and Fisheries Regulation Dept. of the MRRA, who then issue concessions to aquaculture developments, according to the permit conditions established for the zone.

The principle of aquaculture zone operation represents an effective way to streamline and fast-track subsequent aquaculture development applications. Since the permitting process for the aquaculture zone is carried out in advance of any aquaculture development, each specific aquaculture development will not need to implement a time-consuming EIA and subsequent consultation procedures since an EIA for the zone as a whole will apply to all aquaculture development in that zone, subject to specific permitting conditions.

4.3.9 Review of development permit conditions for existing farms

Further details of planning applications for coastal fish farms in Malta since the establishment of MEPA are given in Annex 6. The development permit conditions for existing aquaculture operations in Malta vary widely, reflecting the evolution of both the aquaculture industry itself and its governance over the past 20 years.

4.3.9.1 Permitting situation prior to establishment of MEPA

The very first aquaculture development, P2M, was established in 1990 and the relevant legislation had to be introduced to regulate this industry at that time, based on experience from aquaculture activities in other European countries. At that time, foreign investments were coordinated by the Malta Development Corporation (MDC), one function of which was 'to encourage and promote the participation of private capital, both domestic and foreign, in the development of manufacturing, tourist, agricultural, fishing and other industrial enterprises' (Malta Development Corporation Act, 1967), and this investment was promoted by the Ministry of Productive Development, which was keen to establish an aquaculture industry in Malta. After consultation with a number of bodies, including the Dept. of Agriculture & Fisheries, the Lands Dept. and the Malta Maritime Dept., a Letter of Intent was issued for the production of finfish at three locations at St. Paul's Bay and Mellieha Bay. This development pre-dated the establishment of MEPA and so no planning application is recorded in MEPAs historical records.

4.3.9.2 Seabass and seabream farm permitting situation 1992-1998

Those aquaculture developments initiated between 1993 and 1995 (F&F, MML and MFF) were all granted planning permission by the then Planning Authority or MEPA. All were inshore facilities sited in semi-exposed to fully-exposed waters at depths of 25-40m, and all produced seabream and smaller quantities of seabass by way of full-cycle aquaculture methods. Sources within the aquaculture industry have commented that, at that time, there was little local opposition to aquaculture activities around Malta, and planning permission was normally granted after a relatively brief period of consideration.

The planning application for F&F for the installation of fish cages for fish farming was approved by MEPA in 1993. Interestingly this application took a total of 4½ months to process, as opposed to the very much longer period experienced in recent times. There is no additional data concerning the development permit on the MEPA website, and no indication that any conditions were set.

In 1994 MEPA approved planning guidelines (PDG) for the aquaculture industry in Malta (see Section 4.2.2) which envisaged a substantial increase in the industry to the production of up to 5 million juveniles fish at two hatcheries and the eventual production of up to 6000 tonnes of fish by up to twelve aquaculture operators by 2014. However, the provision to assess the environmental impact of these fish farm developments over the period 2004-2008 was integral to the guidelines. The guidelines included a wide range of conditions controlling the siting, operation and health management of the developments, including detailed guidelines for an environmental impact monitoring system to be implemented by each development. These guidelines were then used as a reference for the consideration of planning permits and the setting of permit conditions for all aquaculture developments established from 1994 onwards.

The application for the implementation of an 'on-going fish farm' in an area of sea off Munxar Reef, St. Thomas Bay, Marsascala by MFF was granted in 1995. This site is significant as it was a candidate Marine Conservation Area at that time. The permit conditions limit the annual production tonnage, emphasise the need for the mooring blocks to be placed well away from Posidonia beds, require the correct installation of appropriate marker buoys and require an environmental monitoring programme to be implemented according to the PDG. Most markedly, the conditions clearly state that if, in the opinion of the Planning Authority, the monitoring programme reveals that the existence of the fish farm is inconsistent with Marine Conservation Area objectives and/or loss of valuable habitat or species close to or under the cages, the planning permit will be revoked without compensation and the cages removed. Lastly, a requirement to submit details of cage structures proposed for Phase II of the development plans to MEPA for approval is included.

4.3.9.3 Permitting conditions for tuna penning operations – 1998-2004

During the period 1998-2001 Azzopardi Fisheries submitted a number of applications for development permission for tuna penning operations off Sannat, Gozo, St. Paul's Bay and the Comino Channel (at the pre-existing cage facility set up by MML). The Gozo application was submitted in December 1998 but was later withdrawn due to the presence of an important colony of seabirds in the area of the proposed development.

Tuna penning was at this time a new industry in the central Mediterranean, and differs fundamentally from the established closed-cycle production of such fish as seabream and sea bass in a number of respects, particularly in the type and quantity of feedstuffs used to feed the fish stock which can affect water quality within the vicinity of the development. Consequently the Planning Guidelines of 1994 would not have addressed these additional issues specific to tuna penning operations. Specifically the EIA for the withdrawn application for a tuna penning development off the south coast of Gozo clearly states that 'the amount and behaviour in the marine environment of wastes generated on the tuna farm through excreta and left-over feed was estimated using methodologies applied to fin-fish farms, since no similar work has yet been done for tuna farming'. Because of the significant difference in the type and quantity of feed used between these two forms of aquaculture, this essentially makes the results of this EIA invalid.

In addition, the EIA approves of the dumping of fish processing waste 'in the high seas' and states that such a practice 'does not create any environmental problems', a remarkable statement considering the risk of disease transmission to both farmed and wild stocks of fish arising from this method of disposal, and the risk of fish processing waste washing up on tourist beaches in Malta.

The EIS (Environmental Impact Statement) for the second application by Azzopardi Fisheries, for 'tuna penning in cages, feed storage, fish packing for export and all other activities normally carried out on land base to be carried out aboard vessel at sea' off is-Sikka l-Bajda, was much improved on the study carried out for the Gozo development above, with a clear recognition of the risks associated with the dumping of processing waste at sea and a recommendation that this waste be disposed of on-shore. However, the fact that little information on the effects of tuna penning operations on the environment were known at that time is recognised, and the EIS admits that 'since this type of farming is new it is not possible to estimate how much leftover food is likely to end up on the bottom and how much of it would be eaten up by the scavengers'. The likely effect of fish excreta on the environment is also extrapolated from existing seabass and seabream production operations in Malta.

Planning permission for this development was granted in May 2000 after an evaluation period of almost 17 months. The permitting conditions for the is-Sikka l-Bajda tuna penning development are strict and comprehensive. They define and limit the total area of operations, and state that cages are not to be moved without the prior authorisation of MEPA. Cage design and size, mooring design and net depth are specified. Despite the lack of availability of accurate information on the effect of tuna penning on the seabed from fish excreta and leftover food, the conditions address this issue by requiring a high standard of husbandry during feeding operations and to carry out regular monitoring of the seabed by video camera to ascertain the level of uneaten food accumulating on the sea floor beneath the cages. The results of this monitoring are to be passed to MEPA, who are authorised to carry out their own monitoring if thought necessary, and the applicant is required to 'clean up' the area should feed be found to be accumulating on the sea bed. A fine of Lm10,000 is payable in the event of uneaten food being allowed to accumulate on the sea floor.

Net washing and the disposal of waste water from this operation must be carried out outside of the 12 nautical mile limit. The disposal of processing waste is also addressed – this must be minced aboard the service ship and disposed of beyond the 12 nautical mile limit *in lieu* of the upgrading of facilities at the civil abattoir for the disposal of this waste. Discharges of net washing waste, bilge water, sewage and other effluents from the service vessels are strictly controlled, and the service ship is obliged to be equipped with some form of tracking device in order to ensure that the vessel does sail outside of the 12 mile limit to dispose of this waste.

The conditions limit the period when the tuna may be harvested and obliges the developer to fallow the site for a period of 3 months per year. Contingency plans are required for action to be taken in the event of an oil spill or a mass mortality of the caged fish stock.

Lastly, strict conditions are set concerning an obligation to carry out regular environmental monitoring. All such monitoring has to be carried out by an independent consultant approved by MEPA, shall monitor sediment parameters, benthic assemblages and basic water quality parameters initially at a frequency of four times per year both at the farm location and at nearby recreational dive sites. This requirement is guaranteed by a refundable deposit of Lm25,000.

In 2001 the operators of the cage facility set up by MML in the South Comino Channel applied for development planning permission to substitute part of its seabream production allocation with tuna penning activities, and approval was secured within only 3 months of the application. This is partly due to the fact that the existing operation was found to have acceptable environmental impact over the previous 8 years of seabass and seabream production, and that no structural changes to the shore base were necessary. The EIA is broadly similar in its results as per the previous applications, relying on data from existing seabream and seabass operations to predict the likely effect of uneaten food and faeces on the sea bed.

The permit conditions for this application were broadly similar to those imposed on the is-Sikka l-Bajda development but had evolved to some extent. For example, the monitoring requirements had been altered to video monitoring of the sea bed on the 4th and 8th month of each production cycle, specified as during October and February. Net cleaning would be carried out at the shore base with waste water being collected by an approved sedimentation tank and disposed of beyond the 12 nautical mile limit. The potential effect of this discharge on the marine environment is recognised, and its disposal is therefore subject to a rigorous monitoring programme.

In September 2001 F&F were granted permission to substitute part of their seabream production allocation to the penning of tuna, together with a relocation of their cage production facilities further offshore to a depth of 50m. The conditions for this permit were almost identical to those for the above development (South Comino Channel) but had additional conditions imposed by the Malta Maritime Authority, the Veterinary Services Dept. and the Dept. of Aquaculture & Fisheries. Then, in 2004 they were granted planning permission to further extend the tuna penning site and operations, increase the production of tuna and relocate the existing seabass and seabream cages.

Malta Fishfarming Ltd. followed suit with a very similar application to reallocate part of their seabream production allocation to tuna penning and to relocate the existing cage facility further offshore to a water depth of 50m, and received planning permission in October 2002 after 17 months of consideration.

4.3.9.4 Offshore aquaculture zone – 2004-2011

The Agriculture and Fisheries Regulation Department applied for planning permission for the development of an aquaculture zone south-east of Malta, to allow the establishment of tuna penning operations in offshore waters away from competing coastal marine resource stakeholders. The application was made in January 2004 and full planning permission granted in December 2005. An appeal from a third party, lodged in January 2006, has effectively held up the granting of planning permission. Despite this fact, three individual tuna penning operations have been granted consent at the aquaculture zone and two have been operational since 2007. A second application for this aquaculture zone was submitted in October 2009, and a decision is currently still pending.

The aquaculture zone was originally intended to allow for the relocation of existing tuna penning operations off the south coast of Malta which, during 2003, consisted of F&F and MFF. With understandable reluctance on the part of the existing tuna penning operations to relocate, all with valid planning permission for their operations, three new investors were subsequently granted permission to operate at the offshore aquaculture zone – Ta' Mattew, Mare Blu and Deep Sea.

The aquaculture zone was originally expected to be able to accommodate up to four individual operators, and a further consent is still potentially available. However, with a maximum extent of 3km x 1.5km presently in use there may not be enough space to accommodate 4 operators whilst still maintaining an adequate separation distance. The potential for a second aquaculture zone is thus being investigated off the north-east coast of Malta and is currently the subject of an EIA study.

4.3.10 Proposed legislation

Supplementary legislation to Chapter 425, entitled 'Aquaculture Operations Regulations, 2008', is currently in draft form and presently in its consultation phase, and is awaiting formal implementation. These regulations set out annual fees for operation licences, based on the total area of concession. These proposed fees clearly differentiate between the production of fish in excess of 6kg (i.e. tuna penning), below 6kg (seabream, seabass and meagre) and other aquaculture operations involving the production of filter-feeding invertebrates, seaweeds and other invertebrates. In addition, it appears that this proposed legislation represents an effort to standardise operating licences for all aquaculture operators in Malta. Under the proposals, the Veterinary Regulation, Fisheries Conservation and Control Division of the MRRA will grant operational licences to aquaculture operators, subject to an initial fee and an annual fee. It will also handle licences for land bases and, most importantly, will hold required development permits for aquaculture operations, to be delegated to those operations through the operating licence.

These proposed regulations also allow for the reassignment of development permissions or operating licences not in use. In addition, they cover a number of fish health issues, including a requirement to keep written records of mortalities and a requirement to submit samples of mortalities to a designated laboratory for analysis. Furthermore, operators are obliged to submit contingency plans for waste management, large-scale mortalities and pollution by petroleum products.

The implementation of these proposed regulations has been held up due to some resistance from the aquaculture industry over a number of issues. There is widespread resistance from existing aquaculture operators to move further offshore to dedicated aquaculture zones, and in some cases aquaculture operators are reluctant to change their existing permitting obligations under which they have operated successfully for many years.

In particular, the status of existing operators needs to be addressed with respect to their ability to continue operations, and a clear mechanism put in place to allow those operators to effectively comply with new licensing regulations. Those aquaculture operators currently situated in inshore waters need a clear roadmap to allow the secure running of operations into the medium and long-term.

4.3.11 Possible improvements to the regulation of aquaculture in Malta

4.3.11.1 Aquaculture governance within the Ministry for Resources and Rural Affairs

At present the aquaculture industry in Malta is governed by two separate departments of the Ministry for Resources and Rural Affairs – Agriculture and Fisheries Regulation and Rural Development and Aquaculture – each with its own Director-General answerable to the Permanent Secretary of the ministry. Consequently, many issues concerning the governance, regulation and development of the aquaculture industry in Malta need to be processed by both departments, which can result in delays and replication of effort.

The Maltese aquaculture industry is concerned at the absence of a clear strategic policy for the development of aquaculture in Malta, which is partly due to the absence of a single body within the Ministry for Resources and Rural Affairs which has the power to represent, promote and provide clear guidance regarding the aquaculture industry to the Minister. This is felt important as there is strong competition for marine coastal resources in Malta and valid environmental concerns associated with the unregulated development of the aquaculture industry which have strong representation within and outside government, and which require the aquaculture industry to have influence consistent with its present and potential value to the Maltese economy.

It is felt, therefore, that administration and governance of aquaculture could be streamlined and improved if it was managed by a single Directorate within the MRRA, under a single Director-General. The new Directorate could become that of "*Aquaculture* and Fisheries Regulation" to include Fisheries Control, Wholesale Markets and Fishing Fleet Facilities, and the MARC. Other Directorates, such as Veterinary Regulation and Plant Health, relating more to agriculture could then logically come under "Rural Development and *Agriculture*". It is understood however that given a re-organisation of the Directorates has recently taken place, further rationalisation is unlikely in the short term. It should however be borne in mind for the longer term.

A more wide ranging reorganisation might consider grouping all maritime activities, including sea fisheries, aquaculture, marine environment, marine planning, compliance, marine energy and marine sciences in Malta under a "Marine Directorate", and under which a specific Aquaculture department might be located.

4.3.11.2 Consistency of licensing arrangements between all aquaculture operators

Existing aquaculture producers in Malta are governed by a variety of operating licences with differing licence conditions, due to the evolution of the aquaculture regulatory requirements along with the development of the aquaculture industry over the past 20 years. Obviously a uniform licensing procedure for all aquaculture operators would help to streamline overall governance of the aquaculture industry in Malta and mechanisms should be explored to find a way of achieving this goal. A number of suggestions are outlined in the sections below, including the establishment of aquaculture zones and the implementation of industry-wide best management practices.

The proposed supplementary legislation to Chapter 425, 'Aquaculture Operations Regulation, 2008', offers a mechanism to unify operating licences for all present and future aquaculture operations in Malta (see section 4.3.11). However, these proposed regulations have experienced some resistance from the aquaculture industry. It is vital that any attempts to modify existing operational licenses be carried out in a fair, efficient, transparent and inclusive way. In particular, the proposed 'Aquaculture Operations Regulations, 2008' are vague and unclear in certain very important areas, and require clarification.

4.3.11.3 Simplification of licensing procedures for aquaculture developments

The existing system for the provision of development permission for aquaculture developments is relatively efficient in that it is already virtually a 'one-stop-shop' for the licensing of aquaculture operations in Malta. In this case the 'one-stop' is essentially MEPA who, provided the Director responsible for Fisheries approves the development, effectively decide whether such permission may be granted. The problem here is that, because of the broad range of stakeholders that need to be consulted for the development of any new aquaculture development, this process may be extremely lengthy, with some development applications taking well over one year to process.

It is clear that a streamlined and, more importantly, a proportionate regulatory framework is essential for aquaculture development licensing in Malta. Accepting that all of the relevant stages in the process flow diagram for aquaculture licensing are necessary (see Section 4.3.6), one effective way to streamline this entire process considerably is to establish areas for aquaculture development, or aquaculture zones, as has already been done by MRRA with the SE Aquaculture Zone. In that way, the entire licensing application process, including the full stakeholder consultations and environmental impact assessment studies, can be carried out in advance for the entire zone. Any aquaculture developer can then apply for an operational permit to carry out aquaculture operations within that zone, under pre-existing and general permitting conditions, and therefore avoid much of the time-consuming, but necessary, aspects of the licensing process.

The proposed Aquaculture Operations Regulations of 2008 attempt to clarify the licensing procedures for aquaculture operations by bringing the development planning requirements and other licensing requirements under the umbrella of the MRRA, partly through the establishment of aquaculture zones which will receive planning permission to be subsequently delegated to aquaculture operators. The establishment of aquaculture zones represents a mechanism to streamline licensing procedures (see section below). However, these proposed regulations run the risk of adding an additional layer of beaurocracy to existing licensing mechanisms, and must be carefully crafted to avoid any potential overlap with planning permitting through MEPA and any other stages in the permitting process.

4.3.11.4 The establishment of Aquaculture Zones

The current policy of the Agriculture and Fisheries Regulation Department to establish Aquaculture Zones (AZ) and then concede operating permits to aquaculture developers represents an effective way to balance the competing interests of coastal marine resource stakeholders and streamline the existing licensing procedures, which can often take well over one year before planning permission is granted.

The formal establishment of AZs, as part of a process for the development of location guidelines for aquaculture in Malta, will go some way to addressing the existing confused state of affairs concerning the licensing arrangements of all pre-existing aquaculture operations in Malta which, due to the evolution of the regulatory processes for the aquaculture industry along with the development of the aquaculture industry itself, have led to most aquaculture operations being governed by very different operation licence conditions. In addition, it would signal a long-term commitment on the part of the Maltese government in the development of the aquaculture industry, since aquaculture operations, with a lengthy application procedure, a fish production cycle of between 6 and 36 months and a high fixed cost investment, typically require a long-term business plan to produce a viable business and attract investment.

However, it is important that the aquaculture development zones represent the right sites in the right places for the aquaculture species in question.

The existing aquaculture zone off the south east coast of Malta was established in 2005 and there are currently plans to establish a similar zone off the north-east coast. Where possible, lessons learned from the establishment of the first zone should be employed to optimise the planning process and establishment of any further aquaculture zones in Malta. The preparation process should be transparent and allow for the participation of all relevant stakeholders.

Where appropriate, any AZ should be sub-divided into specific zones to identify those areas suited to aquaculture activities, those areas requiring any enhanced regulations or restrictions and those areas not suited to aquaculture activities. In all cases, the AZ operational requirements should promote the development of sustainable aquaculture and the AZ itself should possess a clearly defined carrying capacity, based on appropriate scientific studies. The AZ should be subject to appropriate environmental monitoring, based on a pre-existing baseline of environmental parameters, and the results of this monitoring should be available to the public.

The identification and establishment of any AZ should be carried out as part of any national Marine Spatial Planning strategy where possible, and should also conform to any Water Framework Directive and Marine Strategic Framework policy guidelines.

The establishment of AZs would greatly assist the future development of the aquaculture industry by streamlining the licensing process since licensing procedures would refer to any aquaculture operation within a pre-defined AZ, thus avoiding unnecessary and time-consuming application procedures. Recognised and accepted AZs would also help to integrate any aquaculture operation into the Marine Spatial Planning strategy and help to reduce conflicts with other stakeholders.

It is essential that the existing inshore aquaculture operations in Malta (P2M in St. Paul's Bay and Mellieha Bay and the seabream production operations of both Fish & Fish and MFF off the southeast coast of Malta) are recognised, possibly by the establishment of farm-specific, dedicated AZs, in order to avoid uncertainty in the existing operations and future production plans of these operations.

The establishment of AZs should take into account all existing aquaculture operations and the future sustainable development of the aquaculture industry in Malta. It is important to recognise the fundamental difference in the production systems employed between conventional, full-cycle aquaculture and tuna penning operations, and the AZs should reflect this difference. Separate zones should be created for both conventional aquaculture operations and tuna penning operations, with differing operational licence requirements specific to the concerns of other stakeholders in those locations.

The conventional aquaculture AZs should recognise and accept the presence of all pre-existing full-cycle aquaculture operations (P2M, MFF, Fish & Fish) in Maltese waters, and strengthen where necessary the regulatory system surrounding the operation of those facilities, with an emphasis on enforcement of those regulations.

The main disadvantage of AZs is the fact that different operators are obliged to carry out rearing or penning operations in relatively close proximity to each other. This represents a significant risk of the transmission of disease between aquaculture operations, particularly between fishes of different year classes and different species. However, the normal husbandry methods employed in tuna penning operations minimize this risk significantly. Wild-caught bluefin tuna held in tuna pens rarely succumb to disease, and the relatively brief time that the tuna are held in the cages, together with the very low stocking densities employed, minimises the chance of disease becoming established. Furthermore juvenile fish (which typically have a higher incidence of disease) are not stocked, and there is normally no mixing of year classes (which allows the spreading of disease between different year classes). Consequently, the concept of the establishment of aquaculture zones is well suited to tuna penning operations.

More care however needs to be taken when sites for CCS such as sea bass, seabream and meagre are located relatively close together in zones, since the different species grown, and the fact that different year classes are often stocked simultaneously because of the lengthy growth cycle, increases the risk of disease transmission between stocks of fish and aquaculture facilities. Where CCS are located in zones, it should thus be a requirement of the operating licence to enter into a management agreement with other farms regarding the purchasing of juveniles from 'approved hatcheries' and cooperating on issues such as unexplained mortalities and disease outbreaks to reduce such risks. Such agreements could have other benefits, such as the shared use of night watchmen.

Because of the use of large quantities of frozen fish as feed and the attendant risk of pollution of nearby bathing beaches, and because of the general requirements of bluefin tuna for deeper, more offshore waters, AZs for tuna penning operations should be established in offshore waters, where the risk of any significant adverse effect on quality of water at established bathing beaches is minimised. In addition, the operational license requirements should address the legitimate concerns of other coastal water stakeholders, such as prohibiting the feeding of bait fish during periods of onshore winds.

Offshore AZs should be established in areas where commercially viable aquaculture operations are possible, taking into account such factors as water depth, exposure to extreme weather and distance from a suitable work-base.

4.3.11.5 The need for a code of good practice for all aquaculture establishments

The introduction of an Industry Code of Good Practice (COGP), as envisaged in the WCMP and other policy documents, could create a standard for optimum husbandry and other operations to be carried out by all aquaculture producers in Malta. These standards would be designed to minimise any risks to biodiversity, minimise any environmental impact, minimise any effects on other aquatic activities and maintain a high standard of animal welfare amongst the farmed stock. The acceptance and implementation of such a code would go some way to improving public acceptance of the aquaculture industry and could also allow the branding of Maltese aquaculture produce to improve marketability.

Any COGP must be developed openly and transparently with the full collaboration of the aquaculture industry itself in order to be achievable. Although most national COGPs are voluntary, such a system may not work within the context of Maltese aquaculture since the markets for seabass, seabream and particularly bluefin tuna are not considered particularly sensitive to consumer-led pressure for sustainable produce, and therefore adherence to any code may have to be made a condition of all aquaculture development permits.

There should be a provision for different conditions for conventional closed-cycle aquaculture and tuna penning operations, and all codes of conduct should be backed up with regular inspections and monitoring programmes.

4.3.11.6 Role of MEPA

The environmentally sustainable, socially responsible and profitable development of the aquaculture industry in Malta requires careful planning and governance. However, any regulation of the industry must be proportionate and responsive to the needs of the aquaculture industry whilst balancing those needs with the protection of the marine environment and the interests of other stakeholders of coastal marine resources. In particular, decision making must be objective, fair, transparent and, most importantly, inclusive.

On their part, the aquaculture producers should employ best management practices, strictly adhere to planning permission conditions and other regulations and engage constructively with other stakeholders.

There is a clear perception amongst the Maltese aquaculture industry that MEPA has a negative bias towards aquaculture in Malta due to a perceived imbalance within the organisation towards environmental issues at the expense of economic development and a general lack of information on, and experience in, the aquaculture industry as a whole. In addition, the seabass and seabream producers feel that they have been unfairly affected by issues related to the very different tuna penning industry, and that officials at MEPA do not fully appreciate the differences between these two industries.

Many of the environmental issues affecting the tuna penning industry, for example, resulted from the rapid development of a relatively new industry with poorly known environmental effects, such as the release of fish oil from feedstuffs which has subsequently raised some concern amongst users of coastal amenities in parts of Malta. The conditions attached to planning permits approved for these penning establishments and the environmental impact studies carried out in support of those permits all recognised the lack of scientific data on the effect of tuna penning when these facilities were developed, and included careful environmental monitoring obligations on the part of the tuna penning operations to assess any impact.

It is essential that MEPA and the aquaculture industry work together to resolve these issues in a balanced, objective and non-confrontational manner to ensure the continued sustainable development of the aquaculture industry in Malta. One possible mechanism to develop relations between MEPA and the aquaculture industry would be to establish a Working Group, to include the Federation of Maltese Aquaculture Producers, P2M, a representative from the MRRA and MEPA, to act as a forum and promote dialogue between the relevant parties.

More importantly, it is vital that MEPA operate with a full appreciation of the government's overall strategy for the development of the aquaculture industry in mind. In any development, a balance needs to be made between the likely environmental impact of that development and the potential economic and social value of the development, and clear guidance of where this balance should be placed is needed.

Overall competence in aquaculture-related issues within MEPA might be optimised by the formal training of some personnel in commercial aquaculture issues in order to improve the skills and knowledge necessary for decision making within the organisation.

Due to the limited extent of coastal areas in Malta and the consequent high level of competition for the use of these resources by coastal stakeholders, MEPA should consider the multiple use of coastal areas where aquaculture is presently of importance, in order to maximise the potential socio-economic development of coastal communities.

4.3.11.7 Sustainable development of aquaculture

It is widely recognised that any further development of the aquaculture industry in Malta, and throughout the world, should be carried out on a sustainable basis. In order to do this, a generally recognised definition of the term 'sustainable aquaculture' is necessary, together with an accepted list of indicators for the sustainable development of aquaculture throughout the Mediterranean region in order that all stakeholders have a common understanding of the terminology. The Working Group on Sustainability in Aquaculture (WGSA), a subsidiary body of the Committee on Aquaculture of the General Fishery Commission for the Mediterranean (GFCM), is currently working on establishing a minimum set of indicators which should be reviewed and considered for incorporation into any future aquaculture regulatory system.

4.4 Fish health control

4.4.1 Current status of fish health in Malta

A wide range of diseases have been recorded in the Mediterranean aquaculture industry, of bacterial, viral, parasitic, nutritional and even unknown aetiology. Most are relatively easily controllable through appropriate husbandry and biosecurity management and the use of treatments and vaccines, although some do still cause significant mortalities and thus act as a constraint to aquaculture production.

At present, none of the recorded diseases of cultured marine fish in Malta are subject to national or international regulation or require formal notification of their occurrence.

All of the main diseases and health issues affecting the species of finfish currently produced by way of aquaculture in Malta are listed in Annex 7. A number of known pathogens of those species of finfish currently under consideration and under development for aquaculture production are also listed.

After the establishment of an aquaculture industry in Malta based on the production of seabass and seabream a number of health issues quickly emerged. These issues involved those pathogens present in the marine environment which have the potential of being pathogenic to both seabass and seabream, particularly if fish stocks are under stress or subject to any other factors which are capable of compromising the immune system of the fish, such as *Flexibacter*, Vibriosis and Pasteurellosis. Over time a number of health issues then appeared, particularly those involving Myxozoan parasites which have led to economic loss from poor growth and fish condition and are of particular concern since no effective means of control are currently available. A single serious viral disease, VNN, has emerged as a result of its suspected introduction from an Italian hatchery in the mid-1990's, a problem which led most seabass and seabream producers to switch production to seabream. Since 2000, however, the usage of antimicrobials and other chemotherapeutants in the Maltese aquaculture industry has dropped considerably, due to improvements in hatchery management and biosecurity measures, the development of effective vaccines, improvements in feed formulation and the widespread use of immunostimulants, and direct losses of fish stocks due to disease have declined.

Flexibacter infections of newly-transferred seabass and seabream juveniles were initially very common, and most batches of fish were affected on at least one occasion following introduction to nursery cages. These infections were treated by three consecutive daily bath treatments of nitrofurans, the most commonly used form being furazolidone, with a small quantity of formalin, a treatment strategy which proved highly efficacious. However, the use of nitrofurans as a veterinary medicine was banned by the EU in the late 1990's (under

Commission Regulation 1442/95) and forced aquaculture operators to find an alternative treatment strategy. It was soon discovered that treatment with oral antibiotics, such as oxytetracycline, was effective if initiated are the very earliest signs of infection, and that some husbandry techniques, such as changing nets at the onset of treatment and maintaining a high standard of net cleanliness, helped in reducing the severity of the problem. For established or persistent infections, potassium permanganate was found to be effective as a bath treatment, although toxicity issues meant that great care was needed during the treatment application.

Improvements in hatchery health management and the use of oral immunostimulants for fish up to a weight of 15g has almost eliminated the problem of *Flexibacter* amongst stocks of seabass and seabream, and potassium permanganate is now no longer used.

Pasteurellosis is probably the most significant systemic bacterial infection affecting seabream, seabass and meagre stocks in Malta. It can be a serious cause of mortality of small fish during the nursery phase of production, and therefore is most prevalent amongst small fish for the first few months following transfer to cages. The disease occurs regularly but normally responds quickly to oral treatments of antimicrobials, mostly oxytetracycline and flumequine. Outbreaks may lead to a total mortality of 5-15% of stock. Outbreaks have been reduced significantly in recent years by the purchase of juveniles vaccinated against the disease. All seabass juveniles imported into Malta are vaccinated in the hatchery using a combined Vibrio-Pasteurella immersion vaccine prior to delivery. In addition, all seabream delivered to Malta during periods of high water temperature (July to December) are vaccinated in the hatchery prior to delivery.

Vibriosis is occasionally encountered in seabass culture operations in Malta. It is rather uncommon, and usually occurs after routine husbandry operations involving the manipulation of fish stock. Typical losses to Vibriosis amount to between 1% and 10% of total seabass stock. All seabass juveniles imported into Malta are vaccinated against Vibriosis in the hatchery prior to delivery, and the vaccine is considered highly effective.

Winter Disease Syndrome, a condition leading to a severe swelling of the abdomen of seabream, was once a very common occurrence at Maltese seabream producers, causing low-level chronic mortalities but leading to significant marketing losses at harvest. This problem has also almost totally disappeared, almost certainly due to improvements in feed formulation and general fish husbandry.

Juvenile seabass, seabream and meagre, newly introduced to nursery cages, are often susceptible to protozoan parasites infesting the body surface and gill tissues. *Ichthyobodo* is probably the most common parasite of this kind, and is easily controlled by way of bath treatments with formalin.

Another common condition of seabream and seabass juveniles which causes low-level chronic mortalities is the viral disease lymphocystis. In Malta lymphocystis is a very common problem, particularly amongst juvenile seabream. It can result in significant loss of growth and will typically lead to a mortality of 3-5%. No control measures are currently in place apart from the use of immunostimulants and standard fish husbandry practices.

The most serious health issue faced by the Maltese aquaculture industry to date was the introduction of the viral disease Viral Nervous Necrosis (VNN) in 1996. It appears that the disease first occurred in Malta following the introduction of infected juvenile seabass from Italy, and it quickly spread to all seabass farms in the country. Initial mortalities were significant, reaching 30-50% of the entire stock of seabass, and producers with stocks of large fish close to harvest suffered significant financial losses. Most aquaculture producers switched production to gilthead seabream which are unaffected by this virus, and as a direct result of VNN, only a single aquaculture producer, P2M, now produces seabass in Malta.

Fortunately, since its appearance both the incidence and the severity of VNN infections have declined, and VNN outbreaks are now considered an infrequent event. Improved health control measures in hatcheries have reduced the risk of introduction of infected juvenile fish stock, and so most outbreaks are now presumably due to infection from wild fish living in the vicinity of the cage site. However, outbreaks, when they do occur, may lead to significant mortality, typically between 10 and 40% of total stock. As with most viral diseases of fish, there is no treatment or vaccine available for its control.

Myxozoan parasites have emerged as a potentially significant health problem amongst seabream and seabass, and also possibly meagre. The most significant is enteromyxosis, previously known as *Myxidium,* which affects seabream and causes a severe inflammation of the intestine, leading to loss of growth and emaciation particularly amongst stocks of fish in excess of 300g in weight i.e. close to harvest. Although mortalities directly attributable to this parasite are low, typically around 3-5%, loss of growth may be significant and rejection at harvest due to emaciation can lead to economic losses. This disease is of particular concern as no treatments are currently available for this parasite, and so control measures are confined to regular mortality removal and optimum husbandry.

Another myxozoan parasite, *Sphaerospora dicentrarchus* is very common amongst stocks of seabass in Malta, with a peak infestation occurring during the autumn months. Mortalities are low but significant, probably amounting to 5-9% of total stock, and, as with enteromyxosis, there is currently no effective treatment available for this parasite.

A number of new emergent diseases have appeared following the initiation of experimental production of amberjack (*Seriola dumerili*) in Malta, highlighting the fact that new health issues can be expected when new species are developed for aquaculture production. *Cryptocaryon irritans* has, for example, emerged as a serious problem in the experimental hatchery production of amberjack and, in some cases, gilthead seabream at MARC. This disease is controllable, however, and its incidence has been reduced significantly by the introduction of improved water filtration systems (involving filtration to 1µm and subsequent UV filtration) and regular prophylactic bath treatments with formalin.

The gill fluke *Zeuxapta seriolae* has also become a significant health problem of amberjack, affecting fish in the nursery stage of hatchery production and during the early stages of cage culture. This parasite is aggressive and can lead to significant mortalities in a very short space of time. Rapid treatment is essential, and is most effective using bath treatments of formalin or hydrogen peroxide. In cage culture bath treatments are difficult, time-consuming and impractical in offshore conditions, and so MARC has developed a treatment protocol using the anthelminthic product Praziquantel which can be administered orally.

The hatchery production of bluefin tuna remains in its earliest stages, and so no known health issues have emerged to date. The fact that few disease issues have been encountered by Japanese researchers, who are reasonably well advanced in the development of the closed cycle production of tuna, is encouraging.

4.4.2 Fish health control measures already in place in Malta

Existing fish disease legislation in Malta is based on 'Animal Health Requirements for Aquaculture Animals and Products thereof, and on the Prevention and Control of Certain Diseases in Aquatic Animals Rules, 2009' of the Veterinary Services Act of 2009. This implements European Union Council Directives 2006/88/EC and 2008/53/EC and repeals and replaces both 'Measures for the Control of Fish Diseases Rules, 2005' and 'Bivalve Molluscs (Minimum Measures for the Control of Diseases) Rules, 2005'. This act defines animal health requirements with respect to marketing, importation and transit, the minimum preventive measures for disease in aquaculture animals and minimum control measures to be implemented in the event of suspicion of, or the outbreak of, certain diseases.

This act tightens the permitting procedure for aquaculture operations by including processing plants in the permitting process, and requiring each aquaculture establishment to have a unique authorisation number. Authorisation permits are granted only if a number of strict compliance measures are taken, subject to inspection and audits designed to establish the risk of the spread of disease to other farms, mollusc farming areas and wild fish stocks.

As of 12 April 2011, three aquaculture operators were approved establishments for the production of fishery products: P2M, MFF Ltd and AJD Tuna Ltd.

Aquaculture operators are required to keep records of all live stock movements and mortalities, and the movement of all aquaculture products into and out of their processing facilities. In addition, during live fish transportation records must be kept of transport-related mortalities, the aquaculture establishments visited during the transportation and details of any water exchange activities carried out. The aim here is to allow traceability of all aquaculture products, from their origin to their final destination, and aquaculture producers are required to guarantee that such traceability is possible.

This act requires aquaculture operators to implement good hygiene practice, to be approved by the competent authority, together with a risk-based animal health surveillance scheme which is capable of detecting any increase in mortality and the presence of any notifiable disease. Certain live fish stock movements between areas designated as 'disease-free' and areas subject to control provisions, both within Malta and between EU member states, will require animal health certification.

It is the responsibility of the Fish & Farming Regulation and Control division (FFRC) of the MRRA to ensure that all live fish stocks introduced to aquaculture establishments in Malta arrive in a clinically healthy state and do not originate from an area with an unresolved increasing mortality. No live stocks destined for destruction according to disease control measures may be stocked for farming or restocking purposes.

This legislation is based on a list of notifiable diseases and the species of fish susceptible to those diseases, as defined by the EU authorities (see Annex 8). Movement of these susceptible species of fish throughout the EU, including Malta, is only allowed where a notifiable disease-free status is in force in the area of origin, and provision is made to regulate the movement of other aquaculture species which may act as a vector for such diseases. Importation of live aquaculture species from outside of the EU is very strictly regulated.

The disease listing included in this EU legislation does not include any susceptible species of fish, crustacean or mollusc which is currently produced, or is considered to have potential for aquaculture production, in the territory of Malta, and therefore none of the notifiable diseases listed have been recorded in Malta to date. The act does allow the provision for the control of emerging diseases, however, and the FFRC is obliged to take appropriate measures to control the spread of any such disease and to inform the EU authorities of any such event. The act allows for any new emerging disease to be added to its notifiable disease listing in compliance with relevant procedures. The act also allows for the FFRC in Malta to take action in the event of the outbreak of a disease not listed in the act's list of notifiable diseases, where that disease is considered to constitute a significant risk to the animal health situation in Malta.

The above provisions in the act, therefore, theoretically allow the government of Malta to prevent the introduction or control of any disease it considers a significant risk to the health situation of aquaculture species in Malta. Section 2 of Chapter VI of the act requires that the FFRC draw up a contingency plan to specify the national measures required to maintain a high level of disease awareness and preparedness and to ensure environmental protection. Such a contingency plan would then be implemented in the event of the outbreak of either an emerging disease problem or a notifiable disease.

It is considered vital that such a contingency plan be drawn up prior to the widespread establishment of the aquaculture production of fish species new to aquaculture, such as meagre, amberjack and bluefin tuna, since the risk of emerging disease outbreaks can be considered high due to a comparative lack of experience in the commercial production of these fish species.

At present, no routine monitoring of fish health is carried out of existing aquaculture producers in Malta by government authorities.

4.4.3 Fish disease diagnostic and treatment capability

At present, no formal disease diagnostic and treatment services are in use by the aquaculture industry in Malta. This is mainly due to the fact that disease occurrences are few, and those that do exist are well understood and relatively easy to treat. Improvements in hatchery production and health control, and the widespread use of vaccines and immunostimulants have significantly reduced the incidence of disease and the use of such chemotherapeutants as antimicrobials and antibiotics.

Most disease diagnostic and treatment services are provided by a number of freelance individuals with varying amounts of experience. The most experienced by far is Mr. Jes Brinch-Iversen, who has been responsible for the biological management of fish stocks at P2M for over 20 years and provides consultancy services to some other fish farm operators according to demand. Mr. Brinch-Iversen is able to provide basic diagnostic services and can provide advice as to appropriate treatments and more general husbandry and biosecurity issues. All administrations of regulated chemotherapeutants, such as antimicrobials and antibiotics, require a veterinary prescription and input from an authorised veterinarian. A number of veterinarians with experience in aquaculture are used on a routine basis in Malta, including Dr. Trevor Zammitt, and Dr. Angele Casha who is a member of the Animal Welfare Council of the FFRC at the MRRA.

Tuna penning operations do not currently experience disease issues, and so have not to date used any diagnostic or treatment services.

Between 1994 and 2000 a fish health diagnostic service was available at what was then the National Aquaculture Centre at Fort St. Lucjan, Marsaxlokk (now the location of MARC). The facility was well equipped for basic bacteriological, histological and parasitological analysis but was dependent on the skill and experience of the veterinary and technical staff available. For a number of reasons the facility experienced a high degree of staff turnover and eventually ceased to provide fish health diagnostic services to the industry, partly as a result of a change in emphasis to tuna penning operations by some bass and bream operators, a consequent lack of demand for its services, and changes in policy at the Department of Fisheries.

MARC currently carries out vaccine trials and other research and development work for the aquaculture industry and would therefore seem well placed to act as the base for a new diagnostic fish health laboratory. However, the issues which led to the failure of the previous fish health diagnostic service would need to be reviewed and addressed before a viable facility could be incorporated.

The National Veterinary Laboratory at Albertown, Malta, is the main reference veterinary laboratory in Malta, and is responsible for animal disease surveillance (primarily enzootic bovine leucosis, classic swine fever, foot and mouth, avian influenza and blue-tongue), food health surveillance (trichinella and BSA) and zoonotic disease surveillance (including Brucella and Salmonella). This laboratory does not presently carry out routine diagnostic work for the aquaculture industry, but may also represent a potential location for a future fish health diagnostic service in Malta.

The lack of a formal fish disease diagnostic capability in Malta, using a range of diagnostic techniques such as bacteriology, virology and histology, is cause for concern. Although the existing arrangements are possibly adequate for routine diagnosis and treatment of the prevailing health status of fish stocks, they are almost certainly inadequate for the rapid identification and control of any emergent disease issues which may arise once the culture of species of fish new to the aquaculture industry becomes widespread.

4.4.4 Recommendations regarding fish health control in Malta

4.4.4.1 Fish health control measures in other countries

The EU states bordering the Mediterranean Sea with significant cage-based aquaculture industries, including Greece, Italy, Spain and France, base their fish health control measures on the relevant EU legislation. However, the European Union Council Directives 2006/88/EC and 2008/53/EC consist essentially of minimum requirements to be implemented by each member state, and so national fish health control measures may vary somewhat. Each member state is also obliged to draw up a national contingency plan to specify the national measures required to maintain a high level of disease awareness and preparedness and to ensure environmental protection and such contingency measures can be expected to differ between nation states.

The animal health contingency plans that have been developed by EU member states to date typically apply to specific notifiable diseases, and apply to susceptible species present in that member state. For example Greece has approved contingency plans for a number of diseases including foot and mouth disease, blue-tongue and classical swine fever, whilst England and Scotland have devised contingency plans for the control and eradication of the parasite *Gyrodactylus salmonis*, a serious threat to salmonids in the UK. Clearly, an effective contingency plan is required where there is considered to be a significant threat of the introduction of a pathogen in nation states where species susceptible to that pathogen are present.

The following requirements have been highlighted for inclusion in national contingency plans for EU member states (from Olesen, N.J. et al, 2009).

1. The **legal powers** needed to implement contingency plans and put into effect rapid and successful eradication campaigns;
2. The access to **emergency funds, budgetary means and financial resources** in order to cover all aspects of the fight against the diseases;
3. A **central decision-making unit** must be in charge of the overall direction of control strategies and a chain of command must be established to guarantee a rapid and effective decision-making process for dealing with emerging diseases;
4. Detailed plans must be available for the immediate establishment of **local disease control centres** in the event of an outbreak;
5. **Adequate resources** to ensure a rapid and effective eradication, including personnel, equipment and laboratory capacity must be allocated;
6. **Adequate laboratory facilities and skills** to ensure correct diagnosis (e.g. proficiency and quality assurance and quality control processes must be in place in participating and reference diagnostic laboratories);
7. An up-to-date **operations manual** must be available, with a detailed, comprehensive and practical

description of all the actions, procedures, instructions and control measures to be employed in handling the diseases including emerging diseases;

8. Detailed plans must be available for **emergency vaccination**, where appropriate;
9. Staff must be regularly involved in **training** in clinical signs, epidemiological enquiry and control of epizootic diseases;
10. Take into account the surge capacity and **resources needed to control a large number of outbreaks** occurring within a short period of time;
11. Ensure that s**anitary slaughter** is carried out in accordance with recommended welfare principles;
12. Ensure that actions on veterinary and **environmental safety issues** are properly coordinated; and,
13. Take into account any **mass disposal** of aquatic animal carcasses and aquatic animal **waste** is done without endangering animal and human health, including the identification of appropriate sites for the **treatment or disposal of animal carcasses and animal waste**.

4.4.4.2 Recommendations for a national contingency plan for fish health control

The introduction of VNN into Maltese waters in 1996 and its rapid spread throughout the islands demonstrates the risk involved when live fish stock is routinely moved between different geographical areas. In this case, although some mortality or signs of ill health may have been present in the hatchery, the affected fish stock (juvenile seabass in this case) were screened for a range of pathogens normally encountered in seabass, such as gill parasites, systemic bacterial disease and other signs of ill health, and appeared asymptomatic. Since no viral diseases were suspected in seabass at that time, no detailed analysis of viral diseases was carried out. However, following the shipment of those seabass juveniles to cage farms in Malta, all cage producers growing seabass in Malta experienced mortalities associated with VNN within weeks of introduction. Assuming that only one or, at most, two cage operations imported infected seabass stock, the VNN virus managed to spread rapidly between cage operations separated by a distance of approximately 7km. It is likely that escapees and infected wild fish helped to spread the VNN pathogen between farms.

This example highlights the importance of avoiding the introduction of disease into Malta with live fish stock, but also demonstrates that emergent diseases may appear at any time and without warning. Consequently strict regulations concerning the importation of disease-free live fish stock must be supplemented with a strong capability for the identification and rapid control of emergent diseases. An improved and increased hatchery production capability in Malta would further help to reduce the risk of introduction of pathogens with live fish stock imported from overseas.

The existing informal fish health service capability currently in place in Malta needs to be supported or replaced by a more formal diagnostic and advisory capability, backed up by the availability of a well-equipped laboratory capable of routine bacteriology, virology (including PCR), histology and parasitology. This fish health service should be designed to address both existing disease issues and emergent pathologies associated with the development of aquaculture operations for 'new species'.

It is recommended that a national contingency plan be devised to address the risk of new, emergent diseases appearing should the widespread production of such new species as meagre, amberjack and bluefin tuna be widely adopted in Malta. Such a contingency plan could be based on the criteria outlined in the EU-based legislation currently enacted in Malta under 'Animal Health Requirements for Aquaculture Animals and Products thereof, and on the Prevention and Control of Certain Diseases in Aquatic Animals Rules, 2009' of the Veterinary Services Act of 2009, which is based on European Union Council Directives 2006/88/EC and 2008/53/EC.

These directives provide clear criteria for the identification and confirmation of disease and provide clear guidelines for sampling and diagnostic procedures through the use of accredited laboratories. Control measures for the movement of fish stocks are also well established. However, since emergent diseases are, by their very definition, unknown prior to their identification, the contingency plan must be designed to ensure that the time lapse between suspicion of a disease and its identification be minimised and that diagnostic laboratories available be equipped with a wide variety of diagnostic methods to allow the identification of a wide range of fish pathogens.

4.5 Socio-economic impact analysis – historic and present situation

4.5.1 Introduction

This section presents an analysis of the economic contribution generated by the aquaculture industry in Malta and discusses other socio-economic impacts that it is perceived to exert upon the local population. The section is structured under the following headers:

- Overview of economic character and analysis of recent trends
- Separation of results by main species groups
- Economic impact analysis
- Analysis of other socio-economic issues
- Presentation of base-case scenario

4.5.2 Overview of economic character and analysis of recent trends

As already noted earlier in section 4.1.2, the Maltese aquaculture industry is dominated by tuna ranching. In fact 5 out of the 6 local operators are involved in tuna, and half of the farms produce only tuna. The industry output peaked in 2007 with gross revenue of €130m, as illustrated in the table below.

Table 3: Overview of the industry's economic performance

Overview of the industry's economic performance €'000s	2005	2006	2007	2008	2009
Number of farms	**4**	**5**	**6**	**6**	**6**
Gross output of the aquaculture industry	**51,036**	**86,431**	**130,453**	**81,671**	**76,411**
of which:					
Tuna farming	*44,225*	*66,998*	*96,814*	*87,057*	*37,455*
Other fish farming	*4,971*	*6,095*	*6,400*	*6,706*	*7,625*
Change in stocks	*320*	*11,546*	*20,002*	*(13,402)*	*26,728*
Other output	*1,521*	*1,792*	*7,237*	*1,310*	*4,603*
Less intermediate consumption	(33,294)	(56,929)	(99,334)	(78,916)	(69,623)
Less forex differences	(29)	(395)	(1,049)	(11,568)	(319)
Gross value added of the aquaculture industry	**17,713**	**29,107**	**30,071**	**(8,813)**	**6,470**
GVA margin	***35%***	***34%***	***23%***	***-11%***	***8%***

Source: NSO news release

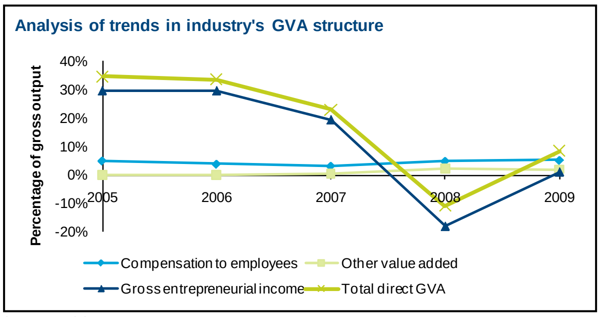
In 2007, sales from Tuna farming accounted for 74% of gross output, an increase of c. €30m from the prior year, equivalent to a 45% increase in tuna sales over the previous year. In fact, between 2005 and 2007, the industry enjoyed a compound annual growth rate in tuna sales of 48%.

Gross output increased at a compound annual growth rate of c. 60% over the same period. This reflects the €20m accumulation of stock in 2007. In this particular year, the industry also benefited from a large element of "other output", which is mostly composed of insurance payouts to cover significant storm damage.

Since 2007 output has fallen drastically, driven mainly as a result of reductions in international tuna catch quotas which have rendered it difficult to stock the farms.

Gross value added dropped considerably in recent years from 35% of output in 2005 to a negative 11% in 2008, after which it increased to 8% in 2009. This is analysed further in the figure below which depicts movements in GVA components when expressed as a percentage of gross output.

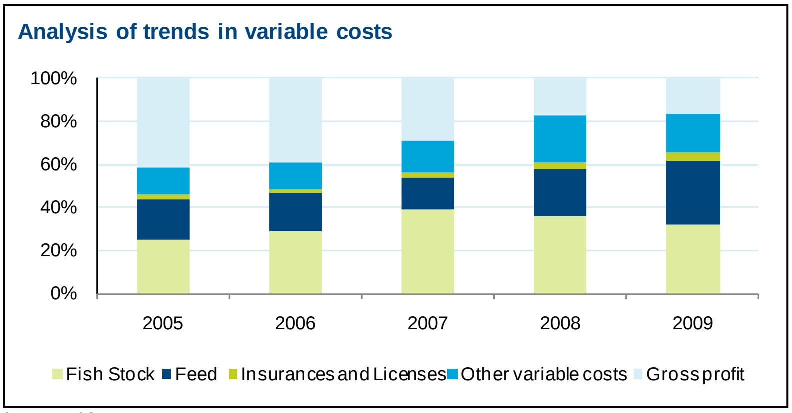
Figure 11: Analysis of trends in industry's GVA structure



Source: NSO news release

Compensation to employees and other value added elements (rent and interest) remained relatively stable throughout the period examined; only increasing slightly as employers have been reluctant to reduce capacity and make staff redundant even though output has fallen dramatically in 2008 and 2009. On the other hand "Gross entrepreneurial income" has fallen from c30% of output in 2006 to --18%% in 2008. "Gross entrepreneurial income" (GEI) refers to profits before depreciation. As illustrated in the chart below, the main reasons behind the fall in GEI is a reduction in gross profit margins, caused by significant upward pressures upon cost of fish stock and upon feed costs.

Figure 12: Analysis of trends in variable costs

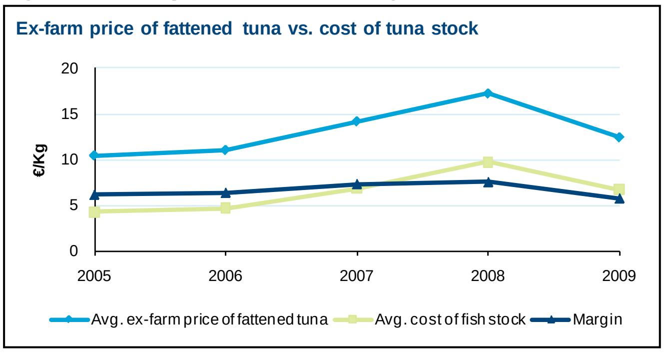


Source: NSO news release

The reason for the increasing share of output allocated to the cost of fish stock is not clear, as traditionally, the cost of tuna fish stocks have moved in-line with the price achievable for fattened tuna as, when compared to other production processes, there is in fact a good correlation between the main input of the production process and its output.

The graph below illustrates that the margin between the average ex-farm price of tuna and the cost of the tuna stock achieved by the Maltese tuna farming industry has however been relatively stable in 2005-2009, peaking in 2008. We conclude that higher mortality due to storm damage is the likely cause of this trend.

Figure 13: Analysis of ex-farm margin of Tuna



Source: NSO news release

4.5.3 Separation of results by main species groups

For the following analysis of the economic performance on a species by species basis, information for the cost structure of all closed cycle (non-tuna) species was constructed from first principles through information gathered through interviews and a separate reference study (Barazi-Yeroulanos, L., 2010). Tuna estimates were then obtained by process of deduction, by first estimating the values relevant to non-tuna species, and subtracting this from the total. The analysis also makes use of data provided by the NSO through an ad-hoc request which provides a detailed breakdown of costs for farms producing only tuna.

A more detailed description of the calculations and assumptions needed is provided in Annex 9.

The table below illustrates the reference cost structure applied to non-tuna species production in Malta, compared to the historic cost structure for all species (including tuna).

Table 4. Reference cost structure for non-tuna species compared to total historic structure

Comparison of resulting cost structure by species group (average 2006-2009)	Total	Tuna	CC species
Revenue	**100.0%**	**100.0%**	**100.0%**
Less cost of sales	**72.7%**	**73.0%**	**69.9%**
Fish stock	*34.5%*	*36.5%*	*10.4%*
Feed	*20.3%*	*18.1%*	*47.0%*
Packing & marketing	*4.6%*	*4.1%*	*11.1%*
Other variable costs	*13.4%*	*14.3%*	*1.2%*
Gross profit	**27.3%**	**27.0%**	**30.1%**
Salaries	4.2%	3.4%	13.5%
Fixed O.H	8.5%	8.8%	5.1%
Rent	0.2%	0.2%	0.2%
EBITDA	**14.3%**	**14.6%**	**11.3%**
Finance costs	0.9%	0.9%	0.9%
Depreciation	2.9%	2.9%	2.9%
Forex	3.6%	3.8%	0.0%
Profit before tax	**6.9%**	**6.9%**	**7.5%**
Selling price/kg	**11.4**	**13.8**	**4.0**
Cost of production/kg (before finance costs, dep'n and forex)	**9.8**	**11.8**	**3.5**
Total production cost/kg	**10.6**	**12.8**	**3.7**

Source: Internal analysis based upon NSO data, interviews and data from reference study (Barazi-Yeroulanos, L., 2010)

From the above table, one immediately notices that costs for stock fish are considerably greater for tuna compared to non-tuna (closed cycle) species. This is due to tuna fish stock being more expensive than juveniles for closed-cycle species, and also that tuna fattening occurs over a period of a few months, whilst growing closed cycle species (e.g. bass and bream) may take longer than a year. This increases the relative weight of other costs such as labour and feed. Packing and marketing costs are also greater for closed cycle species. This is accounted for by the fact that whilst tuna are picked up from Malta by Japanese processing vessels, closed cycle species are transported to Italian markets by truck at the expense of the seller. We note that other variable costs, which include bunkering, fuel monitoring and stock insurance costs, are substantially greater for tuna production.

Interestingly, each species group has a similar EBITDA, ranging between 11.3% for closed cycle species to 14.6% for tuna farming. However, as tuna farming requires dealing in multiple currencies for both inputs and outputs, exchange rate differences occur. In the past four years, tuna operations have consistently resulted in a net exchange rate loss which accounted to 3.8% of output for the period. On the other hand, interviews revealed that current production of closed cycle species is dominated in euro with little foreign exchange risk. The net impact of such exchange rate losses on tuna production signifies that in fact, over the last four years, closed-cycle species farming appears to have offered marginally better profit margins than tuna farming.

Further analysis illustrates that tuna margins were exceptionally low in 2008 and 2009 because of increasingly restrictive catch quotas and due to upward pressures of fish feed prices. The table below illustrates this by comparing the results for Tuna in isolation for 2008 and 2009 against the average for the last four years.

Table 5: Comparison of Tuna results in isolation

Comparison of Tuna results in isolation	Average 2006-2009	2008	2009
Revenue	**100.0%**	**100.0%**	**100.0%**
Less cost of sales	**73.1%**	**82.4%**	**83.7%**
Fish stock	*36.5%*	*38.2%*	*33.7%*
Feed	*17.9%*	*18.9%*	*27.7%*
Packing & marketing	*4.3%*	*6.5%*	*4.7%*
Other variable costs	*14.3%*	*18.8%*	*17.7%*
Gross profit	**26.9%**	**17.6%**	**16.3%**
Salaries	3.4%	4.1%	4.4%
Fixed O.H	8.8%	16.0%	8.7%
Rent	0.2%	0.2%	0.2%
EBITDA	**14.5%**	**(2.7%)**	**3.0%**
Finance costs	0.9%	2.1%	2.0%
Depreciation	2.9%	4.1%	3.8%
Forex	3.8%	15.4%	0.5%
Profit before tax	**6.9%**	**(24.3%)**	**(3.2%)**

Source: Internal analysis based upon NSO data, interviews and data from reference study (Barazi-Yeroulanos, L., 2010)

This comparison illustrates clearly that the tuna ranching is not sustainable at the operating levels reported in 2008 and 2009. This is likely to drive cost cutting measures and other changes to adjust to lower output levels.

The last two years (i.e. 2008 and 2009) were characterised by the following:

- Increase in feed costs: feed costs accounted for 27.7% of output in 2009, compared to 17.9% average over the four year period.
- Increase in other variable costs: the main increases originated from stock insurance costs, probably reflecting the substantial claims made in recent years due to storm damage. Furthermore, fuel in 2008 was also much higher reflecting the record oil prices for that year.
- Marked increase in fixed overheads in 2008: in this particular year, fixed overheads as a percentage of output spiked to 16% of output, thereby distorting the overall average for this line item. The reason behind this is due to the commission of c. €19m worth of ad-hoc contractual works in the year. Based upon feedback from interviews, we understand that this amount may relate to one-off repair costs brought about by the significant storm damage that was reported in 2007 and 2008.
- Increase in salaries: salaries as a percentage of output have risen from an average of 3.4% to 4.4% in 2009. This reflects that operators have not yet adjusted their staffing levels to the reduced quotas and the impact that this has had upon their output levels.
- Foreign exchange differences: 2008 had negative foreign exchange differences of c. €12m, which accounted for 15.4% of output, resulting in substantial losses for the year.

4.5.4 Economic impact analysis

In 2007, the Federation of Maltese Aquaculture Producers commissioned an economic impact analysis (AEC Ltd, 2009). This report had concluded that in 2007 as a whole, the industry supported 964 FTEs and generated €53.5m worth of total value added, of which €30.3m was direct value added, and a further €23.2m was indirect and induced value added. This report draws from the input/output model used in 2007 by applying it to the 2009 and 2008 figures thereby updating the report to reflect the latest available NSO data. However, as the cost structure of the industry as whole has had such significant variations over the last two years, it was not possible to utilise the multipliers produced in the 2007 study without first adjusting them to reflect these shifts. Furthermore, being able to flex the multipliers also allowed for the application of results to the different species groups, thereby producing estimates for the total valued added created by each group.

To flex the multipliers accordingly, each multiplier was expressed as a fraction of the cost items that most influence the multiplier effect – domestic intermediaries and GVA. This is explained in more detail in Annex 9.

In order to interpret the results obtained from the application of these adjustments it is important to understand the inherent assumptions being taken:

- It is assumed that the nature and structure of domestic intermediaries has remained constant, and that no material difference exists in the nature of domestic intermediaries needed for the different species.
- It is assumed that the overall structure of the Maltese economy has likewise remained constant, and that spending and saving habits of Maltese consumers have not changed materially.

The table below illustrates the resulting multipliers of each species and year.

Table 6: Cost structure for Maltese aquaculture and related multipliers

Cost structure of Maltese aquaculture and related multipliers	Average (2006 - 2009)		Tuna		Other Species	
	Tuna	Other Species	2009	2008	2009	2008
Gross output at market prices	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Imported Intermediaries	54.6%	57.5%	64.1%	61.4%	61.4%	61.3%
Domestic Intermediaries	27.2%	17.5%	28.2%	36.8%	17.5%	17.5%
Forex loses	3.8%	0.0%	0.5%	15.4%	0.0%	0.0%
Direct GVA	**14.3%**	**25.0%**	**7.2%**	**-13.7%**	**21.1%**	**21.2%**
of which:						
Compensation to employees	*3.4%*	*13.5%*	*4.5%*	*4.2%*	*13.5%*	*13.5%*
Other GVA (rent and interest)	*1.1%*	*1.1%*	*2.2%*	*2.3%*	*1.1%*	*1.1%*
Gross entrepreneurial income	*9.8%*	*10.4%*	*0.6%*	*-20.2%*	*6.4%*	*6.6%*
Amounts thought to most induce indirect effects (Flexing amount)	**42%**	**43%**	**35%**	**23%**	**39%**	**39%**
Direct GVA effect	**0.14**	**0.25**	**0.07**	**-0.14**	**0.21**	**0.21**
Indirect & induced GVA effect	0.18	0.18	0.15	0.10	0.16	0.16
Total GVA effect	**0.32**	**0.43**	**0.22**	**-0.04**	**0.37**	**0.38**
Direct household income effect	0.03	0.14	0.04	0.04	0.14	0.14
Indirect & induced household income effect	0.09	0.09	0.07	0.05	0.08	0.08
Total household income effect	**0.12**	**0.22**	**0.12**	**0.09**	**0.22**	**0.22**

Source: Internal analysis

From a purely economic perspective, production of closed cycle species adds more to net economic welfare than tuna, on a per unit basis. This is due to the following production characteristics:

- Production of closed cycle species is a year round process thereby generating a higher salary cost per kg of fish produced.
- Gross entrepreneurial profits (profits before depreciation) is higher for closed cycle species, particularly in the last two years, where tuna margins have been squeezed considerably. This is true irrespective of the fact that during the same period, margins for closed cycle species were also lower than average as a result of increases in the cost of fish stock.
- Tuna operations have a higher foreign exchange exposure: Exchange rate losses in 2008 should be seen as being exceptional one-off items. They were so severe in 2008 as to create a negative total GVA effect for the year.
- Both species groups have a relatively low total GVA effect when compared to other industries due to the heavy use of directly imported materials.
- Obtaining economies of scale to the extent that would allow for a full-scale commercial hatchery and/or a local feed mill in Malta would further reduce the industries dependencies on imports.

As illustrated in the table below, the minor output generated from closed cycle species renders the overall economic contribution of this species group low, irrespective of it generating a greater GVA margin than tuna.

Table 7: Estimated economic impact of aquaculture, by species group

Estimated economic impact of aquaculture	Tuna		Other Species		Total		Total as per EIA (2007)
	2009	2008	2009	2008	2009	2008	
Output (€'000)	**69,658**	**74,885**	**6,753**	**6,786**	**76,411**	**81,671**	**128,846**
Direct GVA (€'000)	5,045	(10,252)	1,424	1,439	6,469	(8,813)	30,252
Indirect & induced GVA (€'000)	10,442	7,311	1,101	1,109	11,543	8,420	23,194
Total GVA (€'000)	**15,487**	**(2,941)**	**2,524**	**2,548**	**18,012**	**(393)**	**53,446**
Total GVA effect	*22%*	*(4%)*	*37%*	*38%*	*24%*	*(0%)*	*41%*
Direct household income (€'000)	3,130	3,139	914	919	4,044	4,058	4,159
Indirect & induced h.inc (€'000)	5,176	3,624	546	550	5,722	4,174	11,497
Total household income (€'000)	**8,306**	**6,763**	**1,460**	**1,469**	**9,766**	**8,232**	**15,656**

Source: Internal analysis

As illustrated in the table above, the amount of direct salaries generated by the industry (direct household income) has remained relatively static between 2007 and 2009, irrespective of the significant changes in output. This reaffirms the notion that the industry has not yet adjusted to the changes in catch quotas. As a result of reduced indirect and induced effects, total household income has nonetheless dropped considerably, from €15.7m in 2007 to only €9.8m in 2009. This is driven by a reduction in the amount of domestic intermediaries needed to produce the lower output levels, as well as lower induced spending due to the significant reduction in profits.

The industry also generates a substantial proportion of Malta's exports and therefore supports balance of payments. However, due to the industry's large reliance on imported goods, the net impact on balance of payments is reduced significantly.

4.5.5 Analysis of other socio-economic issues

Throughout the data gathering process, multiple stakeholders, representing various perspectives and localities, where consulted in order to better understand the perceived wider welfare impact of the industry. This highlighted the following issues:

- **Conflicts with diving activity:** The diving community reported reduced water visibility due to increased particulate matter from one fish farm near a dive site. It should be noted however, that the majority of recreational diving tends to be concentrated at relatively few highly attractive dive sites well away from fish farms. The localised nature of any impacts posed by farms coupled with the highly concentrated nature of diving activity limits the conflicts between these activities to manageable levels.

- **Pollution impacting nearby shore communities:** Some shore based communities in the vicinity of fish farms have complained of foul odours originating from the processing of fish and fish bait, and have reported oil run-offs from the thawing of bait. These problems are only related to tuna production, as the use of fish bait is the main cause of oil run-offs and foul smells. This however is not typical of good farming practices and therefore calls for better regulation of such activities to limit the impact on nearby communities. The main tuna fattening period also occurs in the summer, Malta's peak tourism season, thereby maximising the conflicts at localities nearest to the farms. Tourism is a major source of economic activity throughout the majority of the Maltese coastline and the localities interviewed reported their populations more than doubling in the summer period because of tourism. Some local councils raised concerns that the value of real estate in the area may be negatively impacted as a result of the problems highlighted above, although there is no evidence of this.

4.5.6 Presentation of base-case scenario

As at 2009, the industry was still in a state of flux and had not yet fully adjusted to the changes brought about by new tuna catch quotas. This is most evident by the achievement of unsustainably low profit margins in 2008 and 2009. Furthermore, the shocks evident in 2008, as exhibited by large insurance payouts, extensive contractual works and substantial exchange rate loses, significantly distort even the four year averages produced for the different species groups. The output level for tuna is also uncertain and due to changes in catch quotas, past trends offer little insight into a stabilised amount. For these reasons, this section compares past information against the data provided in interviews and attempts to build a more sustainable cost structure and output value for use as a base case scenario and for modelling the impact of proposed strategies in Section 6.5.2. This base case scenario offers a balanced and objective assessment of the current industry profile, without letting the short-run impact of recent changes bias the economic assessment. This facilitates an objective assessment of the impact of proposed strategies, however it is not meant to act as a forecast for 2010 figures.

A reference cost structure for tuna was built by using the data provided by farm operators through interviews, as well as by use of other external studies. The table below compares this reference cost structure to the historical averages for tuna introduced earlier and an adjusted reference cost structure based upon the results of the comparative analysis undertaken.

Table 8: Analysis of sustainable cost structure for tuna

Analysis of sustainable cost structure for Tuna

	Initial reference structure	Historical Tuna value (2006-2009)	Final base-case reference structure
Revenue	**100%**	**100%**	**100%**
Less cost of sales	**53%**	**73%**	**59%**
Fish stock	*31%*	*36%*	*31%*
Feed	*16%*	*18%*	*16%*
Packing & marketing	*1%*	*4%*	*3%*
Other variable costs	*5%*	*14%*	*10%*
Gross profit	**47%**	**27%**	**41%**
Salaries	2%	3%	2%
Fixed O.H	6%	9%	6%
Rent	0%	0%	0%
EBITDA	**39%**	**15%**	**32%**
Finance costs	1%	1%	1%
Depreciation	3%	3%	3%
Forex	0%	4%	4%
Profit before tax	**38%**	**7%**	**25%**

Source: Internal analysis

The preferred cost for stocking tuna farms is the amount obtained from interviews. This reflects the latest available data and reflects the relationship of the cost of stocking tuna and the eventual ex-farm price, which has also been obtained from interviews. Similarly the cost of feed as expressed through interviews is more up-to-date and is therefore preferable. On the other hand interviewees expressed difficulty in estimating selling costs (packing and marketing) and other variable costs specifically for tuna and the values obtained contrast starkly to the data provided by NSO. For this reason a mid-point between the two sources was chosen.

Interview amounts for salaries were retained as these are more indicative of a stabilised level, after the industry adjusts to operate at lower output levels. Similarly, historical values for fixed costs have been distorted by one-off items such as the excessive contractual works in 2008, and have therefore been rejected in favour of the amount obtained from the reference study, which are believed to better represent a typical or stabilised year.

Amounts for rent, finance costs, exchange rate difference and depreciation have however been removed from the reference study amounts by using historical data as these are believed to be accurate and representative and because these amounts need to be taken separately as they form part of gross value added.

Based upon interviews, the estimated output of tuna for 2010 was around 3,520t. The ex-farm price that prevailed for fattened tuna in 2010 was reported to be €20/kg, and this compares to an estimated total cost of production of €15.04/kg. These amounts were taken to be stabilised figures for the base-case scenario.

In terms of the production of closed cycle species, the sales volume as at 2009 was retained, however this was applied to the reference cost structure obtained from interviews, as it reflects more updated prices. The price reported in 2010 was used, and this stood at €4.04/kg (delivered to Italy), with an associated cost of production of €3.84/Kg. The tables below illustrates the resulting multiplier effects and economic impact of this base-case scenario.

Table 9: Base-case (2010) cost structure

	Total	Tuna	Closed cycle species	Tuna €/kg	Closed cycle species €/kg
Revenue	**100%**	**100%**	**100%**	**20.00**	**4.04**
Less cost of sales	60%	59%	72%	11.83	2.92
Fish stock	*29%*	*31%*	*13%*	*6.15*	*0.52*
Feed	*19%*	*16%*	*47%*	*3.23*	*1.90*
Packing & marketing	*3%*	*3%*	*11%*	*0.51*	*0.45*
Other variable costs	*9%*	*10%*	*1%*	*1.93*	*0.05*
Gross profit	**40%**	**41%**	**28%**	**8.17**	**1.12**
Salaries	4%	2%	14%	0.49	0.55
Fixed O.H	6%	6%	5%	1.15	0.21
Rent	0.2%	0.2%	0.2%	0.04	0.01
EBITDA	**30%**	**32%**	**9%**	**6.49**	**0.36**
Finance costs	1%	1%	1%	0.18	0.04
Depreciation	3%	3%	3%	0.59	0.12
Forex	3%	4%	0%	0.77	-
Profit before tax	**23%**	**25%**	**5%**	**4.96**	**0.20**

Source: Internal analysis

Table 10: Estimated economic impact of base-case scenario

Estimated economic impact of base-case	Base-case scenario		
	Total	Tuna	Closed cycle Species
Output (Tons)	**5,445**	**3,520**	**1,925**
Output (€'000)	**78,177**	**70,400**	**7,777**
Direct GVA (€'000)	23,777	22,024	1,752
Total GVA (€'000)	**39,734**	**36,667**	**3,068**
Total GVA effect	*51%*	*52%*	*39%*
Direct employement (FTEs)	189	117	71
Total employement (FTEs)	**724**	**609**	**115**
Direct household income (€'000)	2,786	1,733	1,053
Total household income (€'000)	**10,695**	**8,991**	**1,705**

Source: Internal analysis

Note that the number of FTEs was estimated based upon the average wages paid to manual workers according to the 2008 labour force survey, after adjustments to: (a) bring the wages to prices prevailing in 2011, and (b) add social security contributions to the survey's gross earnings figure. This results in an average wage of approximately €14,800 p.a. and an estimate for employment in the industry of only 189 employees. Applying the same wage cost to the 2009 NSO data results in an estimate of 274 employees. This suggests that once the industry reaches a stabilised position, it would have shed 85 jobs from 2009 levels, highlighting the degree of change expected in the industry as it attempts to cut costs in order to adjust to the lower tuna catch quotas.

5 Key issues raised during meetings

5.1 Introduction

As indicated in Section 2 (methodology), a number of meetings were held with key stakeholders during the first phase of the study. The purpose of the meetings was to obtain information on the role of each stakeholder in the industry, to identify issues of concern regarding their own sphere of operation, and to seek their views on the future direction of the industry, with a view to shaping a future strategy for the industry.

The issues raised and views expressed are given in Annex 10. Other information was also gathered during the interview process and this is reflected in other parts of the report. Views have been amalgamated and anonymised as far as possible. This section summarises the main issues raised under key headings and assesses the findings.

5.2 Summary of issues raised

The issues raised have been summarised as follows:

Strategy

- There is a need for a Government backed and industry endorsed strategy to allow long term planning and investment
- There is a need for an industry Code of Good Practice (COGP) and in particular standards to help prevent equipment failures

Regulation

- There needs to be a level playing field for all producers in terms of sites, permit conditions, and rents
- With regard to safety and navigation, there are considered to be major issues regarding the correct location and marking of sites, perceived to be due to poor maintenance of equipment, irresponsible operators, and lack of monitoring and enforcement
- There is perceived to be a need to rationalise the organisation of directorates within MRRA dealing with aquaculture
- There is a need for a more efficient and consistent planning process

Locations

- The Ministry for Resources and Rural Affairs (MRRA) has a preference for all farms to be located in zones controlled by them, in water depths greater than 50m
- Farms outside the SE Zone have no desire to move to the Zone due to greater risks
- Farms inside the SE Zone accept the conditions (no alternative sites anyway) but resent the limited concession term (5 years) and higher rent compared with other farms
- The proposed NE Zone is only supported by one producer; another producer if forced to move would choose to cease operation
- An alternative SE Zone has been suggested by one producer containing 2 existing sites and a possible hatchery site
- Most non-producer stakeholders are in favour of zoning especially if offshore
- There needs to be a more rational assessment of the relative siting of different species
- There may be scope to integrate aquaculture with the proposed offshore wind farm at Is-Sikka L-Bajda
- Bunkering is an important industry for Malta but shares largely similar requirements in terms of shelter, water depth and type of sea bed

Environmental impacts

- Tuna farms are considered to have no impact on water quality, with benthic impacts normally limited to directly under the cages and occasionally further away
- The monitoring system for tuna sites is considered to be rigorous compared with elsewhere, but no link is made between biomass and impacts
- The bass and bream sites in St Paul's Bay (SPB) and Mellieha Bay are the subject of controversy over perceived impacts on the seabed, given the shallow nature of the sites and the surrounding posidonia beds

- There is a need to clearly define what constitutes acceptable/unacceptable environmental impact
- There is a need to review environmental monitoring procedures to determine necessity, efficacy, and cost

Tuna ranching issues

- The most commonly quoted negative impact of aquaculture is the smell and oil slick arising from the feeding of baitfish to tuna; a secondary concern is the washing ashore of offal from the processing of tuna at sea
- The negative impacts of tuna farming (oil slicks, smell, offal) are considered to be less of a problem than previously by tuna growers; other industry interests however consider tuna impacts still unacceptable
- The negative image of aquaculture in Malta is considered to be primarily due to the problems associated with tuna ranching

Future of tuna ranching

- There is considerable uncertainty regarding the future of tuna ranching, given limited catch quotas, the risks of on-growing, reliance on one market, and regulation that has according to the growers now become too strict
- NGOs express particular concern regarding the status of tuna stocks

Alternative species

- There is widespread interest in alternative species, especially amberjack
- There is a need for a local hatchery for all species

Research

- The present location and operation of MARC at Fort St Lucjan are problematic, and a public private partnership (PPP) with a hatchery and research facility on a more favourable site are considered the best option for the future

General views

- There is concern over the impact of aquaculture on tourism, especially the issue of oil/smell from tuna feeding, yet at the same time recognition that it provides valuable stock (bass and bream) for the restaurant trade and scope to enhance the visitor experience e.g. link with the National Aquarium Project
- Local Councils are naturally very protective of their local economic interests, especially regarding tourism and summer residences, but are generally accepting of aquaculture except where there are issues, in particular that of oil slicks and smells from tuna farms in the SE of Malta; a planning decision on a packing plant near Mellieha was also badly received
- There is concern over the impact of aquaculture on dive sites, yet at the same time tuna cages have become a major diving attraction in themselves

5.3 Assessment of issues raised

The main issues affecting the development of the industry can be further assessed under the following key themes, as set out in Table 11:

- Regulation
- Operation
- Environment
- Innovation

Regulatory issues are mainly to do with matters relating to current policy, differing interpretations of that policy amongst regulators and the industry, and the differing permit conditions applied to operators. In addition, there appears to be a lack of clear governance of the industry due to poor organisational hierarchy within MRRA, and an undue influence of MEPA with regard to determining the future of the industry.

This lack of a clear direction has created an air of uncertainty in the industry such that future investment cannot be planned, indeed there is a danger that such investment may be withdrawn, especially in view of the uncertainties surrounding tuna farming. At the same time, the industry has not helped its cause though lax standards e.g. with regard to marine safety, and the problems associated with feeding of baitfish. Nevertheless it should be possible to address such issues through the adoption of higher standards, whether voluntary or mandatory, and better enforcement. There is also acceptance by some operators of the need to move tuna farming operations further offshore, providing that existing near to shore sites can be used for alternative species.

With regard to environmental issues, there is a fundamental need for a better system of monitoring, one that lays down clear guidelines on what constitutes an adverse impact, over what area in relation to cages such impact is allowed, and to relate all of that to the biomass held in the cages. Only with such a system is it possible to agree on the carrying capacity of a site and lay down clear rules that are accepted by the industry, the regulatory authorities, and the public at large. It is considered that the present system is unnecessarily complicated and costly, and fails to give any real guidance on carrying capacity.

With regard to the environmental impact of the 3 sites operated by P2M at Mistra Bay, St. Paul's Bay and Mellieha Bay, there is a perception by some parties e.g. MEPA that such impact is unacceptable. However, because P2M was the first commercial farm to be set up, no clear guidelines on environmental monitoring were made part of the consent and no baseline survey was carried out. In addition, there are a number of other sources of nutrient enrichment and activities which are likely to contribute to impacts. The water quality reports carried out on a regular basis show no impact from the sites. Benthic surveys carried out in 1995 and 2005 show obvious impacts as expected in the immediate vicinity of the cages, and there has been some impact on adjacent Posidonia meadows, but which declines going away from the cages. Impacts on sediment nutrient levels appear less conclusive. It is important that any judgement of the impact of the P2M sites is based on fact as a result of surveys, and not on hearsay – discussions with some parties suggests that the farm has a much bigger impact than it does in reality.

With regard to R&D, the primary requirement is for a facility on a new site unencumbered by Government bureaucracy and which can respond directly to the needs of the industry, especially with regard to the development of new species. The best vehicle for this is thought to be a PPP between Government and industry.

The issues raised in this Section need to be fully taken into account in the proposed new strategy.

Table 11. Assessment of issues raised and action needed

Key issue	Negative consequences	Action needed	Comments
Regulatory issues			
Inconsistency between policy documents	Creates confusion, deters investment, creates operator antagonism	Govt. must agree its stance on aquaculture, endorse strategy	Authorities must understand industry needs
Differences between permit conditions	Unfair, creates mistrust within industry	Standardise	Potential legal difficulties
Unrealistic policy on sites/zones	Creates operator resentment, prevents improvement	Review and agree policy with all operators	Zones make sense in principal, but need to agree locations and conditions
MEPA appears at odds with industry	Deters investment, creates bad will, prevents cooperation	Planning policy must reflect national policy	Clarify national policy and agree with MEPA
Conflicts with other marine space users e.g. bunkering, tourism	Creates negative sentiment between users, poor public perception of aquaculture	Government must agree on relative importance of aquaculture and reflect in strategy	
Poor organisational hierarchy in MRRA	Confusion within industry and other regulators	Reorganise Directorates	Internal politics may hinder
Operational issues			
Industry needs to know where it stands	Withdrawal of investment, loss of jobs	Review policy and agree strategy	Industry must be involved throughout

Key issue	Negative consequences	Action needed	Comments
Lax standards in the industry	Negative public perception, unnecessary losses	COGP, better enforcement, strengthen permit conditions	Base COGP on EU standards; must be fully transparent and available to public
Marine safety and navigation – bad marking	Ship collisions, insurance claims, negative public perception	Better enforcement	More resources needed? Who pays?
Baitfish feeding of tuna and associated oil slicks/smell	Negative public sentiment, all aquaculture blamed	Relocate tuna farms, agree new rules on feeding	Difficulties in agreeing sites for new locations
Disposal of tuna offal	Negative public sentiment if comes ashore	Must now be disposed of on shore	Ensure enforcement
Uncertainty re. future of tuna farming	Deters investment and rational development	Develop other species	Flexibility regarding use of tuna sites for other species
Lack of commercial hatchery facilities	Dependence on imports, slow dev of alt species	Support development of local hatchery	Difficulties in finding a site
Environmental issues			
Environmental monitoring system not fit for purpose	Unnecessary expense to industry, no framework to fairly assess adverse impacts	Independent expert review of system	System needs to recognise link between impacts and biomass, adopt the AZE concept and EQS, be proportionate, practical and cost effective
Lack of consensus regarding environmental impact of P2M sea sites	Prevents improvement, deters investment, feeds negative sentiment unnecessarily	Independent review, more flexibility from MEPA re. siting	Lack of baseline study and other sources of impact hinder fair assessment
Lack of guidelines regarding carrying capacity and adverse environmental impacts	Confusion, under/over exploitation of resources	R&D priority, engage with SHocMed	Needs guidelines based on Maltese experience and conditions
Innovation issues			
Inefficient operation of MARC	Deters progress on R&D into new species and thus development of industry	Hatchery & research facility set up as PPP on new site	Depends on Government support of concept and MEPA approval of site

6 Future potential

6.1 Site assessment

6.1.1 Identification of potential new aquaculture sites/zones

6.1.1.1 The screening process

A key part of this study is to identify potential aquaculture production from Maltese waters, with a view to setting production targets and around which a strategy can be developed. In doing this, a number of factors need to be taken into account:

- Planning and policy considerations
- Conservation interests and designations
- Marine space available for aquaculture, both at existing and potential new sites
- Other competing users for such space
- The production capacity of such space

With regard to policy considerations, we conclude that the review of national aquaculture policy in Section 4.2 supports the following position:

- Large species occupying large areas e.g. tuna farms relying on captured wild fish, to be located in designated aquaculture zones such as the new SE Aquaculture Zone, or other new zones out with the 1 nautical mile limit and 50m contour; existing tuna farms to be relocated to such zones

- Small species e.g. bass and bream farms occupying small areas and requiring sheltered waters not to be permitted within Tourism Hubs, shallow inlets and bays, in or close to areas which are protected or merit protection, or where they would have significant adverse environmental or visual impacts

For the purposes of this assessment, "small species" are referred to as "closed cycle species" (CCS) such as seabream, seabass, meagre, and amberjack[5]. CCS can be cultured from the egg rather than being dependent on captured wild fish as with tuna penning. They are cultured at higher densities than tuna and for the same production take up less space. For example, a farm producing 1000t p.a. of tuna in 70m water depth requires sea surface and seabed areas of 8ha and 120ha respectively, compared with 2.5ha and 43ha for the same annual production of CCS in 40m water (see Table 12). In addition, CCS are fed on dried pelleted food and thus do not have the problems of smell and oil slicks associated with tuna which are fed on wet thawed baitfish. Finally CCS require more sheltered conditions than tuna by virtue of their size and physiology. Tuna are typically over 70kg in weight when captured and are naturally found in open sea conditions. CCS on the other hand are cultured from the egg, starting life in a hatchery, before being transferred to nursery cages in relatively sheltered conditions with low currents. Once they reach a larger size they may be transferred to more exposed locations, but still not as exposed as tuna as they are typically only grown to a size of up to 0.6kg, or in the case of meagre or large amberjack up to between 1 and 6kg. For these reasons, it makes sense to limit tuna penning to areas further offshore whilst allowing CCS to be cultured closer to the shore, as reflected in current policy documents. In addition, tuna are typically grown over a short period in the summer and autumn, and are harvested before the conditions offshore become too difficult to operate in.

Further to these differences between tuna and CCS, the following basic requirements for cage based aquaculture production are proposed:

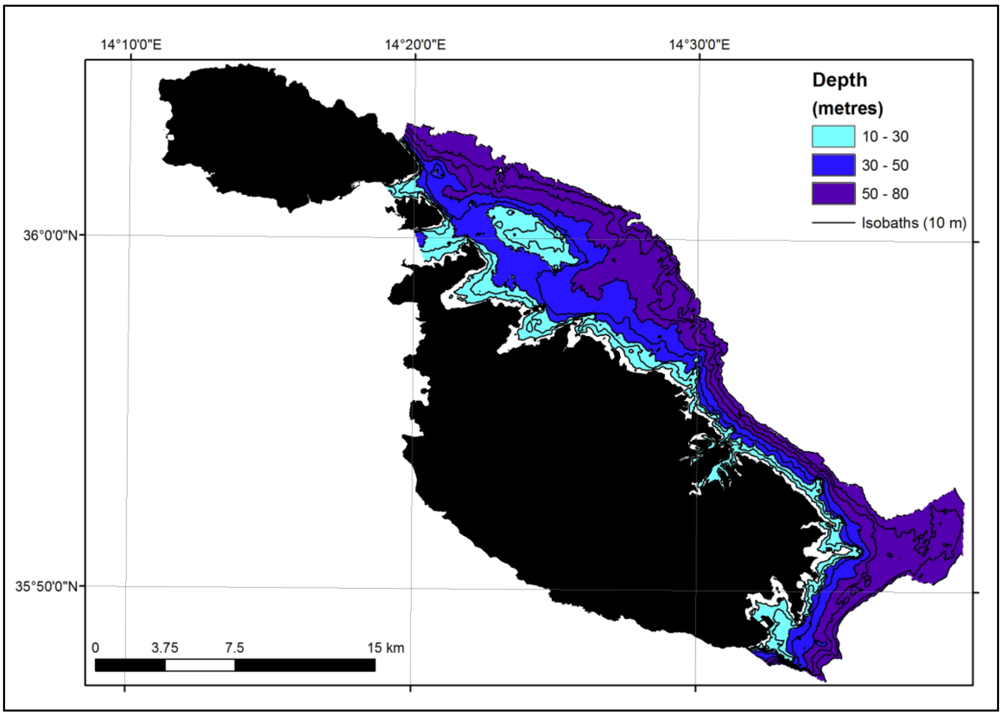
Nursery areas for CCS
- Water depth 10-30m, currents less than 0.5 knots, shelter from WNW/NW

Ongrowing areas for CCS and tuna:
- CCS: water depth 30-50m, currents less than 1.5 knots, shelter from WNW/NW
- Tuna: water depth 50-80m, currents less than 2 knots, shelter from WNW/NW, more than 1 nautical mile (1.85km) from shore

[5] CCS may also one day include bluefin tuna if the production cycle can be closed, in which case the production of small fast growing tuna of 1-2kg fed on dry food and targeted at the European market may be viable.

These depth, current and shelter limits have been chosen to take into account the system and species requirements of CCS and tuna at different life stages. Figure 14 shows the areas around Malta meeting the basic depth and shelter requirements for cage based aquaculture.

Figure 14. Areas around Malta meeting depth and shelter requirements for cage based aquaculture



Source: Internal

With regard to currents, there is little if any relevant published data for Maltese waters. As far as we are aware, there has been no long term monitoring of currents at aquaculture sites in Malta. Spot measurements using current drogues have been taken at some sites for baseline environmental surveys which give an indication of conditions, and there is some anecdotal evidence from on-site experience. At most existing sites it is understood that currents rarely exceed 2 knots. The only exception to this is likely to be the SE Zone where currents in excess of 3 knots are thought to have contributed to the total loss of two farms in 2007 and 2009. Current directions on the west coast are generally NW to SE, in line with the prevailing wind. For the purposes of this assessment, it is assumed that current speeds in the depth zones of interest comply with the limits previously specified, apart from in the SE Zone.

It may be seen from Figure 14, before taking into account any other marine uses or designations, that the only potentially suitable areas for cage based aquaculture in Malta are on the east side of the islands, not only due to shelter from the prevailing WNW winds but also to the water depths in excess of 100m on the west side of the islands. Even so, the 50-80m depth zone which occupies much of the potential area identified is far from ideal for the culture of CCS given the additional exposure and the increased likelihood of currents in excess of 1.5 knots.

The next stage of the screening process was to overlay all other known marine uses and conservation designations, including:

- Shipping lanes, port approaches, bunkering and anchorage areas, underwater cables
- Proposed offshore wind farm
- Fishing zones
- Firing ranges
- Dive sites
- Bathing beaches
- Sewage disposal points
- Spoil grounds

- Proposed Marine Protected Areas (MPAs)
- Sensitive benthic habitats e.g. Posidonia
- Important Bird Areas (IBAs)

The locations of these designations are given on a series of maps in Annex 11, together with an interpretation. These are summarised in Figure 15 and Figure 16 below. Figure 15 shows the main exclusion zones for shipping, trawling zones, dive sites, wind farm, and aquaculture sites, whilst Figure 16 shows conservation zones and benthic habitats.

Figure 15. Showing location of shipping exclusion zones, trawl zones, dive sites, wind farm, and aquaculture sites

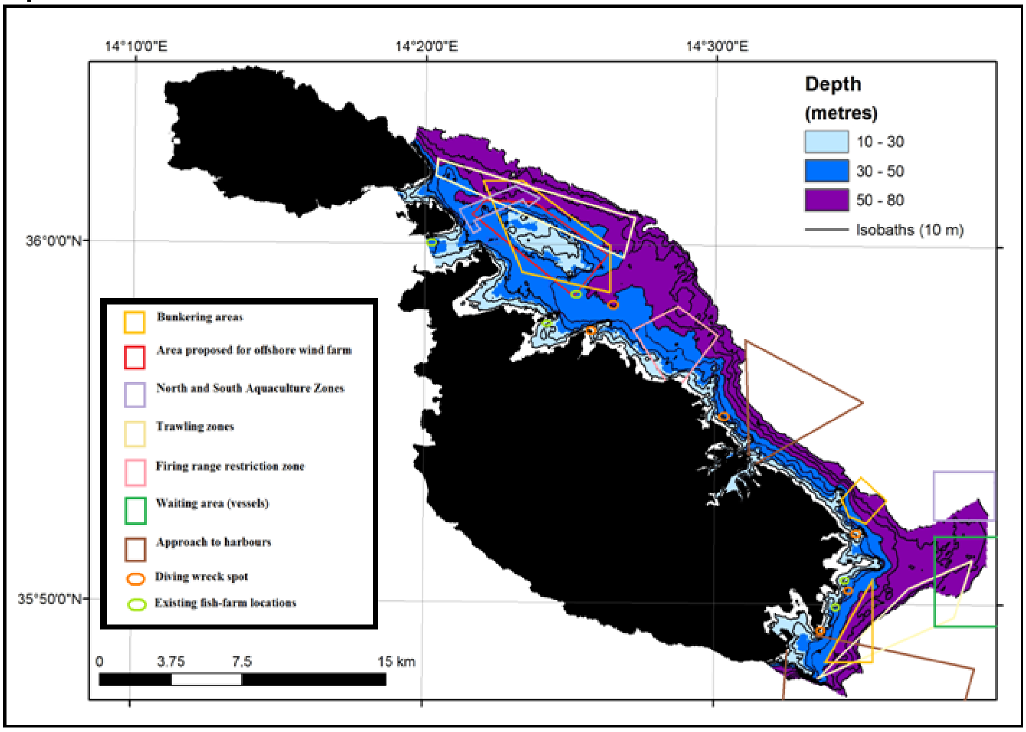
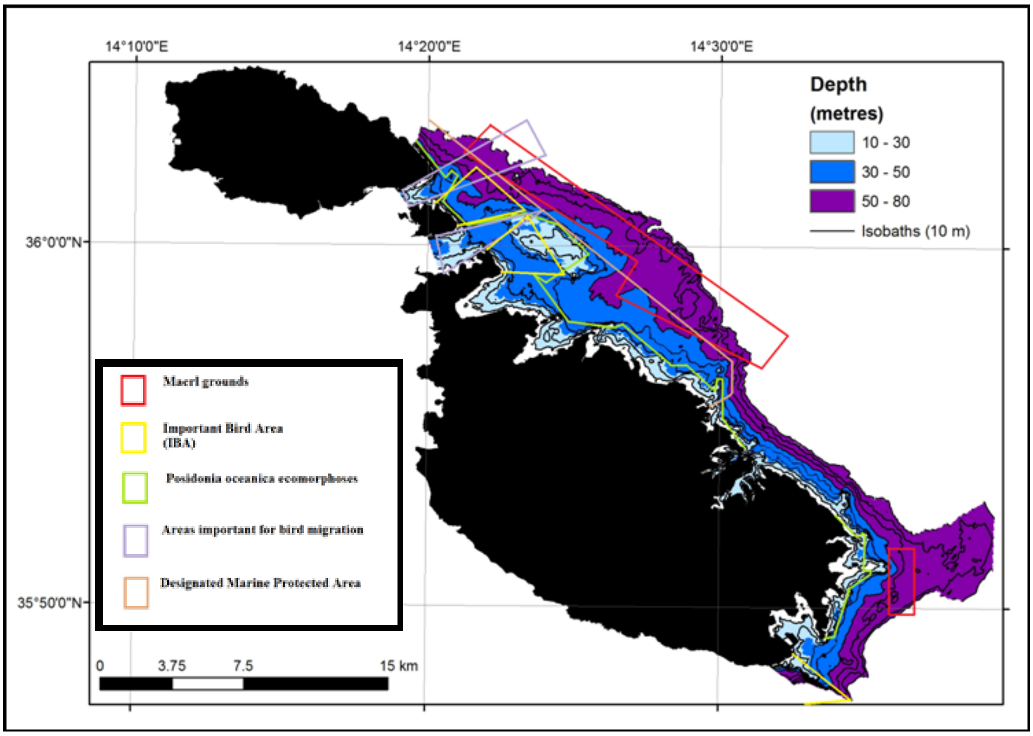


Figure 16. Conservation zones and benthic habitats.



All of this information has been combined to further evaluate what potential new sites for aquaculture there might be in Maltese waters, as well as to assess how existing sites meet current policy requirements.

Figure 17 and Figure 18 show such existing and potential new aquaculture sites. A separation distance between surface cage units of 1 km has been assumed, in line with national policy. It should be emphasised that new sites have been identified on the basis of provisional suitability for aquaculture and lack of obvious conflict with known marine uses. With regard to conservation considerations, Posidonia beds have been avoided, although some areas do overlap with maerl beds and IBAs, and the proposed MPA along the north east coast.

The extent to which any of the suggested new areas for aquaculture are adopted would clearly depend on a great deal of further investigation and discussion with all relevant stakeholders. However, for the purposes of trying to establish a potential production target, these areas, if all were adopted, are likely to represent an upper limit to such a target.

Ideally, this screening exercise would have been done using a GIS system for greater accuracy and better ranking of potential areas (Perez et al, 2005), but this was outside the scope of this study.

Figure 17. Existing (red) and potential new (green) aquaculture sites, NE coast of Malta

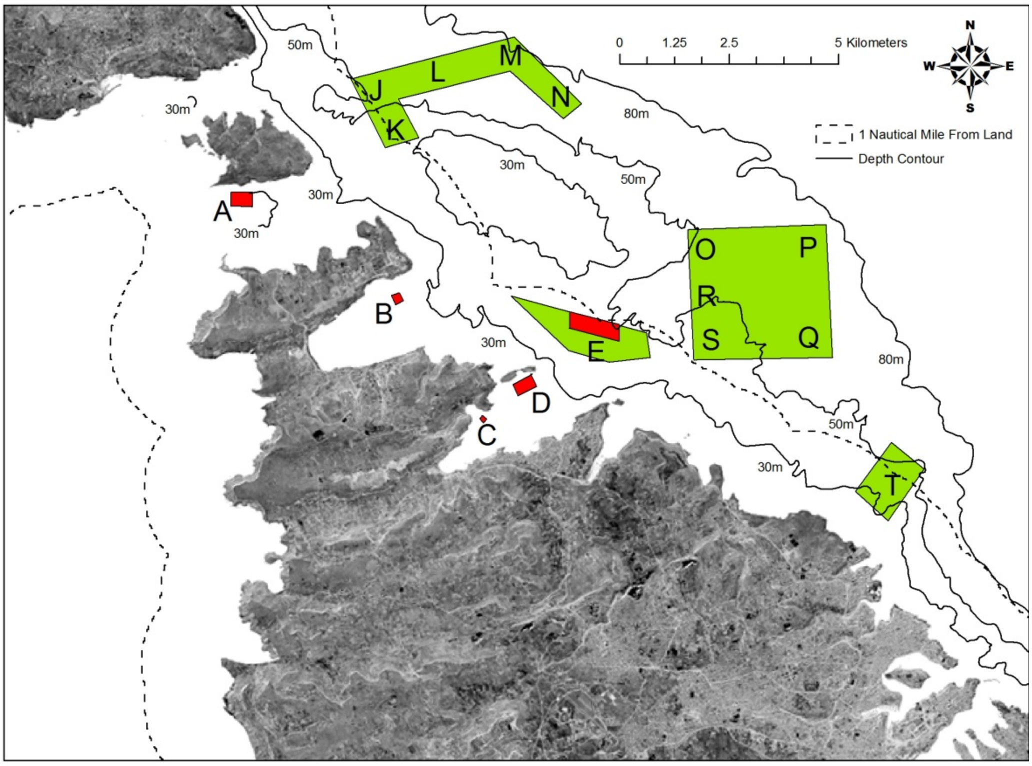
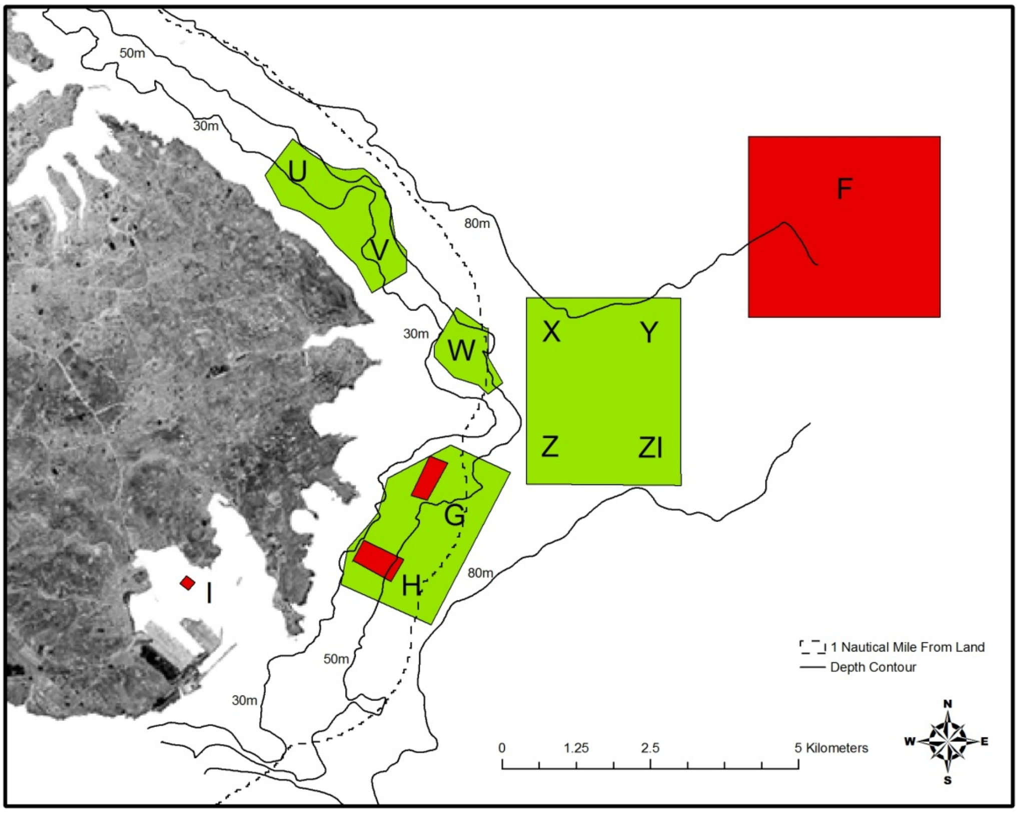


Figure 18. Existing (red) and potential new (green) aquaculture sites, SE coast of Malta



6.1.1.2 Characteristics and limitations of potential new sites/zones

<u>North East coast</u> (Figure 17)

The proposed NE aquaculture zone, shown in Figure 17 as points K to N, is presently undergoing an EIA to determine suitability for aquaculture. The inner sites J and K have a suitable depth for CCS and should have sufficient shelter. Site K however appears to overlap an area of Posidonia and the northern extent of the proposed wind farm, whilst both overlap a bird rafting zone and trawling zone D. Site L is in deeper water but could also potentially be suitable for CCS such as large amberjack. However, it overlaps the northern end of bunkering area 1 and trawl zone D. Sites M and N are likely to be suitable only (if at all) for tuna given the greater water depth and exposure; these sites also overlap an area of maerl.

Moving further south, there is an area just outside the 1 nautical mile limit (sites O to S on Figure 17) and located between the firing zone to the south and bunkering area 1 to the north, which may offer potential. The inner sites R and S lie in the 30-50m depth zone and are not too far from shore, and may thus be suitable for CCS. The outer sites O to Q are in the 50-80m zone and more exposed and thus again may only be suitable for tuna. Again this area overlaps an area of maerl.

Just north of St George's Point (site T on Figure 17), close to the Madalena shoals, there is an area lying just outside the firing zone in a water depth of 20-50m that might be suitable for a CCS site, especially if located close to the northernmost corner away from Posidonia beds.

In addition to the potential limitations described above, the whole of the north east coast has been proposed as an MPA, which if adopted may impose additional restrictions on operations within the area.

South East coast (Figure 18)

The zone containing sites U and V lies SE of the sewage treatment plant (STP) at Xghajra, in an area identified for possible land reclamation. In the past this area was heavily impacted by the discharge of raw sewage, lying as it does "downstream" of the STP. However, the STP has recently been upgraded and as from June 2011 untreated wastewater will no longer be discharged (Water Services Corporation website) and water quality should be much improved. Both BOD and suspended solids which may amount to 100-400mg/l in untreated sewage are to be reduced to less than 10mg/l prior to discharge to the sea (MEPA, 2006). The area identified extends from the 10m depth contour out to 50m depth, and it is suggested that this area might be used for nursery production of CCS, given it is one of the few areas close to shore with no Posidonia meadows or other sensitive benthic habitats. The adjacent coastal land is also relatively uninhabited. This of course assumes that the water quality is now acceptable for aquaculture, and that land reclamation is not pursued.

Site W off St Thomas Point meets the requirements for CCS in that it lies between 30 and 50m of water depth and avoids bunkering zones, Posidonia meadows and other designations. It is however close to Marsascala.

A third possible new zone on the SE coast (sites X to Z1 on Figure 18) lies in 50-80m of water depth half way between the coast and the already established SE aquaculture zone. The inner most sites X and Z lie in 50-60m water depth and may thus be suitable for CCS, whilst the outer most sites Y and Z1 may be suitable for tuna and offer a less exposed option to the SE aquaculture zone. There is some overlap with maerl beds at the southern end. In addition, it would be essential to assess currents in this area given the problems known to have occurred in the already established SE Zone.

The green area around existing sites G and H represents a new possible zone taking in these sites and two further sites (outer G and outer H). The suggestion here is that G and H would be used only for CCS (being inside the 50m depth/1nm limit), whilst outer G and outer H would be used for tuna. This however would require bunkering zone 4 to be moved further offshore.

6.1.2 The potential carrying capacity of new sites/zones identified

6.1.2.1 Sea area occupied

Having identified potential new areas for aquaculture the next stage is to estimate what the production capacity of such areas might be. The first stage in this process is to determine the number of units that could physically be located in a given area, taking into account species cultured, production per unit, sea surface area of cages, the seabed required for moorings, and separation distances.

With regard to sea areas occupied for a given production for different species and production cycles, we have carried out an analysis the results of which are given in Annex 12 and summarised in Table 12.

Table 12. Estimate of sea areas needed for different species

Species	Tuna	Mix of CCS [1]	
Production phase	Ongrow	Ongrow	Nursery
Production p.a. (t)	1000	1000	100
Production cycle (months)	6	16	2
Max. Stocking density (kg/m3)	2.5	15	12
Avg. harvest size (kg)	200	1.35	0.06
Water depth assumed (m)	70	40	10
Sea surface occupied (ha) note 2	8.0	2.5	0.4
Seabed area occupied (ha) note 3	120.0	42.7	3.5

Notes

1 Mix of CCS composed of 50% portion seabream, 25% portion amberjack, 25% large amberjack

2 Sea surface represents area occupied by surface mooring grid for plastic cages, assuming grid is 2x cage diameter

3 Seabed area assumes mooring leg length is 5x water depth

From this it may be seen that for a given production, tuna occupy a much greater area than CCS. This is due to the larger cage volume required due to the size of the fish and the lower stocking density, and also to the greater depth in which the cages are likely to be moored.

A further point to note is that the above calculation of seabed areas needed is not unduly sensitive to production levels. For example a doubling of production might double the sea surface area needed but would only increase the seabed needed for moorings by around 1.5 times.

The site locations identified in Figure 17 and Figure 18 have taken these space requirements into account as well as the mandatory 1km separation distance.

6.1.2.2 Carrying capacity in the Mediterranean

Determining the carrying capacity of sites is clearly fundamental to establishing a sustainable industry and estimating production targets. In the context of this report, carrying capacity is defined as "environmental" carrying capacity i.e. the maximum yield that can be produced without significant environmental change. Carrying capacity depends on the ability of a site to support a healthy stock of fish by maintaining adequate water quality levels such as dissolved oxygen, whilst at the same time dispersing waste products so that they do not unduly impact on the surrounding water body and sea bed.

Whilst the science and practice of determining carrying capacity is relatively well established in Northern European waters for salmon farming, using modelling tools such as "DEPOMOD", the current status of modelling such capacity in the Mediterranean is at an early stage; a model known as "MERAMOD" has been developed for the Mediterranean but is considered ineffective. The difference between the two regions is due largely to the fact that salmon farm sites mostly have predictable tidal currents which can be measured and used to estimate waste settlement around cages, whilst in the Mediterranean the absence of tides makes this much more difficult. Dispersive currents in the Mediterranean are mostly wind generated, and whilst predictions of current speed and duration can be made based on wind speed, such predictions are highly site dependent. It is however generally acknowledged that cages located further offshore have better carrying capacity by virtue of their greater exposure to winds and thus currents, providing of course that conditions still allow the survival of the species and system in question.

In Malta, a strict protocol for environmental monitoring for the majority of farms has been in place since the early days of the industry, and the impacts of farms on the environment are relatively well understood. The impression gained from the consultation process and from monitoring reports is that farms have had little or no impact on water quality, and that seabed impacts are typically limited to the area close to the cages. This is no doubt due to the relatively exposed sites found in Malta, even those close to the shore. However, no connection is made between the biomass held on site and the impacts observed on the environment. Whilst most operating permits specify a permitted tonnage, such tonnage relates nominally to annual production rather than maximum permitted biomass. Thus in reviewing environmental monitoring results, it is difficult to make a connection between actual production and impacts.

In Northern Europe, sites typically have a discharge consent based on the maximum biomass to be held on a site, determined initially on modelling of tidal currents and water depths. Subsequent monitoring determines whether impacts are in line with predictions and within agreed parameters. In Scotland, if they exceed such parameters, a fine is imposed and the biomass consent is reduced.

In order to address the lack of a common approach to determining carrying capacity in the Mediterranean, the FAO sponsored General Fisheries Commission for the Mediterranean (GFCM) has held a series of multi-stakeholder workshops on Siting and Carrying Capacity (known as WGSC-SHoCMed). One of the aims of SHoCMed is to arrive at a common set of standards for site selection and determining carrying capacity. The last workshop was held in Malta in November 2010, concluding amongst other things that there was a need to adopt specific Environmental Quality Standards (EQS) for aquaculture in combination with the Allowed Zone of Effects (AZE) concept to determine the area to be monitored (GFCM, 2011). Work is ongoing to agree on such EQS.

Other guidelines on carrying capacity are at a similar state of development. For example, with regard to site selection, the Guide for the Sustainable Development of Mediterranean Aquaculture (IUCN, 2009) states:

"There is a need, therefore, to establish criteria for the maximal aquaculture production at each site in order to avoid degradation of the marine environment and particularly the coastal zone, which is already under considerable human pressure in most parts of the world. However, at the moment there is little consensus as to what these standards should be for Mediterranean aquaculture."

6.1.2.3 Carrying capacity for farms in Malta

In view of the lack of general Mediterranean EQS and any common consensus on carrying capacity guidelines, it is necessary to rely on the monitoring work carried out in Malta to date. Over the past 10 years, that work has however focussed mainly on the 5 farms producing tuna, which by their nature have quite different characteristics to CCS in terms of evaluating impacts.

The only farm consistently producing CCS in recent years has been P2M, which was established before the requirement for full environmental monitoring came into force. Nevertheless regular water quality monitoring has been carried out and 2 benthic surveys were carried out in 1995 and 2005. P2M does not however serve as a useful model for determining environmental impacts for CCS in more exposed waters given that it lies in relatively shallow and more sheltered waters.

It is necessary therefore to consider the experience with other CCS farms, particularly in the period 1994-2000 before tuna penning began. Farms producing CCS established after P2M from 1994 onwards had to abide by the 1994 PDG requirements for monitoring. One such farm was that established by MML in the Comino Channel in 1994. This farm produced mainly seabream for the first few years of operation, at a production level of around 500t p.a.. It is understood that impacts from the farm on the seabed were limited. MFF and F&F also produced bream and bass at a similar production level, and again benthic impacts are understood to have been limited.

In determining the production capacity of the sites identified in Section 6.1.1 for CCS i.e. within the 50m depth/1nm limit, it is suggested that on the basis of past experience, the minimum capacity would be 500t production p.a.. The upper limit would depend on specific site conditions, but given the exposed nature of most of the sites suggested for CCS, a level of 1000t p.a. is proposed. The actual carrying capacity for any one site would have to be determined over time on the basis of monitoring, working to agreed EQS.

For tuna, given the lower benthic impact per tonne of final output compared with CCS, the ICCAT limit of 1500t/site is assumed.

6.1.3 Scope for onshore developments

6.1.3.1 Opportunities for land based on-growing units

The pressure on land resources in Malta, especially near the coast, means that there are no functioning land based on-growing units at the present time. A farm at St. Paul's Bay, Sealand Ltd, was set up some years ago but was never successful and is no longer operating.

The original 1994 PDG envisaged "a limited number of small scale land based units each producing less than 150t p.a. for species which could not be cultured in offshore cages, located close to shore but no more than 10m above sea level". However, there now appears to be a general presumption against land based farms on the coast, as indicated by the National Aquaculture Policy 2004:

"Land installation involving complete cycles / on-growing:

> (a) Making use of completely closed systems shall be restricted to industrial areas, former quarries etc. These could be located in the countryside on the same basis as new agricultural buildings.
>
> (b) Making use of open systems shall be restricted to areas outside the water protection zone or in areas where their effluent can be properly managed."

Malta's National Strategic Plan for Fisheries states "Modern "low-consumption" recycling systems may also be considered for pre-fattening or nursery stages that can be carried out in land-based systems", and this could certainly make sense if acceptable sites were found.

There are certainly suitable sites for land based operations in Malta near the coast along the lines of those envisaged in the 1994 PDG. However, there are no particular strategic advantages for Malta in land-based units – energy cost is high and there are no hot or cold groundwater sources that could be utilised. In addition, unless planning restrictions on such units are lifted the prospect of their development is very limited.

6.1.3.2 Land based hatchery units

The need for a hatchery in Malta has been recognised since the industry began, and a pilot scale hatchery at the MARC has been in operation most years since 1994. Planning permission was granted for a commercial hatchery with a 5 million p.a. production capacity at a former desalination plant at Hondoq Ir-Rummien in Gozo in 1995, but the permit was subsequently withdrawn without explanation following a change of Government.

A hatchery is again on the agenda as given in Malta's National Strategic Plan For Fisheries 2007-2013, which states:

"One of the first priorities will be the establishment of a land-based hatchery to ensure that the local market will be provided with fingerlings of seabass and seabream and other species. Malta is also seeking to diversify from the species in current production and thus intends to develop the hatching of other species such as *Seriola dumerili.*

It is proposed that the land-based hatchery will be developed through the utilisation of an old quarry located at the south west end of Malta that had been excavated to sea-water level. It is estimated that the construction phase of this project could start in 2010 following the conclusion of studies related to impact on the environment and the issue of the relevant permits. It is confirmed that this project will not overlap with other structural projects covered by the Regional Fund."

At present some 5 million juveniles of CCS are needed each year by the industry, the majority of which are imported. Should the industry grow to a production level of 10,000t p.a., that figure would increase to around 20 million.

The most important justification for a hatchery however is to capitalise on the alternative species know-how built up over the years at the MARC, and to produce commercial volumes of species such as amberjack, and later, if the cycle can be closed, of bluefin tuna. If Malta can maintain its lead in the production of such species, it has an opportunity to gain an advantage over other countries in terms of being "first to market".

Although a site is mentioned in the National Strategic Plan, this has since been discounted and 4 alternative sites on the SE coast are under consideration for a "Bluefin Tuna Spawning Facility and Marine Hatchery". The most promising site is located at Xrobb il-Ghagin on the south east of Malta and close to the ex-Deutsch

Welle Relay Station. This location provides good water exchange and is next to open sea, and appears to be ideal for the proposed facility.

Other sites for additional hatcheries/nursery units should also not be discounted, especially if they could be located in areas likely to benefit local people - for example a unit in or near Marsaxlokk Bay, a traditional area for fishing, could offer employment to ex-fishermen and their families in view of the declining status of the fishing industry.

6.2 Technology appraisal/opportunities for innovation

6.2.1 Unique characteristics of Malta for aquaculture

The coastal waters of Malta have a number of characteristics which together offer a unique environment for aquaculture production.

Because there is no significant freshwater run-off from the Maltese islands, with no permanent watercourses, the coastal waters of Malta are relatively unaffected by freshwater run-off and any associated terrestrial pollutants (although heavy rainfall will lead to localised runoff from roads and drains). Consequently, salinity varies little from 37‰ and water clarity is typically very high. The limited freshwater runoff also minimises the quantities of agricultural and other nutrients of a terrestrial origin from entering coastal waters, and so the nutrient load of these coastal waters remains low. This reduces the incidence of algal blooms, jellyfish swarms and other similar biological phenomena, and no fish stock losses have been reported to date in Maltese waters from such occurrences.

Because of its central location in the Mediterranean Sea basin, minimum winter water temperatures rarely drop below 13.5°C. In parts of the northern Mediterranean, such as the waters of Greece and Aegean Turkey, winter sea temperatures commonly drop to around 10°C. Aquaculture in Malta can therefore offer better opportunities for improved growth rates over competing national aquaculture industries, and minimise the effect of health problems brought on by sustained periods of low water temperatures.

Malta has almost no shallow shelf seas in its coastal waters, and water depths typically drop to over 50m within a few kilometres of the shoreline. Although this fact limits the availability of shallow sites for aquaculture development, it ensures that the coastal waters of Malta are exposed to constant high levels of water exchange with deeper offshore waters. This limits maximum summer seawater temperatures to around 28°C and ensures a relatively high level of dissolved oxygen in coastal waters. Growth rates for most Mediterranean fish species drop off markedly at temperatures higher than 28°C, due partly to the drop in water's ability to hold oxygen in solution as temperatures increase, and so aquaculture in Maltese coastal waters offers advantages compared with industries in countries of the southern and eastern Mediterranean and the Middle East, such as Tunisia, Egypt, Israel, Saudi Arabia and Kuwait, which experience summer temperatures above this level.

The proximity of relatively deep waters (50-100m in depth) to the coast of Malta makes this location ideal for the development of offshore aquaculture requiring large cages using deep nets, such as that required for tuna penning operations and the production of other large pelagic fish species such as amberjack.

In addition to the physico-chemical and environmental characteristics of Maltese coastal waters, the island of Malta's geographical location in the centre of the Mediterranean Sea offers some potential advantages to the Maltese aquaculture industry. Malta is relatively close to Italy, which currently represents the main market for seabream and seabass in Europe, and a potential market for other species such as meagre, amberjacks and groupers. Although a need to employ ferry transfers between Malta and Sicily, and between Sicily and Italy, slows the transportation of a fresh fish product to some extent, typical road haulage times between Malta and Rome are around 15 hours, compared to around 25 hours between Athens and Rome.

Malta also happens to be located close to the migration routes of migratory pelagic fish species, such as bluefin tuna, which facilitates the fishing of these species for capture-based aquaculture operations. The proximity of the migration routes simplifies and reduces the cost of towing procedures between the capture sites and the production sites in Maltese waters.

On a socio-economic level, over 22 years of offshore aquaculture operations have provided Malta with a significant pool of highly-skilled manpower, specialising in the management and operation of large-scale offshore cage culture and capture-based tuna aquaculture operations, supported by specialised service companies e.g. mooring installers and boat builders.

Although of a modest scale, aquaculture research and development activities in Malta are highly specialised and targeted at the development of closed cycle aquaculture techniques for a number of fish species of particular interest to the Maltese aquaculture industry, notably amberjack *Seriola dumerili* and bluefin tuna *Thunnus thynnus*. This capability is supported by the presence of highly skilled research staff with experience of the Japanese aquaculture research industry. This makes the MARC a leader in the development of broodstock management techniques for such species as bluefin tuna and amberjacks in the Mediterranean region. In addition, the availability of a commercially orientated marine fish hatchery at the MARC with a strong research capability is of particular value in the development and improvement of mass production techniques for a range of established (seabass & seabream) and developing species (including meagre, grouper and various sparids).

6.2.2 Scope for "new" species

6.2.2.1 Introduction

In the context of this study, "new" or "alternative" species are defined as those which have not yet assumed a major place in commercial production operations in the Mediterranean, and indeed for the most part are still the subject of R&D but which show promise. Meagre is a slight exception to this in that it has passed beyond the R&D stage and could be produced in commercial volumes if marketing issues could be overcome. Nevertheless it is included here as it is still a relative newcomer to the production scene.

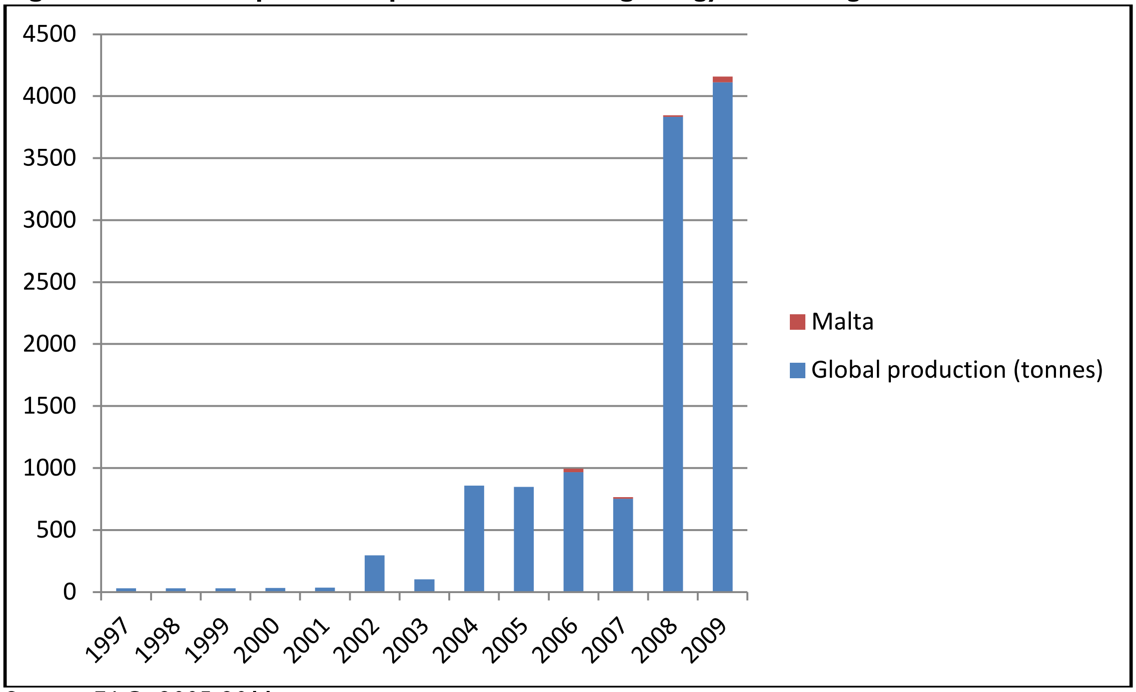
6.2.2.2 New species with immediate potential (meagre, amberjack, bluefin tuna)

Meagre (*Argyrosomus regius*)

Despite being present in the Mediterranean Sea, meagre is largely unknown in the Maltese market and wild specimens are rarely seen even on Mediterranean fish markets. As a fishery product it is only well known in two areas – southern Spain and Portugal, and western France - both on the Atlantic coast of Europe. Fishery capture statistics are unreliable as all Sciaeneids are usually grouped together, but annual catches appear to amount to a few hundred tonnes per annum in Europe. Wild-caught meagre therefore represent a specialised niche product with a limited market in Europe. However, where it is locally common it is a highly-prized fish with specimens in excess of 2kg reaching a market price of €7-12/kg, and so it would appear to have some potential as a fresh product for the Spanish market, and on the wider Mediterranean market with some market development (Monfort, 2010).

It has been established for some time that members of the family *Sciaenidae* are amenable to aquaculture. Red drum, *Sciaenops ocellatus,* is a well-established subject of aquaculture in the southern USA and Caribbean region, and limited hatchery production work has demonstrated the feasibility of the hatchery production of the European sciaenid *Umbrina cirrosa*. However, despite the fact that marine fish hatcheries are capable of producing these species, few hatcheries are prepared to provide them with production space without a confirmed demand for the juvenile fish.

Figure 19. Global aquaculture production of meagre *Argyrosomus regius*.



Source: FAO, 2005-2011

In 1996, however, a French marine fish hatchery agreed to supply an Italian cage farm with juvenile meagre, grown to order, and since that time interest has grown and a number of hatcheries now supply juveniles. By 2008 a total of 8-10 million juveniles were sold to European farmers, and annual production had reached 2500-3000 tonnes (Monfort, 2010), with the bulk of production being carried out by Spanish cage operations. Other producers of note include Turkey, France, Italy and Greece. Figures from FAO (see Figure 19) suggest global aquaculture production of meagre reached just over 4000 tonnes in 2009, and tentative estimates based on juvenile fish deliveries suggest that annual production may have reached 10,000 tonnes by 2010. Most juvenile production for export currently takes place in France and Italy, although significant production is also taking place in Turkish hatcheries, mostly for in-house cage production. In fact, as recently as 2008 a single hatchery was responsible for the supply of 90% of all meagre juvenile production. Because juvenile production is limited to a few suppliers, and production levels are low compared to those of seabass and seabream, meagre juveniles fetch a high price and are currently sold for around €0.80 per fish.

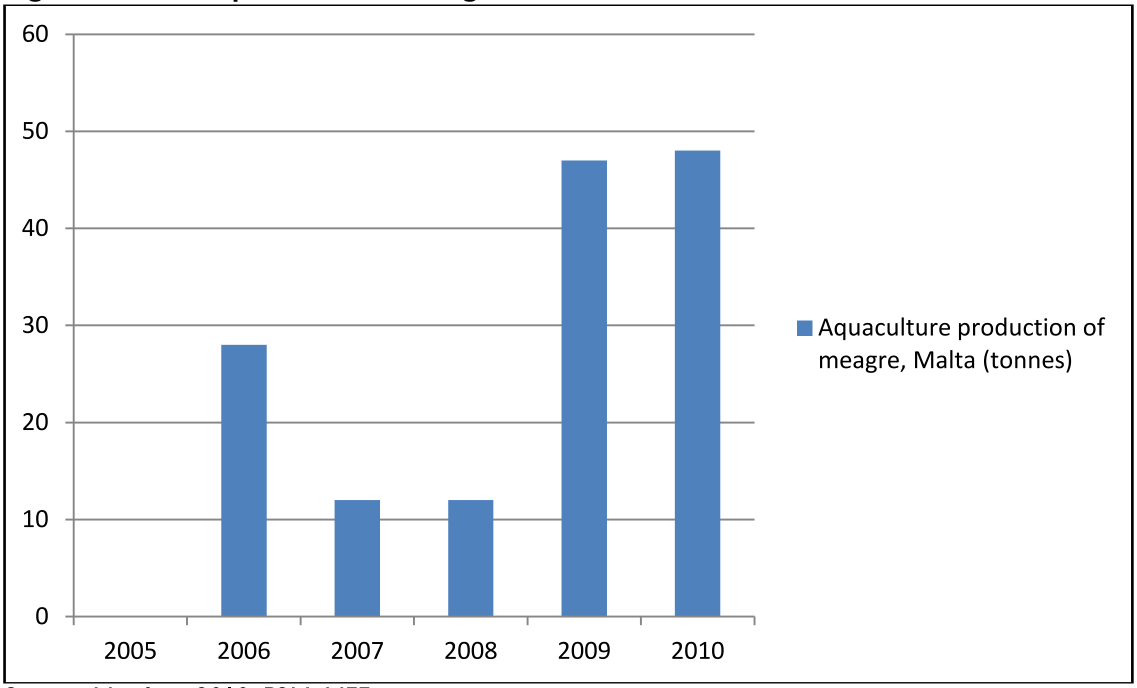
In Malta, meagre can currently be considered a niche species with a rather limited production. Maltese cage farmers were attracted to the production of meagre to supplement their production of seabass and seabream, and a single company, P2M, started production during 2005. Initial cage production reached 28 tonnes in 2006, but subsequently dropped to around 12 tonnes for both 2007 and 2008. Annual production then increased to just under 50 tonnes during 2009 and 2010 (see Figure 20). In 2010 MFF became interested in meagre production and introduced a small number of juveniles into its nursery facilities, due for harvest in 2011.

Meagre can be produced in floating cages of the same design as those used for the production of seabass and seabream. Cannibalism is a problem with juvenile meagre, and juveniles are typically shipped at a size of 5-10g to minimise it. Initial stocking is into nursery cage sites in sheltered waters, with fish being transferred to offshore cages at a size of around 100g, which is normally achieved after around 3 months.

Initial growth performance results in Maltese cage farms were very encouraging, with the meagre reaching a mean weight of 1.2kg within 12 months with a typical food conversion ratio to this size of 1.25 (compared to 1.85 for seabream). Juvenile fish were also found to be robust and resistant to transport handling and other husbandry operations. Feed companies supply pelleted feeds specifically formulated for meagre, containing 45-48% protein and 20-24% fat. Maximum stocking densities employed are 10-15kg/m^3.

Meagre are marketed as a whole, fresh fish product at an average weight of between 1-3kg, and typically reach an ex-farm price of around €5.50-6.00/kg. Market demand in Italy, the main export market for Maltese fish, is reported to be strong. However, there appears to be a lack of demand for portion size fish due to poor meat yield.

Figure 20. Annual production of meagre from Maltese fish farms.



Source: Monfort, 2010; P2M; MFF.

Being a large, fast-growing species suggests there should be potential for processed products such as fillets, loins and steaks. However, the relatively high production costs and poor meat yield (typically 42-45%) mean that the ex-farm price equivalent of fillets would be around €15-17/kg, and therefore a retail price of at least €20/kg (Monfort, 2010). This would limit the market of this product to medium and high-end restaurants.

A significant expansion in the market for this product can only be realised, therefore, if the cost of production and therefore the sales price of this species can be brought down. With the excellent growth characteristics of this species and low production mortalities, and expected improvements in production efficiency, lower production costs should be feasible, particularly if the cost of hatchery-reared juveniles can be reduced by an increase in production and increased competition. In fact, evidence suggests that costs of juveniles have dropped from €1/juvenile to around €0.80/juvenile between 2009 and 2011, and the ex-farm sales price is being pushed down to around €5.50/kg from €6.00 between 2008/2009 and 2011. If the cost of production could be brought down, processing would become more feasible and value-added products such as fillets and smoked meagre for the supermarket trade could have potential.

Further branding and market development, for example exploiting the production of farmed meagre thus reducing the pressure on wild capture fisheries or promoting it as a Mediterranean product, might allow an increase in market demand and therefore higher prices to be achieved. The production of this species according to organic principles could also be considered as part of this strategy.

Any expansion and improvement in production efficiency of meagre in Malta could be supported by research and development provided by the MARC. Meagre eggs were imported from an Italian hatchery in 2010 to carry out juvenile production, most of which will be grown on to be used as broodstock for the future production of meagre eggs and juveniles at the MARC. The planned commercial-scale marine fish hatchery would be well placed to carry out further work into the optimisation of techniques for the production of meagre, and could be used to produce significant numbers of meagre juveniles subject to demand from the Maltese aquaculture industry.

Amberjack (*Seriola dumerili*)

The global catch of wild-caught amberjacks of all species amounted to around 60,000 tonnes during the 1990's, with most of the catch going to Japan, Korea, the USA and Mexico. The European amberjack fishery is based on the capture of the greater amberjack *Seriola dumerili* which is native to the Mediterranean and the warmer waters of the Atlantic, Pacific and Indian Oceans. There appear to be no targeted fisheries for this species in Europe, and it occurs in fish markets regularly as an incidental catch.

Amberjack is a valuable food fish in Malta, fetching €10-12/kg at market and retailing at around €15/kg during 2010/2011. The preferred size for Maltese retailers is around 600g, with the largest fish fetching lower market prices, typically €5-6/kg. This is said to be due to large fish only being suitable for steaks, which then have to compete with swordfish steaks at a lower value. Prices appear to be similar or even higher in Italy and Spain. In north European countries, such as the Netherlands, there appears to be a preference for larger fish of around 3-5kg average weight.

There has been a small amount of amberjack production in a number of Mediterranean countries based on the cage rearing of wild-caught juveniles. Small amberjacks, of around 100g in weight, are a common by-catch of pelagic fisheries using fish aggregating devices (FADs), such as the fishery for dolphin fish in Malta, and may be caught in small numbers for subsequent rearing. There is a significant production of *Seriola dumerili* in Japan, based on the cage rearing of wild caught juveniles, although this species is produced in smaller numbers than the Japanese amberjack *Seriola quinqueradiata*. In 2002 the annual Japanese production of cage-reared greater amberjack was around 46,000 tonnes, accounting for around 30% of all Japanese *Seriola* production (Sawada et al, 2006).

Because of the relatively high market value of this species in southern Europe, there has been some interest in the production of hatchery-reared juveniles over the past 10-20 years, and a number of research institutes have been carrying out research and development, particularly the Hellenic Centre for Marine Research (HCMR) in Crete, Greece and the MARC in Malta. Since the Japanese amberjack aquaculture industry has traditionally been based on the capture of cheap supplies of wild juveniles, little work has been carried out on the hatchery rearing of amberjacks in general, and almost no work on *S. dumerili* until recently, and so there are no established methods of juvenile production. It was recognised early on that one of the main constraints for the hatchery rearing of amberjack was the difficulty in getting captive-held broodstock to spawn, mostly due to the failure of captive females to undergo vitellogenesis (yolk formation) past the very early stages of egg development (Mylonas, et al. 2004), and so most of the initial research work has focused on the maturation of captive amberjack and the development of spawning inducement methods by way of hormonal manipulation. The development of sustained-release hormone delivery systems, in the form of implants, in recent years has minimised the amount of handling required in normal broodstock husbandry operations and has opened up the way to the development of methods for the successful spawning of amberjack broodstock, and thus the production of hatchery-reared juveniles. The HCMR reported its first successful hatchery production of juvenile amberjacks in 2003 (Papandroulakis et al, 2005).

There has long been interest in the aquaculture of amberjack in Malta, following the cage rearing of wild-caught juveniles as long ago as 1995. Amberjack has a high market value in Malta and Italy, and initial growth trials using wild-caught juveniles have revealed a very high growth rate and low mortality rate. In 2005 a total of 300,000 eggs were collected from broodstock amberjack held in cages at the MARC, and this initial success led to the establishment of the Amberjack Project in 2006, a five-year joint venture between Malta Fishfarming Ltd and the MARC, with some EU funding, to study the spawning and juvenile rearing methods of this species.

Using expertise in broodstock management techniques at the MARC, 2.5 million fertilized eggs were collected from broodstock in the first year of the project, 2006, a significant achievement. 2 million of these eggs were incubated and hatching was achieved, with a 75% hatching rate. Valuable research and development work was then carried out on larval development, although no juveniles survived for stocking into cages. However, continued research and development work on a yearly basis, involving broodstock management methods and larval rearing trials, led to the production of 14,000 amberjack juveniles in 2010. These promising results will lead to the extension of this project for a further five years, from 2011 to 2015, which will allow further research and development of larval rearing techniques and cage rearing issues aimed at the production of large volumes of amberjack juveniles and cage rearing on a commercial scale.

A number of constraints have been identified in the hatchery-rearing and cage culture of amberjacks, including early larval mortality, high post-weaning mortality, excessive rates of aggression and cannibalism. Larvae are also known to be very sensitive to environmental conditions, and seem prone to malformations of the vertebrae, head and mouthparts (Sawada et al, 2006). Grow-out operations in cages appear less problematic, although fish are prone to infestations of monogenean parasites.

There is currently no significant closed-cycle production of greater amberjack anywhere in the world. The National Prawn Company of Saudi Arabia has recently announced ambitious plans to build a hatchery and broodstock facility capable of producing 4 million juveniles of *Seriola dumerili* per year and 5000 tonnes of annual production from a cage facility in the Red Sea close to Jeddah. Most of this production would be directed at the Japanese sushi market, although such a significant production could affect the future market of amberjack in Europe to some extent (Forristall, 2010).

It is recognised that the future development of the Japanese amberjack aquaculture industry depends on the replacement of wild-caught juveniles with high-quality hatchery-reared fish, and the development of suitable formulated feeds for all stages of the life cycle. The Fisheries Research Agency of Japan embarked on a 'Kanpachi (amberjack) Project 21' between 2006 and 2010 to study seed production technology, feed development and sustainable aquaculture technology of *Seriola dumerili* in Japan, aimed at developing a closed-cycle aquaculture industry for this species.

Other species of *Seriola* are the subject of aquaculture around the world, the most important being the Japanese amberjack *Seriola quinqueradiata*. This species has been reared in commercial quantities since the 1940's and annual production has levelled off at around 150,000 tonnes since the 1980's (FAO). This production represents around three times that of the global wild catch of all species of amberjack. Almost all production is carried out in Japan, where it is currently the most important farmed fish species, and the product is used for sashimi. The Japanese amberjack farming industry is primarily capture-based, using wild-caught juveniles caught in a specialist fishery. The hatchery rearing of Japanese amberjack juveniles is carried out in small quantities but is unable to make a significant contribution to aquaculture demand, mainly due to a number of difficulties experienced in the large-scale production of juveniles, mostly involving nutrition. Growth rates are high, with juveniles stocked in the sea during June with an average weight of 8-50g reaching a weight of 1.0 to 1.5kg by December, and then 2-3kg by the end of the following year. In addition, mortality is very low.

Japanese amberjack were traditionally fed on trash fish, but the unsustainability of this method of feeding has led to the development of formulated feeds. Further research and development work is required to produce suitable formulated feeds for use during periods of low water temperature and for fish in excess of 3kg in weight, when deficiencies in the use of formulated diets have become apparent. Harvest weight varies according to growth rates, but ranges between 3.5 and 6kg are achievable in a growth period of 20-27 months. This product size is targeted at the Japanese sashimi industry. Market prices in 2005 ranged between US$4.27/kg for 1kg fish and US$5.54/kg for 2-3kg fish.

Other species of amberjack that have been the subject of aquaculture in recent years include the almaco jack *Seriola rivoliana,* produced in small numbers in Hawaii and other locations in the Pacific, and the yellowtail kingfish *Seriola lalandi* which is produced in small numbers in Australia and New Zealand (Poortenaar *et al.*, 2003) and Mexico. Both species are reared using hatchery-bred juveniles, with the cage producers rearing the juveniles in their own hatcheries.

Amberjack culture in Malta is considered to have very high potential for the following reasons:

1) Amberjack is a high value product on the markets of Italy, the main export market for fresh fish in Malta, reaching over €10/kg for optimum-sized fish. It also has a high value as a sashimi product in Japan and is considered of higher quality than the Japanese amberjack, and so could be exported to Japan along with bluefin tuna production.
2) Whole amberjack has a relatively high meat yield, and is amenable to a range of products including fillets, loins, steaks, sashimi, sushi and even smoked products.
3) The wild catch of amberjacks is very limited, particularly in the Mediterranean, and so there is little competition from the wild catch.
4) With further research and development the closed-cycle culture of amberjack appears to be viable.
5) Growth rates are excellent, with an average weight of 1kg being achievable within the first year of production.
6) Experience gained from the production of other species of *Seriola* can be used to optimise the culture of *S. dumerili.*
7) Although inshore nursery sites will be required for initial stages of cage production, the production of amberjacks to a market size of 1kg and above is particularly well suited to the deep, offshore fish production sites available in Malta, since they are adapted to an open-ocean pelagic lifestyle.

Bluefin tuna (*Thunnus thynnus*)

The existing bluefin tuna penning industry in Malta is reliant upon the supply of wild tuna as a stock source, and the use of large quantities of frozen fish as feedstuff, such as sardines, mackerel and herring. The industry is thus dependent upon the health of the seasonal bluefin tuna fishery in the Mediterranean and the fishery for pelagic fish stocks in the temperate regions of the world (particularly the North Sea and north Atlantic). There has been considerable concern in recent years over the health of the bluefin tuna fishery in the Mediterranean and eastern Atlantic Ocean, with a drop in catch quota in recent years to the point where tuna pen operators are having difficulty in procuring sufficient tuna stocks to operate penning operations at a commercially viable level.

The development of juvenile production systems using captive broodstock as a source of eggs, and the development of formulated feeds, would allow the closed-cycle production of this species, and thus reduce reliance on stocks of wild fish. To this end a number of research bodies and private companies have been carrying out research and development into the hatchery production of bluefin tuna, concentrating on broodstock handling techniques, egg production issues, larval rearing, feed formulation and grow-out production methods, all of which are critical for the establishment of the closed-cycle production of the species. Research has been carried out in a number of countries, including Japan (for the Pacific bluefin tuna *Thunnus orientalis*) and Australia (for the southern bluefin tuna *Thunnus maccoyii).*

Research and development in the hatchery-rearing of *T. orientalis* was pioneered at Kinki University in Japan. Initial research started in the 1970's and by 1979 the world's first 'farm-hatched and raised' tuna were produced. The first successful hatchery production of tuna juveniles from hatchery-reared broodstock was achieved in 2002, and a total of 17,000 juveniles were stocked into floating cages. By 2004, after a grow-out period of 22 months, 1100 tuna of 95cm length and a weight of 14kg were successfully produced, thus finally closing the life cycle for this species (Sawada et al, 2005). By 2007 third-generation tuna had been produced (Kinki University, 2011). However, a number of significant constraints in the closed-cycle production of bluefin tuna have severely limited production of both juveniles and adults to date, and much additional research and development remains to be carried out before a viable industry can be established. Current research and development efforts are focusing on the development of broodstock spawning procedures, improving initial larval survival rates, reducing cannibalism during larval rearing and addressing damage of juvenile tuna due to collision with the holding tank or cage walls.

T. orientalis typically reaches sexual maturity at an age of 5 years. The eggs, which measure around 1mm in diameter, hatch after 48 hours and the larvae are initially fed on live feed. After only 20 days the juveniles are ready to be transferred to nursery cages in the sea. After a further 3 months the juveniles reach a length of 30cm and a weight of around 300g. Harvesting is then normally carried out at a size of around 30kg, which takes a total of around 3 years of cage culture.

As part of continued efforts to develop a closed-cycle bluefin tuna production industry in Japan, the Fisheries Research Agency of Japan embarked on a 'Tuna Aquaculture Project' during 2007-2010 to carry out research and development work in seed production technologies, larval and broodstock feed development and the development of offshore aquaculture techniques for this species.

With assistance from Kinki University, the Australian company Clean Seas Tuna Ltd has succeeded in the hatchery production of southern bluefin tuna *Thunnus maccoyii*, a species that is the subject of a significant tuna penning industry in South Australian waters. Initial success was achieved in 2007 by employing recently-developed hormonal manipulation methods on adult broodstock stocked in land-based tanks to achieve the production of viable eggs (Cleanseas, 2011). By 2010 juvenile tuna had reached the stage at which trials could be carried out into their transfer to floating cages. In March 2011 Clean Seas reported that a total of 85 bluefin tuna juveniles had been successfully transferred to sea cages and had reached a length of 15cm by early April 2011.

The first success in the induced spawning of wild-caught cage-held *T. thynnus* was achieved by a collaborative research effort involving a number of Mediterranean states in 2008. This success was built on several EU-funded collaborative projects including 'Reproduction of the Bluefin Tuna in Captivity – a feasibility study for the domestication of *Thunnus thynnus*' (REPRODOTT) between 2003 and 2005, and 'From capture based to self-sustained aquaculture and domestication of bluefin tuna, *Thunnus thynnus*' (SELFDOTT) between 2008 and 2011. The participants of SELFDOTT include research institutes, government departments and private companies in Malta (MFF Ltd, MARC and MRRA), Spain, Italy, France, Greece, Israel, Norway and Germany. Work is also being carried out by ALLOTUNA, a regional research consortium in Puglia, Italy.

SELFDOTT aims to implement existing knowledge on the artificial control of *Thunnus thynnus* reproduction to obtain viable eggs and study the embryonic and larval development for eventual hatchery rearing of this species, and to develop suitable formulated feeds.

Following a memorandum of understanding between ALLOTUNA and SELFDOTT, fertile eggs were produced by cage-held stock near Bari, Italy in 2008 and distributed to collaborating research institutes for larval rearing studies. The following year (2009) large numbers of eggs were produced by cage-held tuna broodstock at facilities in Cartagena, Spain and Puglia, Italy following the fitting of hormone delivery implants. Although a partner in this project, no eggs were successfully collected from tuna broodstock held by the MARC and MFF in Malta in 2009, possibly due to high currents at the broodstock cage site. Spawning results were much better in 2010. Over 50 million eggs were collected from tuna broodstock in Cartagena, Spain by spontaneous spawning events. Results from Maltese broodstock were more modest, with a total of around 0.5 million eggs being collected by way of induced spawning (SELFDOTT, 2010). To date few juveniles have survived to a size where transfer to cages would be feasible. The last juveniles produced under the SELFDOTT programme reached an age of 120 days (post-hatch) at Mazarron, Spain, whilst the last 'Allotuna' juvenile reached a weight of 258g after approximately 5 months post-hatch.

Assuming the broodstock management, hatchery-rearing and grow-out production of *T.thynnus* is similar to that of both *T. orientalis* and *T. maccoyii,* the advances made in the artificial reproduction of these species may be employed to hasten the development of successful hatchery-rearing methods for *T. thynnus*.

The development of a suitable formulated feed for farm-raised bluefin tuna is also considered essential for the long-term sustainability of the closed-cycle aquaculture of this species, and much work remains to be carried out before a suitable feed is developed. Experience from the tuna penning industries around the world suggests that there are likely to be few significant disease problems associated with large, adult fish at least. However, disease issues are likely to arise once closed-cycle production develops, particularly affecting juvenile tuna, and so disease and health-related research and development will need to be carried out hand-in-hand with the early development of the industry.

Any further development of broodstock management and hatchery-rearing techniques for bluefin tuna in Malta will require a dedicated shore-based tuna broodstock and hatchery facility, to allow an optimum control of the spawning and larval rearing environment. Few facilities of this kind exist in the world, and so Malta has the opportunity to become a regional leader in bluefin tuna closed-cycle production should such a facility be constructed.

The potential of closed-cycle bluefin tuna production in Malta needs careful analysis, since a number of constraints exist which may limit its viability, listed below:

1) Although a very high value species, the main market for bluefin tuna is virtually confined to Japan. Bluefin tuna is marketed widely around the world but the Japanese market, being based on sashimi and sushi products, is the only one where demand and therefore market prices are sufficiently high to make the closed-cycle production of this species financially viable. Malta is geographically distant from this main market, and air-freighted or frozen Maltese-produced tuna would therefore need to compete with home-grown, fresh Japanese farmed tuna production.
2) Japan is currently the world leader in the development of technology for the closed-cycle production of bluefin tuna. Consequently any Maltese production of bluefin tuna would compete with an established, home-grown aquaculture industry in Japan.
3) Because of the early stage of development of bluefin tuna broodstock management, juvenile production and grow-out techniques, the development of a viable aquaculture industry for this species will require a significant financial investment, for example in the construction of a land-based broodstock holding facility and hatchery, and many more years of intensive research and development.
4) There is a modest market for bluefin tuna in Europe, and this market could be exploited for a Maltese farmed tuna product with some degree of market development. Wild-caught bluefin tuna is widely perceived by the European public as an endangered species and opportunities exist to promote farm-raised tuna production as a sustainable alternative to the wild product, assuming a suitable formulated feed is developed to replace the use of trash fish as the main feed source.

6.2.2.3 New species with future potential

A number of additional marine fish species have been investigated for their aquaculture potential in the Mediterranean region in the past, but few have developed beyond the stage of limited exploratory production and none has passed to production at commercial levels. Several species of fish are being held as potential broodstock at the MARC, and are currently under investigation for their aquaculture potential.

Groupers

Perhaps the species with the most potential are the larger species of Mediterranean grouper, including the dusky grouper *Epinephelus marginatus,* the white grouper *Epinephelus aeneus* and the wreckfish *Polyprion americanus.* These species have a high market demand and value throughout the Mediterranean region, typically reaching a retail price of €15-20/kg for whole fish. Although generally considered technically difficult, the hatchery production of juvenile groupers is well established and so it is likely that a grouper production industry could be established in Malta within the short term if a reliable supply of juveniles is established. Mediterranean species of grouper differ from tropical species in having a limited reproductive season, which would require a degree of research and development to extend to any significant degree, and by having slower growth rates, particularly during the winter months (Pierre et al, 2007). Therefore, although grouper production could be initiated fairly rapidly, further research and development would be needed to develop a viable industry.

Any grouper production in Malta would require small-scale cage operations in sheltered locations due to the sedentary nature of this fish. Large-scale offshore production of grouper is not considered viable.

Work is currently underway at MARC to develop broodstock management techniques for both *E. marginatus* and *E. aeneus,* with research into larval rearing techniques planned in future. *P.americanus* is considered more problematic due to difficulties in obtaining and maintaining broodstock, which inhabit deep, offshore waters in Malta.

Sparids

Most species of Sparid command a high market price in the Mediterranean region, and so the higher-value species have been the subject of research and development into their suitability for commercial-scale aquaculture by a number of research institutes and private companies since the 1990's (Basurco & Abellán, 1998). Much of this work has been built on the established hatchery-rearing techniques developed for *Sparus aurata,* with a view to reducing research and development costs and holding the possibility of production within existing seabream and seabass hatcheries. However, the main constraint of the production of alternative species of sparid is their similarity to *S. aurata* and therefore competition with this species at market.

The most valuable species of sparid on the Mediterranean markets is *Dentex dentex*, which reaches a retail price of €18-20/kg in Malta and even higher levels in Italy. Much work has been undertaken concerning broodstock management and hatchery-rearing methods, but a number of serious constraints to its mass culture have emerged, including high larval mortality rates, nutritional problems and high levels of cannibalism. For this reason interest in the commercial production of this species is now negligible.

The commercial production of the sharp-snouted seabream *Diplodus puntazzo* has been more successful, and significant quantities of hatchery-reared juveniles were available during the 1990's, mostly from Italian hatcheries. Several cage operations produced this species, but interest declined due to a poor market and apparent market substitution between this species and gilthead seabream *Sparus aurata.* Market opportunities for the white Sea bream, *Diplodus sargus,* appear to be better since this species is better known on the Mediterranean markets, with large specimens reaching a retail price of €15-18/kg in Malta. Hatchery production methods are established, although further improvements in larval survival rates and nutritional requirements would be necessary to increase production to commercial scales, and further research and development into the production of a suitable formulated feed for grow-out is thought necessary to improve growth rates at this stage. This species is considered to have some potential for future aquaculture production.

The common sea bream, *Pagrus pagrus,* has a high market value, reaching a retail price of €18-20/kg in Malta and similar prices in Italy. Research has been carried out into the hatchery production of this species by a number of research institutes in Cyprus, Greece, Italy, Portugal and Spain and initial results have been promising, with a high growth rate and low mortality rates found during the grow-out phase. Further work is required to improve larval rearing methods and, more importantly, to address problems concerning pigmentation during grow-out which have been found to severely affect market acceptability.

Other species

A number of species have been considered for aquaculture development in Malta and the Mediterranean region in the past but are thought to have little potential for commercial development due either to biological or marketing constraints. These species include the following:

Name	Species	Main constraint to aquaculture development
Dolphinfish	*Coryphaena hippurus*	Low market price
Shi drum	*Umbrina cirrosa*	Competition with *Argyrosomus regius*
Senegal sole	*Solea senegalensis*	Not suited to cage culture, husbandry issues
Common sole	*Solea solea*	Not suited to cage culture, husbandry issues
Japanese sea bream	*Pagrus major*	Non-native species, marketing issues

6.2.3 Non-finfish production potential

The potential for non-finfish species in Malta must be based on an assessment of the physical characteristics and suitability of the Maltese coastline for such species. Most important of these characteristics is the low biological productivity of the central Mediterranean due to the lack of nutrients, which means that the commercial culture of filter-feeding molluscs such as mussels and oysters is not feasible.

Seaweed

Although lack of nutrients and the exposed nature of the coastline also rule out large scale culture of seaweeds, there may be potential for the culture of niche species. For example, the culture of marine peacock's tail *Padina pavonica* has been the subject of much interest in Malta, for use in the pharmaceutical industry, and this species is currently being used by Institute of Cellular Pharmacology (ICP) Ltd to prepare pharmaceutical products.

The peacock's tail, *Padina pavonica,* is a small species of brown alga growing naturally throughout the Mediterranean. It is very common in intertidal and shallow coastal areas in Malta, and has been 'cultured' by the laying of paving stones in suitable areas of seabed which act as a suitable substrate for the natural settlement of this alga. ICP Ltd produces a number of pharmaceutical, cosmetic and health products from the extracts of this species. Extracts of the *Padina pavonica* are used to make products which claim to improve the absorption of calcium by osteoblasts, and so act as a treatment for increasing bone density in humans. Extracts from this alga are also sold to cosmetics companies for the production of such products as anti-ageing skin creams and hair lotions, and to produce a range of animal feed additives, designed to promote the uptake of calcium in feeds for broilers, shrimp and finfish.

Padina pavonica is considered well suited for small-scale culture in Malta, since it has a requirement for calcareous rock as a substrate for growth. ICP Ltd currently consume in excess of 10 tonnes of this product, 50% of which is imported as a dried product and the remainder either harvested from the wild or cultured in Maltese waters. The potential for the production other species of seaweed is probably extremely limited, mainly due to the lack of availability of suitable areas of shallow seabed needed for mass production, the large quantities of seaweed required by the industry and strict permitting regulations for shallow coastal development which may affect existing seagrass beds.

Cephalopods

There is interest in the culture of cephalopods, especially octopus (*Octopus vulgaris*) and cuttlefish (e.g. *Sepia officinalis*) due to their high value and rapid growth. However, progress towards commercial production has been relatively slow. Octopus has been ranched commercially in Spain using inshore sea cages, but with marginal economic results (Garcia Garcia et al, 2004). The two major constraints have been lack of juveniles (hatchery techniques are being developed, but survival rates are very poor) and lack of suitable artificial diet (they have mainly been fed on trawl bycatch). Cuttlefish have a simpler lifecycle, a faster growth rate, and can be cultured at higher density, but so far diets have been restricted to live prey (sometimes enriched) such as grass shrimp. This, together with other factors, has so far restricted their culture to tank systems. Research on cephalopods is being undertaken in many countries including Spain and Portugal. If current technical obstacles were overcome, octopus culture could be interesting for Malta, but for the foreseeable future is likely to be restricted to inshore cages which are unlikely to be supported by environmental and planning authorities.

6.2.3.1 Integrated Multi-trophic Aquaculture

Integrated Multi-Trophic Aquaculture (IMTA) production systems involve the culture of two or more species together, typically a nutrient producing finfish species and nutrient extractive species such as macro-algae and filter feeders. Thus whilst the ambient waters of Malta lack the nutrients to support such nutrient extractive species, they may thrive if placed close to land based farm outlets or fish cages, at the same time minimising the environmental impacts of nutrient discharges from such operations.

There are a number of marine invertebrate species with commercial value that support a local fishery in Malta and other southern European countries and which might be amenable to IMTA systems, for example the following non-predatory marine invertebrate species:

Name	**Species**	**Retail value, Malta**
Warty venus	*Venus verrucosa*	€15/kg
Date mussel	*Lithophaga lithophaga*	to confirm
Sea urchin roes	*Paracentrotus lividus*	€80-100/kg

The high market prices of these species suggests that their culture could be economically viable, and research and development into the viability of the culture of these species in integrated multi-trophic aquaculture systems, in collaboration with existing finfish cage farm operations in Malta, should be pursued. Other Mediterranean species of bivalve of commercial importance, such as *Ruditapes decussatus* and *Callista chione*, both of which are currently imported into Malta from Italy, should also be investigated for production by way of IMTA techniques.

A number of studies have demonstrated the viability of mussel culture in the vicinity of cage finfish production systems, where the mussels are found to feed on particulate waste derived from the feeding of fish pellets, and such production systems could be the subject of further research in the Mediterranean using caged finfish, as a means of alleviating nutrient inputs in the environment and employing the increased nutrient levels to improve productivity of filter-feeding organisms such as clams (Chopin et al, 2007). Studies in the Bay of Fundy, Canada, have failed to detect excessive levels of medicines, heavy metals or pesticides in mussels grown under IMTA systems involving salmon cages. The Scottish Association for Marine Science in Oban, Scotland has been carrying out detailed research into the integrated culture of salmon, bivalves, urchins and seaweeds, and the results of this work could be used to assess the feasibility of projects of this kind in the Maltese environment.

In conclusion, however, it is considered unlikely that non-finfish species, whether in IMTA systems or otherwise, have a significant part to play in Maltese aquaculture. However, there may be niche opportunities for the production of high value species on a small scale at selected locations.

6.2.4 Scope for integration with offshore wind generation

The proposed wind farm at Is-Sikka L-Bajda would occupy a large area of Bunkering Area One off the east coast of Malta (see **Figure 21**). The MRRA, which is behind the project, is interested in exploring ways of reducing the cost of offshore wind generation and has expressed interest in the potential of aquaculture in achieving that aim. For example, an aquaculture operation located within the wind farm site, assuming such a location offered a greater advantage than being located elsewhere, could help to offset the cost of the lease to the wind farm operator. Probably the most significant benefit however to integrating aquaculture with wind farming, given the pressure on marine space in Malta, is that of multiple use.

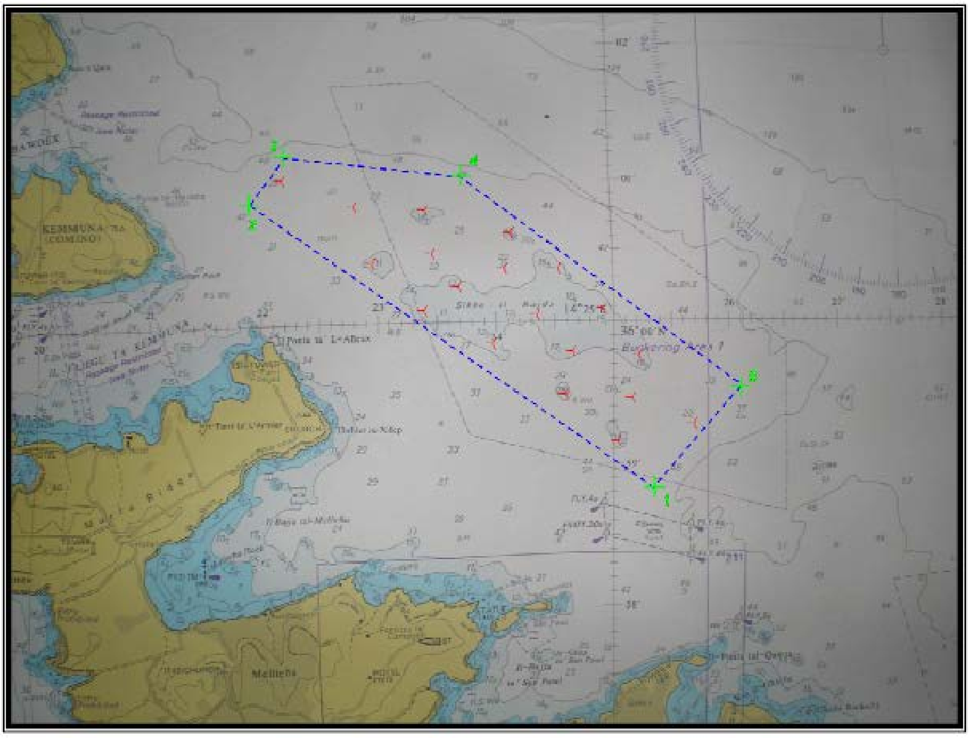
In assessing the feasibility of this option a number of issues would need to be taken into account, including:

- The relative income generating potential of aquaculture on the site compared with the revenue from the wind farm
- The suitability of the site for aquaculture e.g. shelter, depth, sea grass meadows
- The risk of aquaculture installations or service vessels causing damage to underwater cables and the turbines themselves, leading to higher insurance costs

- The risk of turbine maintenance vessels colliding with aquaculture installations
- The restriction on access for maintenance of the turbines
- The sub-leasing of a site within the wind farm area to an aquaculture operation

In reality, the relatively shallow nature of most of the site and the extensive sea grass meadows may rule out possibilities for aquaculture.

Figure 21. Indicative offshore wind turbine layout at Is-Sikka L-Bajda



Source: MRRA, 2009

6.2.5 Scope for new systems

At present most successful commercial offshore farm operations employ HDPE circular cages, due to their exceptional strength, flexibility, simple design, relatively low cost, ease of construction and resistance to corrosion. Consequently, HDPE designs can be considered the state of the art at present for offshore fish production systems. The very largest HDPE cage designs, such as the 3 x 450mm ring Fusion Marine Triton cage, are exceptionally strong and can withstand most storm conditions (although the mooring system employed and the net strength will affect the survivability of the whole cage system). Manufactured cages of this type range in size from a circumference of 60m (19m diameter) to 150m (50m diameter), equivalent to a cage volume of 3000m^3 to over 30,000m^3 depending on net depth. The larger cage designs are normally employed in the tuna penning industry where large cage volumes are required (due to the large size of the fish and the low stocking density employed). Cage cost will depend on the number of floatation pipes used and the stanchion design, but is typically €2-3.5/m3 for existing proprietary cage designs.

Over the past 20-30 years a great deal of research and development has been carried out in the design of more complex offshore fish holding systems, typically employing manned barges and submersible cage systems, with the aim of allowing aquaculture operations to be carried out in the open sea, far from competing users of coastal marine resources. Manned barges have however proved too expensive and complex with respect to the existing economics of fish farming activities.

Submersible cages offer the advantage of being able to keep the fish stocks well below the surface of the sea during periods of extreme weather, and so out of the main area of wind generated waves and surface currents. This could be of particular value to offshore finfish aquaculture in the Maltese environment, which is subject to regular periods of significant wind and wave action. It could also address the need for relatively sheltered water for the rearing of juvenile fish during the nursery period, assuming surface currents could be avoided.

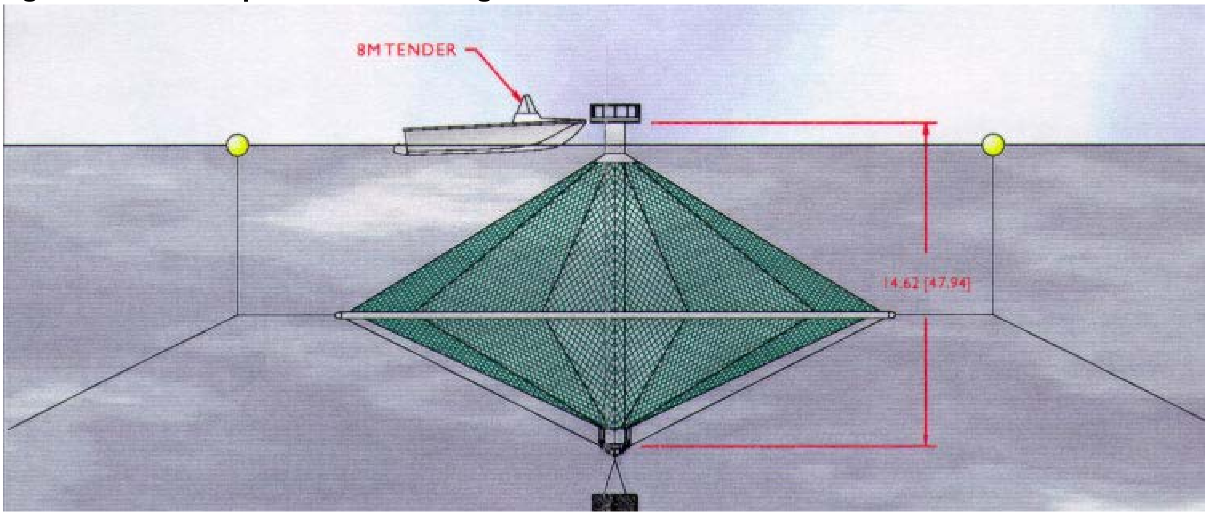
Submersible cages also require a working depth of 50-100m, which again would suit the conditions in Malta, where there is strong competition for coastal resources.

Although now considered relatively dated designs, the main fully-submersible cage systems currently in use are specially designed HDPE circles, 'Oceanspar cages' and 'Aquapods'.

Submersible HDPE circular cages are similar to conventional HDPE circles, with the exception that some of the floatation pipes are blanked off and can be either flooded with water or filled with air, and thus act as floatation or ballast tanks. These cage systems require a well-fitted top net (to prevent the escape of the fish stock) and a suitable mooring system that will allow the cage to be securely held at the required depth. Typically this would involve a conventional mooring grid system, from which the cage will be suspended when submerged. Although the most cost effective design of submersible cage, these systems have not proved popular, mainly due to the difficulty in maintaining a balanced sinking or floating action with such a flexible cage design. Typically, during either the sinking or floating of the cage, due to water movement and the flexibility of the cage, the cage will take on a vertical posture in the water, leading to a severe loss of net volume and the consequent crowding of the fish stock. To date an effective system for the balanced flooding or floatation of this cage design has been lacking. The maximum holding volume of such cages is limited by the flexibility of the cage which affects the issues outlined above concerning problems in cage attitude during sinking and floating, and so would be most suited to smaller cages (for example 60m and 70m circumference cages) with a normal holding volume of 2200-4600m^3.

The OceanSpar Sea Station cage, designed and built by the US company Ocean Spar Technologies, consists of an upright galvanised steel spar from which a bi-conical net is stretched (see illustration below). The cage is designed to be moored at depths of 40-50m, so that the top of the cage is at a depth of around 8-10m. The cages can be moored individually by way of radial moorings, or in a group, within a submerged high-tension mooring grid system. The cages may be raised to the water surface for various husbandry operations. Cage volumes of up to 6000m^3 are produced. Access to the cage is through a small access zip.

Figure 22. Ocean Spar submersible cage



Because the cages are normally positioned underwater, all normal husbandry operations are complicated by the difficulty of access to the fish stock. Feeding can only be observed by underwater camera systems, and such activities as grading, fish transfers and harvesting need the cage to be positioned at the water surface. In addition, nets cannot be changed, and therefore complicated methods of net cleaning need to be devised. But the main disadvantage of cages of this type is the very high cost – Ocean Spar cages cost an equivalent of €20-35/m^3 – and considerably more if mooring and installation costs are added (Aquaculture Development Council, 2007). This makes them uneconomic for most forms of commercial aquaculture.

Another submersible cage design currently on the market is the 'Aquapod'. This cage design, marketed by Ocean Farm Technologies of the USA, consists of individual triangular net panels fastened together in a geodesic spherical shape. The cage is manufactured from reinforced HDPE, and uses plastic-coated galvanised steel wire netting. The cage is designed to be moored underwater, and thus avoid surface wave action during storms, and, like the OceanSpar, can be lifted to the surface by way of ballast tanks for surface –based husbandry and maintenance operations.

Figure 23. Aquapod at water surface, Panama

The disadvantages of this cage design are similar to those of the Ocean Spar – namely the high cost (€30/m^3) and the inherent difficulties involving the husbandry operations of a submerged cage. Another disadvantage of this particular cage is that an adequate mooring system is yet to be designed for it. The cage manufacturer supplies cages in a range of sizes between 8m diameter (115m^3) and 28m in diameter (11,000m^3).

Submersible cage designs have a high relative cost compared with surface cage designs due to the fact that actual cage volumes are limited for structural reasons, and normally require expensive support and ballast infrastructure not required in surface cage designs. In addition, complex mooring systems are also typically required to maintain the cages at the chosen depth of water. Running costs are also typically higher than surface cage designs, with complex feeding and harvesting systems required and a need for skilled teams of divers for routine husbandry operations. Nets cannot be changed, and so complex systems for net cleaning normally need to be employed.

6.2.6 Offshore aquaculture – limitations and implications

Most definitions of the word 'offshore' imply a position 'at some distance from shore'. In aquaculture, the term 'offshore' also has implications with respect to exposure to weather and water depth.

6.2.6.1 Distance from shore

In general terms, the further the fish cage production unit is positioned from the shore base (or ship-based or platform-based installation) the higher the fuel costs for operating that site. Beyond a certain distance, typically around 10km, some form of manned floating workstation is required to allow efficient husbandry operations to be carried out, primarily feeding and inspection and maintenance work but also harvesting. To date, such work stations have proved expensive to operate. There are also security implications for fish production sites situated beyond visual sight from the shore, and so complex and expensive security arrangements may need to be implemented.

In order to carry out daily husbandry operations efficiently in offshore locations, if personnel are unable to visit the fish holding facility regularly for such tasks as feeding, some form of automated system would typically be required. Feed barges are employed in certain sectors of the aquaculture industry, particularly the salmon industry, and can increase production efficiency significantly under certain conditions. However, such systems are not normally well suited to offshore sites with extreme weather conditions. The systems that are, such as the concrete circular Gael Force feed barges, still require regular servicing from supply vessels to load feed. In addition, because of the very high cost of such facilities (often in excess of €1 million, depending on size) they are only cost effective where the total tonnage of production if very high (for example, thousands of tonnes) and where labour costs are high.

6.2.6.2 Exposure to weather

The open waters of the Mediterranean Sea are regularly subject to storms of wind force 8, gusting to 9 and 10, with wave heights in excess of 7m and strong surface currents (often in excess of 2 knots). Such conditions are extremely challenging for the cage and mooring infrastructure, net integrity and the health of the fish stock in floating aquaculture production systems. Those species of fish more suited to inshore waters, such as seabream and meagre, and in particular juvenile fish of all species, are unable to endure extreme turbulence, wave and current action. In addition, more modest weather conditions can still prevent routine husbandry operations from being undertaken, such as feeding, maintenance and repair work and harvesting, and therefore lead to loss of growth from missed feeding days, an increased risk of fish stock losses from missed days of maintenance and repair, and marketing problems from being unable to harvest and supply fish to buyers who require deliveries on a regular basis. Such problems increase the cost of production of fish stock produced in exposed offshore conditions considerably.

The extreme weather conditions also require a significant increase in investment into cage equipment, moorings and nets which can withstand such conditions. Such fixed costs of an aquaculture operation can be significant, and when added to the higher production costs of servicing offshore sites can quickly render such operations unable to compete with other inshore production systems and production from other countries with a greater availability of inshore locations for aquaculture development.

For this reason, most fish cage production systems are sited in sheltered waters where some degree of protection is afforded from prevailing winds and wave action. Because of the shape of the island of Malta such protected waters will only be available in inshore locations on the east coast. The aquaculture zone off the south-east coast of Malta, for example, is situated in an extremely exposed location, and is regularly subject to extreme weather, such as wind speeds of force 8-9, wave heights in excess of 5m and surface currents of over

3 knots. Over the past 3 years two of the tuna penning operations at this site have suffered total losses of both fish stock and cage infrastructure, bringing both operations to the point of financial collapse. For this reason, investors are difficult to find for such operations, insurance cover is either very expensive or unavailable and business plans need to factor in a high risk of stock loss in order to approach profitability.

In addition, such sites as the offshore aquaculture zone are only able to produce those species of fish large and robust enough to withstand these conditions, such as adult bluefin tuna and possibly large amberjack. Other smaller, demersal species of fish are totally unsuited to such conditions. Such locations require the use of large mesh nets to reduce the drag effect of surface currents and wave action, which limits such facilities to the production of large species of fish. Consequently such exposed conditions are totally unsuited to the nursery production of all fish species and the on-growing production of such fish species as seabream, seabass and meagre.

6.2.6.3 Water depth

With increasing water depth and increasing exposure to extreme weather conditions, the mooring system of floating cage installations requires an additional investment in the increased strength of the mooring components, and the increased quantity of such mooring components as rope and ground chain. This leads to a significant increase in the fixed cost of a deep-water offshore fish production unit. In addition, any water depth beyond the limit of standard, safe commercial diving operations, required for mooring inspections and maintenance work, typically around 40m, necessitates the use of expensive remotely operated underwater vehicles (ROVs) and underwater cameras for such inspection procedures, and significantly complicates the repair and replacement of mooring components.

6.2.6.4 Summary

Although offshore conditions may have some advantages for the fish production process, such as the availability of high water quality, fewer impacts from land-based drainage, with more stable temperature, salinity and dissolved oxygen levels, such conditions are also available at well-chosen inshore locations. Once a floating fish production system is sited a) more than 10km offshore, b) in totally exposed waters and c) at water depths of more than 40m, the fixed costs of the fish farm installation, maintenance and repair costs, and the production costs of the fish stock increase dramatically, almost certainly beyond the cost benefits of any of the advantages achieved from improved water conditions at such sites. Commercial aquaculture is an extremely competitive business, and any significant increase in production costs can quickly lead to loss of profitability and the subsequent closure of such operations.

Tuna penning is perhaps an exception to this rule, due to the need to be located offshore to reduce the effect of the feeding of fresh fish on water quality in coastal areas, and the greater size and depths of the holding nets employed for tuna production. Adult bluefin tuna are also well suited to open ocean conditions. Although proximity to the coast is necessary for the regular delivery of feed, harvesting directly onto fish processing vessels at sea further limits the need of such facilities to be sited close inshore. Lastly, the bluefin tuna penning industry is less competitive than the seabream and seabass production industry, for example, and may possess the financial flexibility to be able to withstand the additional costs inherent in operating in offshore conditions.

Therefore, some distinction needs to be made between the tuna penning industry, which may be capable of operating in offshore conditions, and more conventional closed-cycle production of such finfish as seabream, seabass, meagre, grouper, amberjack, etc. Nursery production, in particular, requires sheltered inshore waters due to the small size and delicate nature of the fish, use of fine-mesh holding nets (typically 5mm at the introduction of fish juveniles), and the need to feed at regular intervals with a very fine-grained feed product. Husbandry operations required for smaller fish, such as bath treatments, grading and vaccination, also require calm conditions and a proximity to shore to be carried out in an efficient manner.

6.3 Market opportunities

6.3.1 Introduction

The development of a sustainable aquaculture industry in Malta is highly dependent on having secure market outlets for its products. As already indicated in Section 4.1.8, sales of bluefin tuna are almost entirely dependent on the Japanese market which can also fluctuate markedly from year to year. At the same time, the prospect of Japan developing its own closed cycle production of tuna may limit the market for tuna produced elsewhere, although this is considered unlikely in the short to medium term.

As also already indicated in Section 4.1.8, Malta has a long established presence in the Italian market for seabream and seabass, and a recognised national identity. It is however at the mercy of the cyclical nature of the Mediterranean industry as a whole, with prices fluctuating from below the cost of production to those allowing a good return to be made. There is therefore a need to differentiate the Maltese product to better protect it during downturns.

This section considers the market outlook for CCS and tuna and looks at the prospects for product diversification and improved marketability.

6.3.2 Market outlook

The market for Maltese aquaculture products has always been volatile. Bluefin tuna prices have been very sensitive to supply and demand, although the use of freezing places some limits on this. The main market is Japan for largely traditional reasons. Prospects for market diversification are limited as long as wild stocks are considered to be under severe threat. Events such as the 2011 earthquake and tsunami may be expected to reduce demand, but supplies are also constrained, so prices are unlikely to fall substantially. Looking to the future, the main issue is whether the industry can be placed on a sustainable basis through well managed fisheries, or full-cycle aquaculture. However, this will remain a high value species with limited market for the foreseeable future.

Sea bass and sea bream markets have also been variable, with seabream prices being particularly depressed in 2008 and 2009, although strengthening significantly in 2011. Both species have mainly sold in traditional Mediterranean markets as whole fresh fish with limited differentiation from capture fisheries supplies, not least as the farmed product is often perceived as inferior by consumers (usually due to adverse publicity rather than actual differences in product). With relatively low fillet yields and high production costs, value added products based on fillets can be uncompetitive with many competing whitefish products both from capture fisheries (cod, pollock, haddock, hake etc.) and aquaculture (mainly pangasius). Nevertheless, there are increasing examples of processed sea bass and sea bream entering the market chain and achieving greater distribution into Northern Europe than was previously the case. Even in core markets retail sales are increasingly driven by supermarkets. In Italy for instance, the share of fish sales going through traditional fishmongers has fallen from around 90% in 1990 to around 25% in 2008, whilst sales through supermarkets have risen to almost 70% (Barazi-Yeroulanos, 2010). Although larger supermarkets include fresh fish counters, the bulk of sales are driven through frozen and value-added pre-packed products. There is also a trend towards ready meals and chilled food that requires no further preparation. Overall expectations are that limited growth is possible mainly through expansion of the market for sea bass and sea bream into Northern and Eastern Europe in processed formats (with seabass remaining much more important than seabream). For these species to compete for volume with mainstream white fillets the cost of production would need to be reduced by at least 50%.

With regard to the domestic market in Malta, in 2004 it was estimated to be in the region of 2,600t (FAO, 2011). Given the low per capita consumption of 6.5kg this equates to, and the limited consumption of only around 100t of CCS species (predominantly seabream), there is clearly scope for increasing consumption of CCS on the domestic market.

6.3.3 Product diversification and improving marketability

There have been a number of reviews of the Mediterranean aquaculture section (which is principally sea bass and bream) which have recommended greater focus by producers on final markets (e.g. University of Stirling, 2004, Monfort, 2007 and Barazi-Yeroulanos, 2010) rather than just production. This implies examining the changing needs and wants of consumers and the competitive environment for all aquatic food products. The market for whole fresh fish is still the most important for sea bass and bream, but is becoming a gradually smaller proportion of the total European market. Changing lifestyles and patterns of retailing are increasing the opportunities for value-added products. However, whilst the unit prices of such products can be very high, the value of the original raw material within them can remain fairly low. Additionally, few producers are able to make the investments necessary to enter this market, and indeed it is increasingly controlled by the supermarkets that prefer to place their own branding on the products and capture all the added value.

Figure 24. Value added sea bass fillets sold chilled in the UK

There are an increasing range of fish-based products aimed at lunch or light snacks in addition to main meals, capitalising on the healthy image of seafood and delicate flavours and textures. The challenge for the sea bass and sea bream industry is whether these species with their lower fillet yields can capture sufficient extra value over other white fish. Consideration could be given to whether there are any traditional Maltese preparations for these fish that could form the basis of a unique value added product. However, producers in Malta are also faced with insufficient production at present to justify a major processing plant, and little existing fish processing in Malta which might form the basis for further investment.

Example sea bass products at a UK supermarket (Waitrose, June 2011)

Fresh Anglesey sea bass fillets	€31.46/kg
Fresh Anglesey sea bass with fennel butter (head off)	€32.42/kg
Fresh Anglesey whole sea bass	€16.85
Own label Seabass fillets with ginger and spring onion (MAP)	€22.45
Own label Greek sea bass fillets with fennel butter (MAP)	€31.21/kg
Own label Greek sea bass fillets (frozen)	€30.10/kg
NES* label rocket and pesto sea bass fillets (MAP)	€31.20
NES* label rosemary and lemon sea bass fillets (MAP)	€33.67

*New England Seafood

Note: for comparison only one sea bream product was available (fresh Greek sea bream at €16.85 /kg) and 116 salmon products.

The Fisheries Operational Programme for Malta (2007-2013) states "The fish processing industry in Malta is very limited. This relates mainly to aquaculture harvesting and packing with little or no value added. There is also some limited activity relating to capture fish both local and imported, both fresh and frozen. In this case some activity in terms of slicing, filleting, portioning, rewrapping and smoking takes place. The main reason why this activity has remained rather limited is that the local catch usually consists of high-value fish which is consumed in its fresh state or indeed exported."

The market for whole fresh fish however is not entirely homogenous. In general, larger fish are worth more per kg than smaller fish (although this can vary during the year and in different markets). As it is more expensive to produce larger fish, fewer are placed on the market and therefore the potential market is not fully satisfied and the prices are higher. At least one Maltese producer has found it profitable to produce a proportion of larger sea bass and seek out premium markets for this product.

Table 13: Sea bass European average prices by size grade (€/kg)

GROUP	PRODUCT	2005	2006	2007
Sea Basses	European Seabass 400/600 gr	4.82	4.58	4.79
	European Seabass 200/300 gr	3.38	3.09	3.26
	European Seabass 300/400 gr	4.42	3.95	4.39
	European Seabass 600/800 gr	6.25	6.61	6.24
	European Seabass 800 gr /1 kg	9.17	9.06	9.37
	European Seabass 1 kg +	10.1	10.43	10.91
Sea Basses Total		**4.72**	**4.72**	**4.94**

Source: FEAP

Table 14: Sea bream European average prices by size grade (€/kg)

GROUP	PRODUCT	2005	2006	2007
Sea Breams	Gilthead Seabream 300/400 gr	4.23	4.09	3.95
	Gilthead Seabream 200/300 gr	3.53	2.99	2.68
	Gilthead Seabream 400/600 gr	4.54	4.3	4.16
	Gilthead Seabream 600/800 gr	5.94	6.25	5.6
	Gilthead Seabream 800 gr /1kg	8.82	8.54	8.45
	Gilthead Seabream 1 kg +	10.2	9.96	9.61
Sea Breams Total		**4.54**	**4.31**	**4.15**

Another attribute of fresh whole fish is of course their freshness and condition (for instance bright skin colouration is considered desirable in gilthead sea bream). Some premium may be obtained in relatively local markets. Other differentiation factors that Maltese producers can potentially exploit are quality of service (responsiveness to orders, reliability of deliveries, consistency of quality etc.) and strength of business relationships (e.g. financial arrangements, diversity of products supplied, readiness to assist with sourcing from other suppliers when necessary).

One of the most visible differentiation strategies for small aquaculture producers in Europe over the past 10 years has been via organic certification and labelling. This route is being developed by some French and Greek producers (and probably other countries as well) with standards in place by AB Bio (Agriculture Biologique - France) and Naturland (Germany). A price premium of at least 15% can be achieved for organic produce (Barazi-Yeroulanos, 2010), but production costs are usually higher due to both management methods and the overhead of applying the certification scheme. The organic "label" encompasses a range of attributes that are considered desirable by consumers; for instance care for the environment, minimal use of pharmaceutical and other chemicals, animal welfare and often social benefits of supporting smaller producers.

The market for organic produce is relatively small and a range of other labelling schemes have appeared which potentially dilute the value of the organic "brand". Most are essentially eco-labels which focus primarily on responsible production methods and minimisation of environmental impacts, but there are also specialist welfare labels and social good labels (e.g. fair-trade). For capture fisheries the most important label has been the Marine Stewardship Council blue fish logo to certify products from sustainably managed fisheries. This was originated by WWF who have now developed standards for some aquaculture species with certification to be managed through a new Aquaculture Certification Council. Also significant internationally is the Global Aquaculture Alliance Best Aquaculture Practices Certification and the independent Friend of the Sea scheme. The ACC and GAA have yet to introduce standards for Mediterranean aquaculture but at least one farm in Spain and one in France are producing sea bream certified by Friend of the Sea.

Also significant is retailers own brand labels which provide quality assurance and may also encapsulate environmental and social values. For instance Coop Italia market seabass and seabream under their own brand label whilst Carrefour (France and Italy) market under the "Filiera de qualita" brand. The UK supermarkets have adopted a three tier private label strategy (basic, standard and premium). Whilst ethical values may be highlighted more clearly in the premium range, the differentiation also includes ingredients and recipes. The key factors is perhaps the requirements placed on producers who supply for these labelled products as the retailers need to ensure the product meets the standards advertised. For this, retailers often rely the Global GAP scheme and on other quality assurance schemes such as ISO 9001 and ISO 14001 involving independent certification to provide business-to-business assurance of quality management including HACCP and optionally elements of environmental and social good practice.

Within this wide landscape of quality and certification schemes are those promoted by retailers, government agencies, the industry themselves, and private organisations (NGO and commercial). Whilst it is unclear which if any scheme will come to predominate in the future, it is certain that the management and sustainability of production operations will come under increasing scrutiny with rising standards and increased requirement for third party certification by the market. The adoption of these quality and certification schemes will not be a means to add value to products but rather a necessity for market access. As it takes time to develop appropriate quality management procedures and to train staff, this will need to be an area of attention within the future strategy for Maltese aquaculture. A model adopted by some industries is the development of a code of best practice which is a voluntary standard promoted by the industry as a means to enhance reputation. It is also a useful way of introducing best management practices without the overhead costs of a formal certification scheme.

The development of new products based on sea bass and sea bream is therefore possible, but challenging, especially those requiring significant secondary processing. Some companies have attempted their own branding of fresh and primary processed product, but this requires substantial investment in marketing to have any noticeable effect in the market and is often resisted by retailers and other market chain participants who prefer flexibility of supplier and use of their own label. With respect to new products therefore, most attention has probably been given by the industry to new aquaculture species.

The possibilities for new species are discussed in Section 6.2.2. In commercial terms, most progress has been made with meagre/corvina (*Argyrosomus regius)*. This has many desirable features for the market (good shape, firm flesh, low fat, excellent taste, good yield), but is relatively unknown in the market place and the dark colour has proved a barrier (Monfort, 2010). It is therefore currently sold as a niche market product with limited volumes. Prices are generally better for larger fish, which in any case are relatively more economical to produce due to higher fry cost but faster growth and better feed conversion efficiency. Potential exists to develop higher value processed products utilising fillets, stakes, pieces or cubes to develop a variety of portion-sized pre-packed products including smoked, breaded, battered, marinated or with sauce etc. It also has good potential for sales to the increasing number of Japanese sushi restaurants. However, to achieve a sufficiently high price for producers, it would be desirable to identify the source material and provide strong marketing support to develop the image of the product in the marketplace. This objective is probably well beyond the means of the existing producers in Malta, but cooperation with Italian or French companies might prove a viable strategy. Further feasibility and market study work is required to develop this potential.

The case of the amberjack (*Seriola dumerili)* has also been discussed in Section 6.2.2. This is an attractive fish that already sells well into the traditional fish markets as well as having potential for value-added products. According to one company, prices for whole fish are better for the smaller portion-size as they compete favourably with portion-size bass and bream. This can be an advantage for most fish, as shorter lifecycles can be translated into higher production per unit of capital employed. However, whilst the production cost of the fry is very high (which is anticipated to be the case for some time as technology is still being developed and refined) this benefit could be outweighed. The optimum strategy may again be to utilise the fast growth of the fish and sell at a larger size for a wider variety of value added products. Amberjack has an existing reputation as a quality ingredient for sushi and sashimi and is very adaptable to a wide variety of prepared products including Asian or American style marinated fillets or pieces. As a steak product it is perceived as being in competition with swordfish, which has limited its price. However, as supplies have been relatively low, it does not have a regular place in the pre-packed fish range or as a catering staple so there is scope for substantial market development. It would therefore be very advisable to develop an active marketing strategy alongside any development of production capacity in order to exploit the full potential of this species.

Although the longer-term future for both meagre and amberjack could be in processed product for consumers, the closest international market is Italy, which has a particularly high share of seafood distributed through the hotel, restaurant and institutional sector. This is a fragmented sector with over 130,000 outlets (www.foodexport.org) offering great potential for niche products. However, it will also be looking for maximum value and perhaps only primary or limited secondary processing. A market development strategy might therefore be to focus on raising the profile of the species through higher-end restaurants and associated promotion and then focus on consumer products once production volumes are higher and the reputation of the fish is better established. The sustainability of aquaculture product, especially in comparison with wild-caught swordfish and other carnivorous species should be a positive factor in marketing. The existence of quality assurance and eco-label schemes would further strengthen claims for sustainability and product quality.

These general conclusions are in broad agreement with Malta's Strategic Plan for Fisheries 2007-2013 which envisages both investment in processing and packing facilities for fisheries and aquaculture products and marketing and promotional campaigns. That plan states that "To be more competitive Malta requires further investments in its processing and marketing establishments. Malta intends to direct its investments with a view to improve product quality and presentation, and hence their value-added and may also consider investments in new technologies such as developing electronic commerce. Employment within this sector has to be increased and preserved through investments in better working conditions and vocational training, improving and monitoring public health and hygiene conditions on the place of work (HACCP audits)." It goes on to say that "Due to the small size of the internal market, the administration considers that the Maltese sector needs to tap foreign markets better if the local industry is to achieve growth. Thus Malta intends to concentrate on developing new markets for its products and new products for established markets. Funding will be made available for promotional campaigns of Maltese products in new markets and to encourage the participation of Maltese producers in fairs and expositions. To encourage consumer confidence in Maltese products, Malta also intends to develop brand names and improve the traceability of these products."

The implementation of international certification schemes (at least business to business) would be a strong first step towards these goals with substantial processing capability a secondary aim once production volumes justify such investment. The cost of this can vary widely, depending on the current status of producer facilities and management procedures, and the demands of the chosen certification scheme. Typically the implementation of such schemes will require consultancy assistance and training and probably the purchase of some equipment or software and possibly additional staff. The cost for this can typically be €10,000 -50,000 for small companies. Individual certification schemes will then have a membership and inspection fee structure costing between €500 and perhaps €5,000 per year (more for larger companies). As an interim step, the Maltese industry could develop a set of voluntary standards, using FEAP and other codes of practice as a guide. These do not have the same degree of credibility in the market, but are better than no standards at all. Any of the mainstream aquaculture certification schemes will encompass EU and national standards in addition to voluntary standards. Cooperation between companies would be beneficial however, both in sharing implementation costs and enhancing the overall reputation of Maltese aquaculture.

The investment costs for fish processing depend on the type of processing to be carried out and the daily throughput volume. This is linked with the sophistication of the machinery required and aspects such as hygiene controls. Basic filleting and perhaps freezing or packing operations can become financially viable with throughputs of 10-20 tonnes per day. More sophisticated plants might require throughputs of at least 50 tonnes per day to be financially viable with the largest able to process 200-300 tonnes per day. A small plant might require an investment of at least €1.5 million, whilst the largest can involve investments of up to €100 million.

6.4 Supporting research needs and sources of finance

6.4.1 Research needs

Aquaculture is essentially a multidisciplinary activity, combining aspects of biology, engineering, marketing and management with inputs from environmental, veterinary and other specialities. Each of these areas requires research and development support, especially for new activities, or the establishment of existing activities in new environments. With a relatively small research base, it is necessary for Malta to seek to integrate aquaculture into wider research and technological development programmes and utilise international collaborations where appropriate to access expertise not otherwise available.

The starting point for assessing research needs is a review of current constraints and future ambitions for the sector. The latter are set out in strategic plans and focus on continued development of offshore aquaculture and the exploitation of new species, although the potential for landbased aquaculture using recirculated systems is also highlighted. Engineering, both offshore and onshore can to some extent be accessed from other sectors, although adaptation for aquaculture is certainly necessary. More specialist is the specific biology of the species to be cultured, the key areas of which are summarised in the following table with respect to the main species cultured in Malta.

	Bluefin tuna	Amberjack	Meagre	Bass & bream
Reproductive physiology, broodstock management & spawning	Still early stage, but spawning in captivity achieved	Early stage but broodstock successfully maintained and spawned	Procedures well established and commercial hatcheries operating in other countries	Procedures well established and commercial hatcheries operating
Larval rearing, development, cannibalism	Very early stage	Early stage	Well developed but issues with survival and deformities	Well developed but issues with survival and deformities
Larval nutrition (including live feeds)	Very early stage	Early stage	Reasonably well developed	Well developed
Juvenile & adult nutrition	Early stage, no commercial products yet	Early stage, no specialist products yet	Reasonably well developed	Well developed
Health and welfare including disease diagnosis and management	Early stage, no therapeutants or vaccines yet	Early stage,	Relatively early stage, no specific products	Reasonably well developed with some specific products
Genetics, selective breeding,	Very early stage	Early stage	Early stage,	Selective breeding programmes underway
Environmental requirements (water quality etc.)	Early stage	Moderate knowledge	Reasonable knowledge	Good knowledge
Environmental interactions	Early stage, further work required on all aspects	Moderate knowledge, further work required on carrying capacity and mitigation measures	Reasonable knowledge, further work required on carrying capacity and mitigation measures	Reasonable knowledge, further work required on carrying capacity and mitigation measures
Social, economic, market	Potential future constraint	Will be needed as production increases	Needed for further development	Urgent need to develop markets

The key elements of the required research are firstly expertise in the form of qualified human resources, secondly aquarium facilities for rearing the species under research and thirdly the laboratory and analytical infrastructure for nutritional analysis, water quality analysis, advanced imaging, and increasingly the equipment for genomic studies and bio-informatics.

Some of the required facilities are present at MARC, but space for broodstock and larger juveniles is very limited, as are live-food facilities. The centre also has very limited laboratory equipment, especially with respect to more advanced analytical, imaging and genomic techniques. Collaboration with The University of Malta or other institutions that might be able to provide access to such equipment and the necessary expertise to work with them is recommended.

6.4.2 Financial sources for research

Financial support for aquaculture research in Malta is limited. The Malta Aquaculture Research Centre (MARC) is the only significant facility for aquaculture research. Core funding is provided through the Ministry for Resources and Rural Affairs. MARC employs around seven staff of which only three are active researchers. The range of expertise available is therefore limited, as are facilities for more advanced scientific work such as biochemical analysis, genomic studies or microstructure imaging. Nevertheless, the MARC has established a successful programme of practical mariculture research and in recent years has operated as a joint-venture with Malta Fish Farming for the development of amberjack culture. This is part-funded through the commercial value of the juvenile output, which in addition to amberjack include sea bass and sea bream fry. Some funding has also come to the centre through participation in the EC RTD projects REPRODOTT and SELFDOTT and contract research for an International aquaculture vaccine company. The total annual research budget for MARC is not available, but is thought to be less than €0.5 million.

The main centre for general scientific research in Malta is the University of Malta. There is some coverage of aquaculture within the Department of Biology, although the main research interests of the three core academic staff are marine ecotoxicology, marine ecology and environmental interactions of aquaculture. In addition to core funding, the group have participated in EC FP7 RTD projects such as "Prevent Escape" in relation to aquaculture.

Apart from core institutional funding, the main source of national research funding in Malta is the Malta Council for Science and Technology (http://www.mcst.gov.mt/ which has a budget of around €1.1 million for 2011. An annual call invites proposals that focus on technology transfer between academia and industry by means of research projects lasting between one and three years and requiring funding of between €50,000 and €200,000. Priority is currently given to projects that address the four priority sectors of the National R&I Strategy, namely Environment and Energy Resources, ICT, Value Added Manufacturing and Health and Biotech. However, only one aquaculture project has been submitted since 2006 and none funded.

There is potential for additional funding of aquaculture research through various European measures. The 7th Framework Programme for Research and Technology Development has already been mentioned, which incorporates a range of funding mechanisms. These include both "top down" and "bottom up" approaches, although almost all require international collaborations. The main opportunities exist in the Cooperation programme with its funding for collaborative research projects (top down), Capacities (e.g. research for the benefit of SMEs – which is mainly bottom up) and People, which if focused on mobility and training of researchers. Support is also potentially available to aquaculture SMEs through the Eurostars programme (http://www.eurostars-eureka.eu/) which is part of the EUREKA project for cooperation between European firms and research institutes. Access to EC RTD funding is becoming more competitive, but as demonstrated by existing projects, provides both a useful source of funding and a means of accessing wider European expertise for the benefit of the Maltese aquaculture sector.

Funding for research and innovation can also be found within the EC Structural Funds. The European Fisheries Fund does not directly fund research projects, but can be useful for industrial piloting of new innovations. Structural funds linked with the Cohesion Policy such as the European Regional Development Fund provides further facilities that could be useful for aquaculture research and innovation, most notably through the funding of infrastructures and specific schemes established by government agencies to support innovation in local SMEs. Malta's Cohesion Policy for 2007-2013 is being implemented through two Operational Programmes with funding from the European Regional Development Fund (ERDF) and European Social Fund (ESF). The first focuses on investing in competitiveness for a better quality of life and specifically on knowledge and innovation. This has three pillars of action. i) the upgrading of industrial space and expansion of incubation facilities), (ii) Enterprise aid schemes to the manufacturing and service industries to support the restructuring of local enterprises (managed by Malta Enterprise) and (iii) Investments in RTDI and related infrastructure and ICT. The second Operational Programme is concerned with the development of human resources in science, technology and engineering; mainly in higher education. The use of Regional Development Funding is based on the National Strategic Plan for Research and Innovation 2007-2013 (Malta Council for Science and Technology, 2006). Whilst there are a large number of measures within this programme with potential to support aquaculture research and innovation, aquaculture does not feature as a priority sector.

6.4.3 Possible models for engaging the private sector in research funding

The Malta Aquaculture Research Centre (MARC) is seeking to expand its facilities for researching breeding techniques for new fish species. The infrastructure required for such a setup would be common to that required for a new commercial scale hatchery. In this regard Government may wish to explore the possibility of partnering with the private sector for developing the common infrastructure required for a commercial scale hatchery and research facilities.

There are various public private partnership models which Government could consider depending on how the investment in the hatchery / research facilities would be funded and how the risk and rewards are shared between Government and the private sector. The following are three broad options which Government may wish to consider:

- Option 1: Investment in new hatchery / research facilities is carried out by the private sector and research facilities are leased out to Government
- Option 2: Investment in new hatchery / research facilities is carried out by a joint venture between the private sector and Government
- Option 3: Investment in new hatchery / research facilities is carried out by Government and the operation of the hatchery is awarded as a concession to the private sector by competitive tender

There are also a number of variants to the above options depending on

- whether the project is carried out on Government or privately owned land
- who would own the intellectual property (IP) from the research or how this IP would be shared between the private and public sector

In all cases it would be advisable that the private sector partner is selected through an international call for expressions of interest followed by a competitive process. Local operators may wish to group together to form a local consortium however it is equally possible that each of the local operators would act individually forming their own consortiums with overseas partners.

Out of the above three options, Option 1 is probably the most attractive particularly if Government provides the land and facilitates a smooth process in terms of planning approval. This again could be structured as an international call with Government setting out the broad project parameters including its research facility requirement and inviting competitive bids for the annual lease cost for the research facilities. The annual cost to Government under this option could possibly be reduced through an IP sharing agreement.

6.5 Establishing a production target

6.5.1 Potential production capacity

One of the key requirements of the TOR is to establish a production target, with a suggested deadline of 2025. In setting such a target, a range of factors need to be taken into account, including the following:

- Market demand
- Return on investment
- Availability of finance
- Site availability
- Quotas for tuna

Given the relatively small production potential of Malta in relation to the Mediterranean as a whole, the increasing demand for fish products, and the existing experience of Maltese producers, market demand is not considered to be limiting in the widest sense. Similarly, assuming that Malta is able to capitalise on alternative species know-how e.g. amberjack, the financial returns available at least in the early years should not be limiting in terms of attracting investment.

Site availability however is the most important factor limiting production of CCS in Malta and is thus most likely to determine future production targets. With regard to tuna, the quotas set by ICCAT are most likely to be limiting rather than sites, given their ability to survive in more exposed conditions and the greater range of site options thus available.

Taking into account the assessment of sites and carrying capacity, three potential production capacities are proposed which give guidance as to possible production capacity assuming different site availability and usage. It should be emphasised that the capacities illustrated here ***do not*** represent production targets: for tuna in particular, they represent possible site capacity based on historic ICCAT consents – actual production would depend on quotas and a host of other factors. The actual production that might be achieved is examined in Section 6.5.2.

Production capacity 1

Essentially reflects the status quo and permit conditions for existing sites, with no new areas allocated except for extension of sites G and H to allow tuna to be moved further offshore.

- No NE Zone
- All existing sites retained
- Such sites used for CCS with exception of SE Zone and AJD site E
- CCS capacity for sites A, G and H based on original PDG guidelines of 500t/site
- P2M sites unchanged
- Nursery production at Marsaxlokk site I
- New outer site G for tuna 2km from shore, 1500t (assumes shift in BA 4)
- New outer site H for tuna 2km from shore, 1500t (assumes shift in BA 4)
- Other tuna capacity as per current ICCAT permits

Resulting capacity: 2,500t CCS, 11,500 tuna

Production capacity 2

Reflects current policy intentions eg to move Comino site to new NE Zone, move tuna production from sites G and H further offshore

- NE Zone approved
- Assumes Comino site exchanged for 2000t CCS production in NE Zone
- P2M sites unchanged
- Other existing sites used for CCS with exception of SE Zone and site E
- AJD site E stays for tuna (permit not as flexible as for F&F and MFF sites G and H)
- CCS capacity 1000t/site
- Tuna capacity as per current ICCAT permits
- Nursery production at Marsaxlokk site I
- New outer site G for tuna 2km from shore, 1500t (assumes shift in BA 4)
- New outer site H for tuna 2km from shore, 1500t (assumes shift in BA 4)

Resulting capacity: 5,000t CCS, 11,500 tuna

Production capacity 3

Reflects retention of all existing sites, development of all potential new sites, all tuna farms moved further offshore

- All existing sites retained
- NE Zone approved
- P2M sites unchanged
- Newly identified sites approved
- Inshore sites i.e. <1 nm from shore/50m depth, used only for CCS
- Tuna farms at E, G and H moved further offshore
- Area around site E used for 2 x 1000t CCS sites
- CCS capacity 1000t/site
- Tuna capacity as per current ICCAT permits
- Nursery production at Marsaxlokk site I
- New nursery production at Xghajra sites U and V
- New outer site G for tuna 2km from shore, 1500t (assumes shift in BA 4)
- New outer site H for tuna 2km from shore, 1500t (assumes shift in BA 4)

Resulting capacity: 15,000t CCS, 19,500 tuna

Further details of these capacity scenarios are given in Table 15.

Table 15. Potential production capacity under different site availability scenarios

		Capacity 1		Capacity 2		Capacity 3	
Site	Location	Tuna	CCS	Tuna	CCS	Tuna	CCS
Existing sites							
A	AJD Comino		500				1,000
B-D	P2M		1,000		1,000		1,000
E	AJD SPB	2,500		2,500			2,000
F	SE Zone	6,000		6,000		6,000	
G	MFF Munxar		500		1,000		1,000
H	F&F Il-Hofra		500		1,000		1,000
I	MARC						
	Total	8,500	2,500	8,500	3,000	6,000	6,000
Potential new sites							
G outer	MFF Munxar	1,500		1,500		1,500	
H outer	F&F Il-Hofra	1,500		1,500		1,500	
J	NE Zone-inner				1,000		1,000
K	NE Zone-inner				1,000		1,000
L	NE Zone-middle						1,000
M	NE Zone-outer					1,500	
N	NE Zone-outer					1,500	
O	E Zone					1,500	
P	E Zone					1,500	
Q	E Zone					1,500	
R	E Zone						1,000
S	E Zone						1,000
T	Madalena Shoals						1,000
U	Xghajra						Nursery
V	Xghajra						Nursery
W	San Tumas point						1,000
X	New SE Zone						1,000
Y	New SE Zone					1,500	
Z	New SE Zone						1,000
Z1	New SE Zone					1,500	
	Total	3,000	0	3,000	2,000	13,500	9,000
Total all sites		11,500	2,500	11,500	5,000	19,500	15,000

Notes: see Figure 17 and Figure 18 for site locations

6.5.2 Production scenarios

It should be emphasised that the capacities summarised in Table 15 do not represent production targets. With regard to tuna, actual production is dependent on a host of factors, including ICCAT quotas and regulations and the ability of the fishing fleet to actually fulfil quotas. Given that the highest production of tuna in Malta was just under 7,000t in 2007, there is clearly more than enough potential site capacity to regain that level if quotas allow. We suggest that 3 production scenarios are considered for tuna:

1 Quotas fall from present levels, production falls to 2,000t p.a., possibly a minimum level for industry to remain viable depending on number of operators
2 Stocks increase moderately, quotas increased, production reaches 4,500t p.a.
3 Stocks increase significantly, production returns to 2007 levels of around 7,000t p.a.

With regard to CCS, production will be totally dependent on which if any of the potential new sites/zones identified are approved, and the capacity agreed for these and existing sites. In addition, there would need to be negotiations with existing operators to agree on the rationalisation of sites especially if site exchanges or modifications are proposed which are outside the terms of individual leases. Which of these scenarios eventually materialises will depend on the priority accorded by the Government of Malta to the development of the industry. In view of these provisos, 3 production scenarios are proposed for CCS:

1 As in capacity 1 for CCS: essentially reflects status quo and permit conditions for existing sites, with no new areas allocated except for extension of sites G and H to allow tuna to be moved further offshore, production 2,500t p.a.

2 As in capacity 2 for CCS: reflects proposal to move Comino site to new NE Zone, move tuna production from sites G and H further offshore, and greater site carrying capacity, production 5,000t p.a.

3 As in capacity 3: assumes all tuna moved further offshore, all existing sites except the SE Zone used for CCS, existing production consents for CCS are increased, *but only some of potential new sites approved*, production 10,000t p.a.

These scenarios are summarised in Table 16. It should be emphasised that overall production of both tuna and CCS would depend on any combination of the scenarios for each species, given the different limitations for each. Thus a scenario 3 outcome for CCS of 10,000t p.a. might be combined with a scenario 1 outcome for tuna of 2,000t.

Table 16. Summary of production scenarios

	Scenario 1	Scenario 2	Scenario 3
Tuna	2,000t	4,500t	7,000t
CCS	2,500t	5,000t	10,000t

6.5.3 Timescale

The TOR suggests 2025 as a deadline for a given production target to be achieved. The progress towards a given target will depend amongst other things on:

- Agreement on site locations and capacity
- Agreement on an industry strategy
- Adoption of the strategy in the revised Structure Plan
- Legislation in determining site and other issues
- The rate of development of know-how in culturing alternative species such as amberjack
- Market conditions in the period to 2025
- ICCAT tuna quotas

As already discussed, tuna production depends mainly on quotas. Given the current strict regulatory environment, it is to be hoped that tuna stocks recover sufficiently within the coming years to allow an increase in quotas, in which case production could return to 2007 levels of 7,000t p.a. or higher. For CCS, it is considered that a production of 10,000t could be achieved by 2025 providing that the industry is fully supported.

Production targets and associated timeframes are evaluated further in Section 8.5.

6.6 Prospective socio-economic impacts of future production scenarios

6.6.1 Introduction

This section illustrates the possible socio-economic impacts of different future production scenarios outlined in Section 6.5.2 compared to the base case based on indicative 2010 volumes presented in Section 4.5.6. The analysis is performed independently for tuna and for closed cycle species and in this regard this analysis does not investigate the trade off between shifting production between the two species groups. In many respects this trade-off is not as evident as one may think given that tuna ranching is largely constrained by the catch quota (with arguably unlimited offshore potential), whilst closed cycle species are largely site-constrained particularly with respect to the requirement for more sheltered sites.

Furthermore, the scenario of a new local hatchery is overlaid on the three production scenarios of the closed cycle species group. The proposed hatchery is sized at an output of 20 million fry split equally between seabream and amberjack. It is assumed that the hatchery operates as a separate company supplying the requirements of the local farms and exporting the balance.

6.6.2 Tuna scenarios

The illustrative financial and economic impact for tuna is based on the cost structure set out in Section 4.5.6 assuming a sales price of €20/kg and a cost price of €15.04/kg as set out in the table below.

Table 17. Illustrative cost structure for tuna ranching

Tuna illustrative cost structure	Tuna €/kg	Base case Tuna
Revenue	20.00	100%
Less cost of sales:	11.83	59%
Fish stock	*6.15*	*31%*
Feed	*3.23*	*16%*
Packing & marketing	*0.51*	*3%*
Other variable costs	*1.93*	*10%*
Gross profit	**8.17**	**41%**
Salaries	0.49	2%
Fixed overheads	1.15	6%
Rent	0.04	0.2%
EBITDA	**6.49**	**32%**
Finance costs	0.18	1%
Depreciation	0.59	3%
Forex	0.77	4%
Profit before tax	**4.96**	**25%**

Source: Internal analysis

The table below builds upon the above assumptions and illustrates the potential financial impact of tuna ranching for the three production scenarios outlined in Section 6.5.2, compared to the 2010 base case indicative volume of 3,520 tonnes.

Table 18. Illustrative financial impact for tuna ranching

Illustrative financial impact for tuna ranching	BASE CASE Tuna	LOW Tuna	MID Tuna	HIGH Tuna
Sales price per kg	20.00	20.00	20.00	20.00
Sales volume (tons)	3,520	2,000	4,500	7,000
Output €'000	70,400	40,000	90,000	140,000
Cost per kg	15.04	15.04	15.04	15.04
Revenue	**70,400**	**40,000**	**90,000**	**140,000**
Less cost of sales	**41,631**	**23,654**	**53,222**	**82,789**
Fish stock	*21,662*	*12,308*	*27,692*	*43,077*
Feed	*11,372*	*6,462*	*14,538*	*22,615*
Packing & marketing	*1,788*	*1,016*	*2,286*	*3,556*
Other variable costs	*6,809*	*3,869*	*8,705*	*13,541*
Gross profit	**28,769**	**16,346**	**36,778**	**57,211**
Salaries	1,733	984	2,215	3,446
Fixed overheads	4,037	2,294	5,161	8,028
Rent	143	81	183	284
EBITDA	**22,857**	**12,987**	**29,220**	**45,453**
Finance costs	628	357	803	1,250
Depreciation	2,073	1,178	2,650	4,122
Forex	2,708	1,538	3,462	5,385
Profit before tax	**17,448**	**9,914**	**22,305**	**34,697**

Source: Internal analysis

The economic impact analysis of the tuna production scenarios illustrates that at the high production target of 7,000t p.a. (in line with 2007 volumes) the industry could generate a total GVA of €73m and support direct employment of 233 employees and indirect and induced employment of 804.

Table 19. Illustrative economic impact for tuna ranching

Illustrative economic impact for tuna ranching	BASE CASE	LOW	MID	HIGH
Output (tons)	**3,520**	**2,000**	**4,500**	**7,000**
Output (€'000)	**70,400**	**40,000**	**90,000**	**140,000**
Direct GVA (€'000)	22,024	12,514	28,156	43,798
Indirect & induced GVA (€'000)	14,642	8,319	18,719	29,118
Total GVA (€'000)	**36,667**	**20,833**	**46,875**	**72,917**
Direct employment (FTEs)	117	67	150	233
Indirect & induced employment (FTEs)	405	230	517	804
Total employment (FTEs)	**522**	**297**	**667**	**1,038**
Direct household income (€'000)	1,733	984	2,215	3,446
Indirect & induced Household income (€'000)	7,258	4,124	9,279	14,434
Total household income (€'000)	**8,991**	**5,108**	**11,494**	**17,879**

Source: Internal analysis

6.6.3 Closed-cycle species scenarios

6.6.3.1 Future scenarios excluding the possibility of a new hatchery

The illustrative financial and economic impact is based on the cost structure set out in Section 4.5.6 adjusted for a sales/production mix of 50% amberjack and the remaining 50% predominantly sea bream (with a small proportion of sea bass and meagre). On this future target sales mix the weighted average selling price is assumed at 5.77/kg based on an assumed sea bream selling price of €4.04/kg and an amberjack selling price of €6.00/kg for portion sized fish (600g) and €9.00/kg for large fish (4kg). It should be noted that these prices for amberjack assume a time in the future when production has increased and prices are likely to have fallen from current levels. The cost structure assumed for closed cycle species given in the table below is based on the assumptions set out in Annex 13.

Table 20. Illustrative cost structure for closed cycle species

Cost structure for closed cycle species	BASE CASE		FUTURE	
	€/kg		€/kg	
Revenue	4.04	100%	5.77	100%
Less cost of sales:	2.92	72%	3.03	53%
Fish stock	*0.52*	*13%*	*0.48*	*8%*
Feed	*1.90*	*47%*	*2.03*	*35%*
Packing & marketing	*0.45*	*11%*	*0.45*	*8%*
Other variable costs	*0.05*	*1%*	*0.08*	*1%*
Gross profit	**1.12**	**28%**	**2.74**	**47%**
Salaries	0.55	14%	0.58	10%
Fixed overheads	0.21	5%	0.16	3%
Rent	0.01	0.2%	0.01	0.2%
EBITDA	**0.36**	**9%**	**1.99**	**34%**
Finance costs	0.04	1%	0.05	1%
Depreciation	0.12	3%	0.17	3%
Forex	-	-	-	-
Profit before tax	**0.20**	**5%**	**1.77**	**31%**

Source: Internal analysis

The table below builds upon the above assumptions and illustrates the potential financial impact of the three production target scenarios for closed cycle species, as outlined in Section 6.5.2, compared to the 2010 base case indicative volume of 1,925mt.

Table 21. Illustrative financial impact for closed cycle species

Illustrative financial impact for closed cycle species		EXCLUDING NEW LOCAL HATCHERY		
	BASE CASE	LOW	MID	HIGH
Sales price per kg	4.04	5.77	5.77	5.77
Sales volume (tons)	1,925	2,500	5,000	10,000
Output €'000	7,777	14,425	28,850	57,700
Cost per kg	3.84	4.00	4.00	4.00
Revenue	**7,777**	**14,425**	**28,850**	**57,700**
Less cost of sales	**5,627**	**7,576**	**15,153**	**30,305**
Fish stock	*1,007*	*1,190*	*2,380*	*4,760*
Feed	*3,658*	*5,074*	*10,148*	*20,295*
Packing & marketing	*866*	*1,125*	*2,250*	*4,500*
Other variable costs	*96*	*188*	*375*	*750*
Gross profit	**2,151**	**6,849**	**13,697**	**27,395**
Salaries	1,053	1,457	2,913	5,826
Fixed overheads	398	394	789	1,577
Rent	16	29	59	117
EBITDA	**684**	**4,968**	**9,937**	**19,874**
Finance costs	69	129	258	515
Depreciation	229	425	849	1,699
Forex	-	-	-	-
Profit before tax	**385**	**4,415**	**8,830**	**17,660**

Source: Internal analysis

The economic impact analysis of the closed cycle production scenarios illustrates that at the high production target of 10,000t p.a., the industry could generate a total GVA of €39m and support direct employment of 395 employees and indirect and induced employment of 381. This is besides the potential for additional value added from a local hatchery as outlined in the next section.

Table 22. Illustrative economic impact for closed cycle species

Closed cycle species - Illustrative economic impact		EXCLUDING NEW LOCAL HATCHERY		
	BASE CASE	LOW	MID	HIGH
Output (tons)	**1,925**	**2,500**	**5,000**	**10,000**
Output (€'000)	**7,777**	**14,425**	**28,850**	**57,700**
Direct GVA (€'000)	1,752	6,454	12,909	25,817
Indirect & induced GVA (€'000)	1,315	3,448	6,896	13,791
Total GVA (€'000)	**3,068**	**9,902**	**19,804**	**39,609**
Direct employment (FTEs)	71	99	197	395
Indirect & induced employment (FTEs)	36	95	191	381
Total employment (FTEs)	**108**	**194**	**388**	**776**
Direct household income (€'000)	1,053	1,457	2,913	5,826
Indirect & induced household income (€'000)	652	1,709	3,418	6,836
Total household income (€'000)	**1,705**	**3,166**	**6,331**	**12,663**

Source: Internal analysis

6.6.3.2 Financial and economic impact of a new hatchery

This section looks at the economics of a new local hatchery in isolation. The financial and economic impact of this hatchery is then combined with the closed-cycle species fattening operations.

As already indicated in other sections, the proposed new hatchery for CCS will be a vital part of the local aquaculture industry going forward, and will contribute significantly to overall socio-economic impact along with the ongrowing sector. A key element of the new hatchery would not only be to reduce reliance on imports of fry, but also to capitalise on Malta's know-how with regard to new species such as amberjack.

The proposed scale of the new hatchery is for a production of at least 20 million juveniles p.a.. For the purposes of this assessment, and in line with the assumptions for future scenarios for CCS with regard to species mix, it is anticipated that 50% of the output would be amberjack, with a sales value of around €0.4 per juvenile, and 50% seabream and similar species with a value of €0.20 per juvenile, giving an average of €0.30 each. The amberjack price is based on the current price for meagre juveniles of €0.80 each, making allowance for a future relative decline in prices once production increases.

Although at the low and medium future scenarios for ongrowing of CCS the fry requirement would be less than 20 million, it is assumed that any excess could be exported especially if consisting of alternative species.

The cost structure for marine hatcheries varies considerably depending on local circumstances, and the assumptions used are based on past work carried out in the sector by Stirling Aquaculture. The main cost element is typically labour, accounting for up to 40% of costs. The specialised feeds and nutrients that are necessary for juveniles make up a further 20%, whilst the high capital costs associated with this type of development are reflected in high annual depreciation, making up around 20% of costs. Energy makes up a further 10% of costs reflecting high pumping, heating and lighting requirements.

The reference model for hatchery costs is given in Annex 14. The cost structure for the hatchery is given in the table below.

Table 23. Illustrative cost structure for hatchery

Hatchery illustrative cost structure	
	HATCHERY
Sales price per kg	0.30
Sales volume (tons)	20,000
Output €'000	60,000
Cost per fingerling	0.18
Revenue	**6,000**
Less cost of sales	**741**
Fish stock	*-*
Feed	*741*
Packing & marketing	*-*
Other variable costs	*-*
Gross profit	**5,259**
Salaries	1,358
Fixed overheads	730
Rent	35
EBITDA	**3,135**
Finance costs	-
Depreciation	731
Forex	-
Profit before tax	**2,405**

Source: Internal analysis

The economic impact analysis of a new local hatchery with a 20 million fry output illustrates that this new hatchery by itself could generate a total GVA of circa €7m and support direct employment of 69 employees and indirect and induced employment of 61. The combined effect of the local hatchery and the closed cycle species fattening operations is illustrated in the next section.

Table 24. Illustrative economic impact for hatchery

Closed cycle species- estimated economic impact	
	HATCHERY
Output ('000)	**20,000**
Output (€'000)	**6,000**
Direct GVA (€'000)	4,529
Indirect & induced GVA (€'000)	2,222
Total GVA (€'000)	**6,750**
Direct employment (FTEs)	69
Indirect & induced employment (FTEs)	61
Total employment (FTEs)	**130**
Direct household income (€'000)	1,358
Indirect & induced household income (€'000)	1,101
Total household income (€'000)	**2,459**

Source: Internal analysis

6.6.3.3 Future scenarios including the possibility of a new hatchery

This section combines the financial and economic impact of the preceding two sections.

Table 25. Illustrative financial impact for closed cycle species, hatchery & ongrowing

	INCLUDING NEW LOCAL HATCHERY		
	LOW	MID	HIGH
Revenue	**20,425**	**34,850**	**63,700**
Less cost of sales	**8,317**	**15,894**	**31,046**
Fish stock	*1,190*	*2,380*	*4,760*
Feed	*5,815*	*10,889*	*21,036*
Packing & marketing	*1,125*	*2,250*	*4,500*
Other variable costs	*188*	*375*	*750*
Gross profit	**12,108**	**18,956**	**32,654**
Salaries	2,815	4,271	7,185
Fixed overheads	1,125	1,519	2,307
Rent	65	94	152
EBITDA	**8,104**	**13,072**	**23,009**
Finance costs	129	258	515
Depreciation	1,155	1,580	2,429
Forex	-	-	-
Profit before tax	**6,820**	**11,235**	**20,065**

Source: Internal analysis

Table 26. Illustrative economic impact for closed cycle species, hatchery & ongrowing

	INCLUDING NEW LOCAL HATCHERY		
	LOW	MID	HIGH
Output (tons)	**2,500**	**5,000**	**10,000**
Output (€'000)	**20,425**	**34,850**	**63,700**
Direct GVA (€'000)	10,983	17,437	30,346
Indirect & induced GVA (€'000)	5,670	9,118	16,013
Total GVA (€'000)	**16,653**	**26,555**	**46,359**
Direct employment (FTEs)	168	266	464
Indirect & induced employment (FTEs)	156	252	442
Total employment (FTEs)	**324**	**518**	**906**
Direct household income (€'000)	2,815	4,271	7,185
Indirect & induced household income (€'0(	2,810	4,519	7,938
Total household income (€'000)	**5,625**	**8,791**	**15,122**

Source: Internal analysis

Based upon the scenarios illustrated above, the impact of a local hatchery integrated with the fish farm production is assumed to be equal to the aggregate effect of both operations. In practice however there could be the potential for further value added generation gained through competitive advantage as a result of the local vertical integration of the industry.

6.6.4 Other un-quantified socio-economic benefits and costs

6.6.4.1 Further socio-economic benefits of the future aquaculture industry

In considering the future for Maltese aquaculture, and assuming that the ongrowing sector is allowed to flourish, a natural progression from the current situation is to capture as much as possible of the socio-economic benefit of the industry within Malta, and to reduce imports as much as possible. Plans are already underway to establish a hatchery in Malta, potentially allowing for partial or full import replacement. Feeds make up around 50% of costs and are thus another input which could potentially be manufactured in Malta. However, feed ingredients make up the majority of feed costs and these would still need to be imported. In addition, modern feedmills are highly automated, and labour requirements low. Finally, a feedmill would probably only be justified if the industry has sufficient economy of scale, producing at least 10,000t p.a. If such a scale can be achieved, the main benefits of a feedmill would probably accrue from increased entrepreneurial income whether from the mill itself or from the increased profitability of ongrowing operations due to vertical integration.

The National Strategic Plan for Fisheries 2007-2012 places great emphasis on fish processing, and there is no doubt that this could add significantly to the value of the aquaculture industry. At present, CCS are packed whole without any form of processing. This is largely a reflection of consumer requirements and the high production cost of the raw material, which renders further processing uneconomic. However, if large amberjack of 4-5 kg could be produced at relatively low cost, there would be potential for processing into similar end products as in the salmon farming industry. A study on the UK salmon processing sector (Seafish, 2009) suggests that one FTE job is created for every 25t of raw material processed. If 25% of say the high production scenario of 10,000t p.a. was processed, this could create a further 100 FTE jobs in the aquaculture sector, along with any associated benefits to the local economy.

Some tuna producers are also keen to carry out processing of their product for the Japanese market, replicating the high added value preparation of product currently carried out on Japanese processing vessels in Maltese waters at harvest time. If successful, this could undoubtedly add further value to the industry.

6.6.4.2 The potential socio-economic costs of increased levels of production

As well as benefits, the development of the aquaculture industry may incur costs as a result of negative socio-economic impacts. These might relate to:

- Impacts on other activities e.g. tourism, diving, shipping
- Impacts on the environment

Providing that mutually acceptable sites are chosen and agreed on by all stakeholders, and the environmental carrying capacity of such sites is respected, there should not be any significant cost associated with further development. Indeed it is to be hoped that the opposite would apply with regard to tourism and diving, given the opportunities for farm visits, diving experiences, and the like.

Impacts on Posidonia meadows, which are recognised as providing a variety of "ecosystem services" such as provision of spawning habitat, should be avoided by careful choice of sites and should in any case be protected through the EIA process.

One area that may provoke discussion is the competition for space with ship bunkering, which is also a valuable industry for Malta and shares much the same site requirements. However, until the location of any potential new sites is agreed, and depending on whether there is any overlap with bunkering sites, it is difficult to evaluate possible costs.

7 Conclusions

7.1 Introduction

This study has examined the aquaculture industry in Malta in some detail, considering the evolution and present status of the industry, current and potential future markets, the availability of sites for development, production potential, national policy, regulation, fish health control, and research needs. In addition, consultation with all main stakeholders has been carried out and key issues identified.

It is clear that some difficult choices will have to be made in determining where the industry goes from here. Whilst Malta has carved out a niche as a leading Mediterranean player in the tuna penning business, this niche has been rapidly eroded in the face of declining stocks and reduced quotas, and the sustainability of this sector is in serious doubt. The production of CCS even assuming the most optimistic growth projections will continue to be relatively insignificant in overall production terms, without the economies of scale available elsewhere. Malta's best prospect therefore appears to be to build on its strengths and exploit its opportunities (Section 3.2.3), seeking to be at the forefront of innovation especially in the development of alternative species.

Despite the limited potential size of the industry, there are however a number of reasons why the Government should support aquaculture in Malta:

- It contributes to the overall diversification of the economy, especially in primary food production
- It has the potential to provide up to 2,000FTE direct and indirect jobs
- It has the potential to provide GVA to the Maltese economy of up to €120m
- It is a valuable provider of fish for the local retail and foodservice sectors
- It provides valuable export earnings
- It contributes positively towards the EU trade deficit for fisheries products
- It has an opportunity to lead the way as an innovator in the culture of alternative species and other technologies

Although even assuming the most optimistic growth projections the socio-economic impacts of the industry may be dwarfed by that of other industries sharing similar resources such as tourism and shipping, there is no reason why these industries cannot live side by side providing that all their requirements are taken into account.

In addition, although there may appear to be conflicts between aquaculture and the environment, these can be resolved through good management practices and effective environmental monitoring. Fundamental to this issue is agreeing carrying capacity limits for Maltese conditions and what determines an adverse impact in relation to any particular conservation designation.

A further issue is that relating to existing sites and the differing operating conditions attached to each, and the need to create a level playing field. Whilst this is clearly a difficult issue, there is no reason to think that it cannot be resolved providing that national policy is clarified and the needs and views of all industry operators are taken into account.

In this section the main conclusions from the study are drawn. These provide the basis for the recommendations on strategy set out in the following section.

7.2 The tuna penning sector

Malta has the potential to be a leading producer of bluefin tuna in the Mediterranean, as it has been in the past. It has a good strategic location on tuna migratory routes and has substantial offshore farming expertise. It also has strong links with Japan for marketing built up over a number of years.

However, the realisation of such potential can only be achieved first and foremost if the capture of sufficient wild fish for penning can be assured. This depends on the recovery of tuna stocks, ICCAT regulations, CITES concerns, and fishing capacity, all of which are largely outside the control of the industry in Malta. Further concerns are the dependence on Japan as the main market, the strength of which fluctuates according to factors also out with the control of Maltese growers.

The production of tuna from Malta has declined from 7,000t in 2007 to what is expected to be less than 1,000t in 2011, a level that may well be financially unsustainable, and it is possible that the industry will go into “standby” mode until such time as the availability of stock improves.

In the meantime, it is necessary for the tuna industry to address the issues associated with it to ensure that it is accepted by the public in Malta. The most important issue is that of feeding of baitfish and the associated smell and oil slicks that can result. Disposal of offal has also occasionally been an issue. Even though incidences may be infrequent, they have a disproportionate negative effect on public opinion, and damage the image of the aquaculture industry as a whole.

Possible solutions to the baitfish issue include: moving existing inshore tuna farms i.e. AJD, MFF and F&F further offshore, restrictions on feeding of baitfish in onshore wind conditions in the summer tourist season, and developing new methods of feeding to limit the problem. The feed company Skretting has also been working on a formulated diet for tuna with some success[6], although not yet available as a commercial product.

7.3 The seabream and seabass sector

The two companies growing seabream and seabass (mostly seabream) in Malta produced around 2,000t in 2009, in comparison with a total for the Mediterranean of around 250,000t. Although the Maltese product is well regarded in its main market of Italy, the cyclical nature of the industry means that it is subject to periods of low prices at times of over-production. Whilst there may be scope to differentiate the product on the basis of specific product attributes and thus to some extent assure sales, such an approach is unlikely to have a significant effect on price. In addition, the slow growth and high production cost of seabream and seabass mean that they will never be competitively priced compared with other white fish products if processed. Growers in Malta will therefore need to focus on reducing production costs as far as possible in order to remain competitive. The warmer temperatures in Malta compared with elsewhere give a growth advantage, and the industry is not weighed down by debt as is said to be currently the case with competing Greek producers. However, feed and juveniles that make up a large part of costs have to be imported, whilst exports of fish to Italy are subject to logistical issues regarding ferry services. Given the limited availability of sites in Malta, it is unlikely that the production of seabass and seabream will ever increase enough to capture the economies of scale enjoyed by other operators in the Mediterranean, some of whom produce in excess of 30,000t p.a.. In conclusion, Malta will continue to be a minor player in terms of the overall production of seabream and seabass in the Mediterranean, but the species will continue to play an important part in the local industry especially in the short to medium term, with some scope for increased production providing site issues can be resolved and the right marketing approach adopted.

7.4 Alternative species

Malta has placed great emphasis in its vision for the industry on the production of new closed cycle species such as meagre, amberjack and bluefin tuna, viewing this as a way of capitalising on Malta’s limited site resources and know-how built up as a result of R&D at the MARC. Meagre is already in commercial production and can be produced at significantly lower cost than seabream and seabass, but market acceptance is poor due to unfamiliarity with consumers and an unattractive appearance. Closing the production cycle for bluefin tuna has already been achieved in Japan, and research efforts are underway in the Mediterranean. If the cycle can be closed and production difficulties overcome, the production of small fast growing tuna up to a size of 1-2kg for sale on the European market may offer an opportunity, and provide a basis for growing some fish on to a much larger size. However, research progress is slow and it is likely to be some time before commercial production becomes a possibility.

The species with the most potential in the short to medium term is amberjack. It grows fast, has good market acceptance and has potential for processing at larger sizes. In addition, the significant amberjack farming industry in Japan using wild caught juveniles demonstrates the commercial potential if hatchery reared juveniles can be produced. MARC, which is at the forefront in the breeding of the species, has succeeded in closing the lifecycle and has produced the first hatchery reared juveniles. Although significant further work needs to be done on refining the production process, particularly nutrition, the prospects look promising.

[6] http://www.skretting.co.uk/Internet/SkrettingUkIreland/webInternet.nsf/wPrId/33C97833BDD1CE01802577450051 94EB!OpenDocument

Plans are underway to establish a hatchery and spawning facility for seabream and other species including amberjack and bluefin tuna, and providing the site is approved this would provide a launch pad for the production of amberjack juveniles for the industry, as well as allowing some import substitution of seabream and seabass juveniles. The establishment of a full scale commercial hatchery in Malta is long overdue, and is essential if Malta is to realise its vision of developing alternative species.

Consideration has been given to opportunities for non-fish aquaculture. There is one company producing phytoplankton in Malta, and another testing land-based intensive shrimp farming. Integration of aquaculture with hydroponic horticulture is also receiving greater attention. Innovations such as these should be encouraged, but the commercial potential remains uncertain and no specific competitive technical advantage for locating in Malta has been identified.

7.5 Identification of sites and potential production scenarios

An assessment of marine sites has been carried out taking into account national policy, the suitability of different areas for different species, potentially conflicting marine uses, and conservation designations. A number of potential new areas for aquaculture have been identified off the east coast of Malta on the basis of this initial screening (see Figure 17 and Figure 18). It should be emphasised that each area identified may present some sort of challenge in terms of acceptance: all this screening exercise has done is to identify areas that may be suitable for aquaculture in terms of depth and shelter requirements and which do not at first sight present obvious conflicts. The extent to which any such areas are adopted would clearly depend on a great deal of further investigation and discussion with all relevant stakeholders. However, for the purposes of trying to establish a potential production target, these areas, if all were adopted, are likely to represent an upper limit to such a target.

The potential production capacity of the sites identified has been considered taking into account the sea space occupied by marine installations, suitability for different species, separation distances, and the possible carrying capacity. The composition of CCS assumed for future production is 50% seabream and 50% amberjack. For both tuna and CCS, three different production scenarios are suggested (see table below).

Table 27. Summary of production scenarios

	Scenario 1	Scenario 2	Scenario 3
Tuna	2,000t	4,500t	7,000t
CCS	2,500t	5,000t	10,000t

Source: see Section 6.5.2

For tuna, the scenarios make certain assumptions regarding availability of stock, which is regarded as the most limiting factor. Potential capacity of existing sites based on ICCAT consents is 11,500t, and so is not considered limiting.

With regard to CCS, production will be totally dependent on which if any of the potential new sites/zones identified are approved, and the carrying capacity agreed for these and existing sites. In addition, there would need to be negotiations with existing operators to agree on the rationalisation of sites especially if site exchanges or modifications are proposed which are outside the terms of individual leases.

It should be emphasised that overall production of both tuna and CCS would depend on any combination of the scenarios for each species, given the different limitations for each.

With regard to timescales, 2025 has been suggested as a deadline for certain production targets to be achieved. For tuna, given the current strict regulatory environment, it is to be hoped that stocks recover sufficiently within the coming years to allow an increase in quotas, in which case production could return to 2007 levels of 7,000t p.a. or higher. For CCS, it is considered that a production of up to 10,000t could be achieved by 2025 providing that new sites are agreed and the industry is fully supported.

7.6 Aquaculture Policy

Aquaculture policy at present is reflected in a number of different documents produced at different times e.g. the 1994 PDG, the 2001 amendment to PDG, the 2004 "National Policy for Aquaculture", the National Strategic Plan for Fisheries, the WMCP, and the 2006 draft Structure Plan. There is a clear need for the 2004 Policy document to be updated to reflect the latest situation, and in particular for better guidance on the location of marine installations, which is often contradictory with regard to what species can be grown where, in what depth, and at what distance from the shore. Anecdotally, there is a belief in some official quarters that all aquaculture is to be relocated to offshore zones such as the SE AZ, regardless of species cultured or life cycle stage, whereas this position is not reflected in the various policy documents. A clear policy statement for the aquaculture industry is an essential part of strategy.

7.7 Regulation

The basic legislation necessary for the regulation of the industry is essentially in place and EU legislation has been or is being implemented where necessary. However, there are a number of regulatory issues that need to be addressed including licensing procedures, enforcement of operating conditions, the feeding of baitfish, and environmental monitoring.

The existing licensing process which may take a year or more involves approval by MRRA and MEPA, an EIA, consultation, and a public hearing before a decision is made. This process is not dissimilar to those in other industries, however, in the case of Malta the process is lengthy and appears to be unduly dominated by MEPA, which is seen by the industry to be un-sympathetic to aquaculture. A further feature of the existing industry is the different operating conditions applying to different sites, with different durations, rents, and obligations to move (or not). This creates uncertainty and resentment amongst the industry and stakeholders.

Partly with a view to improving the existing system, and partly to rationalising the location of farms, MRRA have in mind a concept whereby all existing and new installations are located in dedicated Aquaculture Zones (AZs), the permission and head lease for which has been granted to MRRA, which then issues concessions to individual operators. This is the principle behind the already established SE AZ. In principle, this concept makes much sense, with only one application to MRRA being necessary, thus creating the "one stop shop". However, whilst such a system may work for new farms, it would only work for existing farms providing that they are not disadvantaged financially or operationally. It is not clear to what extent new legislation seeking to oblige existing operators to move sites could be enforced, given that the operators most likely to be affected have what are assumed to be legally binding operating consents.

The term of some site concessions in Malta is as short as one year. Longer terms (25 years is typical in the UK) are essential if businesses are to make significant investments in the sector given the high risk nature of the business and the often lengthy period before a return can be expected.

Given that requiring existing operators to move from their existing sites to new offshore zones is not considered feasible other than for tuna, and would seriously curtail if not completely rule out the prospects for CCS culture, it is suggested that the principle of zoning could be applied to existing sites providing that the above concerns are taken into account.

With regard to what species can be cultured where in the available space, whether existing or new sites, the policy should essentially be as it appears to be now i.e. for all tuna farms to be located in more than 50m water depth and 1nm from shore, whilst CCS would mostly be in less than 50m water depth at varying distance from the shore. This would address the need for CCS to be grown on relatively sheltered sites, and to move tuna further offshore to reduce the impacts of baitfish feeding, where in any case they are better able to withstand the more exposed conditions. There would need to be flexibility in the application of this policy depending on individual permit conditions, carrying capacity, and what if any new sites are approved.

Further streamlining of existing licensing procedures could be achieved through the rationalisation of the 2 Directorates within the MRRA that currently deal with aquaculture, bringing them under a new "Aquaculture and Fisheries Directorate". This would bring greater focus and direction to the industry and allow more efficient implementation of strategy. It is understood however that the Directorates were recently re-organised and that such a rationalisation would have to be considered at some future date.

Enforcement of operating consent conditions is currently considered to be inadequate, particularly with regard to the correct placement and maintenance of navigational markers. There is a need for the present process by which farms are monitored and enforcement instigated to be reviewed and if necessary additional resources made available.

At present there appear to be no specific obligations on tuna penning operators to minimise the impact of baitfish feeding i.e. smell and oil slicks. Appropriate conditions therefore need to be imposed, such conditions to be determined following a study of the nature, frequency and timing of the impacts in relation to individual farm locations.

A further way of improving operating standards within the industry would be the introduction of an industry Code of Good Practice (COGP), as envisaged in the WMCP and other policy documents. This should be based on other EU and national COGPs and adapted for the Maltese industry, which ideally should take the lead in the production of the Code to ensure industry acceptance. Such a Code could be one means of improving the public image of the industry and of backing up marketing initiatives.

MEPA has a key role to play in the regulation of the industry and as such it is important that it is seen to operate in a fair, timely and well informed manner. At present it is viewed by the industry as un-sympathetic to aquaculture, and if the industry is to have any chance of developing from its present state it is essential that relations with MEPA are improved. Some of the present difficulties stem from a lack of clear policy direction given by MRRA, especially with regard to locational guidelines. It is essential therefore that current policy is reviewed and amended as a result of this study so that MEPA are aware of the strategic intentions of the Government regarding the industry.

7.8 R&D

The key areas for research are closely related to the needs of the industry, including the following:

- Commercialisation of amberjack culture, especially juvenile production and nutrition
- Closing the cycle for bluefin tuna culture
- Research into other potential species (grouper etc)
- Developing environmental carrying capacity criteria
- Development of offshore cage technology
- Development of improved feeds and feeding methods for tuna

At present, the only R&D facilities are at the MARC and research work is carried out through a joint venture with MFF through the Amberjack Project. This appears to work well, although activities are restricted by difficulties with the management of Government staff and the limitations of the facilities available. In addition, only one company is funding research and is therefore the main beneficiary.

Proposals are underway for the establishment of a large scale spawning and hatchery facility which would also include research facilities to replace those currently at the MARC. It is proposed that this would be run as a Public Private Partnership (PPP) on a similar basis to another Government PPP, the Environmental Landscapes Consortium Ltd. Shares in this PPP would be offered to all growers in the industry on an equitable basis, however it is by no means certain how many would wish to participate. At present, there is a strong link between the MARC and MFF by virtue of work already done on the Amberjack Project, and the intellectual property from this project would need to be valued if transferred to the new PPP. It goes without saying that the more growers that decide to participate in the PPP, the more likely it is to be supported by the Government, and the better it would be for the industry in Malta as a whole.

Providing the proposed site for the new hatchery is agreed and the PPP model successfully adopted, this should provide a good vehicle for undertaking applied R&D in Malta.

7.9 Human resource development

Direct employment in the aquaculture sector was estimated to the 197 full-time equivalent (FTE) personnel, made up of 163 full-time employees and 73 part-timers in 2007-2008 (Applied Economic Consulting Ltd, 2009). Future employment potential could rise as high as 700 based on maximum projections presented in this report. Of these, around 35 would be expected to be managerial positions requiring degree or post-graduate level qualifications. Assuming managers remain active in the industry at least 10 years on average, this suggests annual recruitment at this level would be no more than 3.5 people. Given the limited current capacity for teaching aquaculture at this level, the best strategy would be to encourage students with an interest in aquaculture to study in other European countries so as to access the best courses and bring wider expertise back to Malta.

For farm-level staff there would be a good case for improving vocational level training with more intense provision for new entrants and short courses for more experienced personnel. A comprehensive framework for defining and assessing aquaculture skill requirements and attainment levels has been developed through the EC funded WAVE and VALLA projects. For many competencies, detailed training and assessment programmes may already be developed by the relevant bodies in other countries. Detailed examination of these involving industry representatives, training providers (e.g. Malta College of Arts, Science and Technology)(MCAST) and accreditation authorities (e.g. Malta Qualifications Council) is required to prioritise needs and determine likely demand so that the training providers can invest in the necessary resources and the appropriate qualifications can be established.

For existing managers and business owners, further innovation and developments might be stimulated by holding regular seminars, most likely linked with the R&D programme and making full use of visiting experts.

7.10 Environmental monitoring

The requirement for environmental monitoring of farms has been in place since the earliest days of the industry, with such monitoring being a condition of operating licences, the only exception being for P2M which as the first farm to be established did not have such conditions attached. However, prior to 2000 it is not clear how strictly such monitoring conditions were enforced. Since the start of tuna farming in 2000, monitoring of the tuna farms would appear to have been strict, with water quality, benthic, sediment and video surveys all being required on a regular basis. Although such monitoring has no doubt been carried out with the best of intentions, there is a perception that it is unnecessarily complex and costly, and fails to provide any useful link between impacts and carrying capacity. There is a need therefore for a review of monitoring methodology in order to make it better "fit for purpose". This is in line with the need to provide clear EQS by which adverse impacts can be judged, and an AZE over which such impacts are allowed.

This review should also take advantage of the work that is being carried out under the GFCM Committee on Aquaculture in this area. Specifically InDAM (Indicators for Sustainable Development of Aquaculture and Guidelines for their use in the Mediterranean) and SHoCMed (Mulistakeholder Workshop on Siting and Carrying Capacity). The latter is working on EQS for Mediterranean aquaculture.

7.11 Fish health control

Malta has experienced a number of diseases of seabream and seabass over the past 20 years, however these are now mostly kept under control by good husbandry, and occasionally through appropriate medication. There are no so-called "notifiable diseases" of the fish species currently cultured in Malta. Fish disease control in Malta is covered under the Veterinary Services Act of 2009, which implements the latest EU legislation on the subject.

The most serious threat the industry has experienced was an outbreak of VNN virus in seabass in the 1990s originating from the import of infected fish, which caused very heavy losses and is one reason why seabass is no longer cultured on a large scale in Malta. This outbreak spread rapidly between farms despite the relatively high separation distance between them and illustrates the need for strict control measures especially with regard to the source of stock.

Such problems have not affected tuna, which is less susceptible to disease. The fish are not usually kept much longer than 6 months and sites then lie fallow for a time before restocking, allowing any potential disease cycle to be broken.

With regard to improving fish health control, normal biosecurity practices should be followed, especially with regard to the import of juveniles from overseas hatcheries. It is understood that individual farms follow such practices and these are reinforced by statutory obligations regarding the import of fish.

The issue of health control within zones has been raised, given that potentially a number of sites could be located quite close together even though they would still be subject to a statutory 1km separation distance.

Given the experience with VNN that spread rapidly between farms over much longer distances, increased separation distance is in itself not going to prevent the spread of disease. The fundamentals include preventing the import of infected stock and good husbandry. Existing regulations should thus be reinforced by a COGP as already discussed, and by Area Management Agreements (AMAs) between all the operators in a zone. Such AMAs could include agreement on fallowing practices and disease treatment strategies, as is the case in the Scottish salmon farming industry for example.

There are no notifiable diseases of seabream and seabass in the EU at present. Should there be a risk of such disease, there is a requirement by the EC for member states to prepare a contingency plan should such a disease occur. There is also provision for such a plan to apply for potential emerging diseases, and in view of the potential risk of such disease occurring in new species such as amberjack, it is strongly recommended that such a plan be developed. A further requirement should production of CCS be increased over present levels is an improved fish disease diagnostic capability such as the one that used to be provided by the NAC. Whether such a service is provided by the Government or the private sector would depend on perceived threats and the capabilities of individual companies.

7.12 Socio-economic impacts

An analysis of socio-economic impacts has been carried out both for the industry as it is now and how it might appear in the future given certain future growth scenarios. An important part of this assessment was to separate tuna and CCS culture as they are effectively two different sectors with different financial and operating characteristics.

Gross industry output (both tuna and CCS) reached a peak of €130m in 2007 when tuna production reached 6,800t, with total gross value added (GVA) of €53m, and supported an estimated 964 FTE jobs (direct and indirect). This output was largely attributable to tuna penning. In the two following years however tuna penning made a loss due to increased costs, storm losses, foreign exchange differences, and (in 2009) low prices, and as a result total GVA for the industry as a whole was negative in 2008 and only €18m in 2009.

With regard to possible future outputs, analysis of economic impacts was made for three different scenarios for both tuna and CCS. For these future scenarios, it is assumed that CCS comprise 50% amberjack and 50% seabream and other species. The high production scenario for tuna of 7,000t p.a. (in line with 2007 volumes) indicates that the sector could generate a total GVA of €73m and support direct employment of 233 employees and indirect and induced employment of 804.

The analysis of the CCS scenarios including a new local hatchery illustrates that at the high production scenario of 10,000t p.a. and a hatchery producing 20 million juveniles p.a., the sector could generate a total GVA of €46m and support direct employment of 464 employees and indirect and induced employment of 442.

Whilst these two sectors could reach such production levels simultaneously and thus the overall impact could be an aggregate of the two, in practice it is likely that they will proceed at a different rate given they are influenced by different factors.

7.13 Marketing

The market for bluefin tuna is primarily in Japan, with Japanese companies purchasing direct from Maltese cages. As long as demand remains high in Japan there will be few incentives to develop alternatives. Should the production cycle be closed in both Japan and Europe, increased production will drive down prices and open new markets, placing tuna in a similar situation to other CCS.

For CCS Malta is a minor producer and must either accept whatever prices prevail in commodity markets or seek to differentiate products and target niche markets. Differentiation can be achieved in various ways. For relatively local markets, the local providence and freshness may be sufficient to attract a small premium. Producers are also able to differentiate on the basis of customer service which can involve fairly basic issues such as fulfilling orders on time and within specifications, ensuring good and consistent quality of products, or packing the fish in specific box sizes etc. It can also relate to the range of products on offer particularly the supply of larger than normal sizes. With provenance becoming an increasingly important factor throughout European markets, opportunities for differentiation are presented through eco-labelling or certification for production in accordance with other ethical or quality standards. Premiums may be limited however, as compliance with approved standards will probably be increasingly necessary for market access.

The market for CCS is predominantly whole fresh fish. The market for alternative products from sea bream and sea bass is gradually developing, especially various presentations of sea bass fillets or ready to cook whole or head-off fish. These are opening up sales into more northern European countries. However, the relatively high production cost of sea bass and sea bream (particularly when measured by unit weight of fillet) seriously limits opportunities for substantial market expansion in this way since the products are in competition with many others derived from cheaper white fish raw materials. Greater opportunities exist for market expansion and value addition through the processing of meagre, which has a lower cost of production per unit of fillet and potentially a wider range of products. However it is still in competition with other whitefish and due to current unfamiliarity of consumers will require a substantial marketing effort to raise demand and maintain adequate prices.

The establishment of a high quality processing facility for farmed fish in Malta would open up new opportunities for the sector, but for more sophisticated products, greater throughput would be required to justify the investment necessary. At present it is estimated that a throughput of between 10 and 20 tonnes per day would be necessary to ensure financial viability. Further market research is required to identify specific opportunities for value-added products, considering the mix of product, target market and distribution logistics. Outbound chilled air freight for instance can often be somewhat cheaper from small islands than major countries since they are net importers of chilled food so there is spare capacity on return flights.

As a small player in European aquaculture and seafood, marketing budgets in Malta are probably best spent on researching customer needs, identifying competitive advantage and supporting actions necessary to exploit those. Promotional marketing, whether focused on specific brands or generic products is expensive and only effective if everything else is in place to ensure the product delivers on the promises made. An exception to this could be considered for generic marketing of aquaculture products in Malta to help enhance industry image and strengthen local markets.

The potential introduction of amberjack offers a short-term market advantage to Malta as it could be the leading producer until other countries catch up. As this fish sells very well into traditional fresh whole fish markets there is no immediate need for value adding processing or marketing activities. However, as competition increases, processing could help expand the market and further enhance the value for Maltese producers. A clear industry marketing strategy in the early stages of this species development could help to ensure the potential value is exploited as effectively as possible.

7.14 Improving the image of aquaculture

It is a generally held view that the negative image of the aquaculture industry only developed after the advent of tuna farming in 2000, as a result of baitfish feeding and disposal of offal. Whilst this may largely be the case, there is also a view, for example in the diving community, that impacts from all farms, including those for seabream and seabass, on water quality and/or benthos are unacceptable. In order to counteract such views, it is necessary to demonstrate compliance with both statutory operating conditions and a publicly available COGP. Above all, ways must be found to mitigate the impacts of baitfish feeding through moving tuna farms further offshore and preventing smells and oil slicks.

Aquaculture has a good story to tell and there is much scope for educating the public through for example school visits to farms and farm open days. The new national aquarium also provides an educational opportunity, as also would an aquarium/educational display at the proposed new hatchery and research facility. Farms are already the subject of visits both from tourist boats and divers especially in the St. Paul's Bay area, all of which are an opportunity to promote the positive side of aquaculture. The abundance of wild fish in the area around cages also provides an opportunity for promoting fishing, which in turn would create a positive impression of aquaculture

8 Recommendations

8.1 Introduction

The overall objective of this study is to lay down a path for the development of a sustainable aquaculture industry in Malta. Furthermore, the measures necessary to achieve such an industry must be specified, as well as the timeframes involved.

Conclusions regarding the state of the industry and the issues affecting it have been discussed in the previous section. In this section, recommendations and proposals for policy positions are made, strategic objectives identified and associated action plans and timeframes proposed. The action plans are closely correlated with the recommendations or measures needed.

Strategy summary tables for the tuna and CCS sectors are presented, giving indicative production scenarios, economic impacts and timescales, and the main assumptions and constraints. Finally, indicative roadmaps are given for each of the CCS and penned tuna sectors, summarising the timeframe for the accomplishment of specific action plans.

8.2 Recommendations

Drawing on the conclusions presented in Section 7, overall recommendations are as follows:

The tuna penning sector

1. ***Tuna farms on near shore sites should be relocated to sites with more than 50m water depth and more than 1nm from shore to limit impacts.***

2. ***Consideration should be given to restricting the feeding of baitfish to tuna cages during onshore wind conditions in the summer tourist season if alternative solutions are not found.***

3. ***A review of tuna offal disposal should be carried out.***

The seabream and seabass sector

4. ***Seabass and seabream will remain important species for the industry for the foreseeable future so account must be made of this in strategic planning.***

Alternative species

5. ***The main emphasis with regard to development of alternative species should be on amberjack.***

6. ***A hatchery and spawning facility for amberjack, bluefin tuna and other species should be established at the earliest opportunity.***

7. ***Other species groups such as groupers, sparids, octopus and sea urchins may have potential for production in Malta in the future, and research into such species should be encouraged providing commercial potential can be demonstrated.***

Identification of sites and potential production scenarios

8. ***Additional marine sites will be needed for future expansion of the industry in both nearshore and offshore areas. Potential sites are proposed together with possible production scenarios in this report.***

Aquaculture policy

9. ***It is recommended that the 2004 policy document (see Annex 3) is updated to reflect the findings of this study, making sure that it reflects the needs of the industry and current issues, and taking into account the views of all stakeholders, especially the growers themselves.***

Regulation

10. ***Whilst the concept of zoning is desirable in principle for existing sites as well as new sites, it should only be pursued providing that operators are not financially or operationally disadvantaged and they are fully consulted.***

11. ***It is recommended that the minimum term for concessions is 25 years, or in accordance with normal commercial lease terms in Malta, subject to compliance with operating conditions.***

12. ***It is recommended that all tuna farms be located in more than 50m water depth and 1nm from shore, whilst CCS should mostly be in less than 50m water depth at varying distance from the shore.***

13. ***The present process by which farms are monitored and enforcement instigated should be reviewed and strengthened.***

14. ***The introduction of conditions regarding methods of feeding baitfish to tuna should be considered.***

15. ***The industry should be encouraged to prepare a COGP, if necessary supported by funding from the Government.***

16. ***MEPA must be made aware of the strategic intentions of the Government regarding the industry through a revised policy document based on the findings of this study.***

17. ***It is recommended that an appropriate individual within MEPA is trained as an aquaculture specialist to act as a liaison officer between MEPA and the industry.***

18. ***An Aquaculture Working Group made up of representatives from the industry, MEPA and MRRA should be established to address specific issues affecting the industry.***

R&D

19. ***A mechanism should be put in place to ensure regular (e.g. annual) reviews of research priorities and funding are carried out involving government, industry and academic stakeholders.***

20. ***Resources should be committed to the development and testing of alternative tuna feeds that reduce reliance on baitfish.***

21. ***The PPP model of R&D funding appears to be working well and should be developed further, although it must allow participation by all growers in Malta.***

22. ***The development of a new Marine Hatchery and R&D centre is a high priority under the aquaculture strategy and full costings and finance model, most likely using a PPP, should be developed as soon as a site has been agreed.***

23. ***Collaboration between MARC and the University of Malta and other institutions in the Mediterranean, whether to provide access to specialised research equipment or expertise is recommended.***

Environmental monitoring

24. ***It is recommended that a review of environmental monitoring methodology is carried out by an independent international authority with relevant expertise and that procedures are brought into line with guidance under development within the GFCM workshops InDAM and SHoCMed.***

Human resources development

25. It is recommended that a consultative forum is established to develop formal vocational training programmes for Maltese aquaculture. This should involve industry representatives, training providers (e.g. MCAST) and the Malta Qualifications Council.

Fish health control

26. It is recommended that disease control is strengthened through the establishment of Area Management Agreements (AMAs) between all operators in a zone or area.

27. It is recommended that a contingency plan is prepared by Government and industry to deal with the possibility of a notifiable or other serious disease becoming established in Malta.

28. In the event of increased production, the need for and delivery of an improved fish disease diagnostic capability, such as the one that used to be provided by the NAC, should be assessed.

Socio-economic impacts

29. A commitment to the development of the aquaculture industry is needed to ensure potential future gains in economic impact are realised. GVA from penned tuna has the potential to reach €21, 47 and 73 million in 2015, 2020 and 2025 respectively, whilst for Closed Cycle Species the equivalent figures could be €17, 26 and 46 million.

Marketing

30. Support should be given to companies keen to improve the marketing of their products especially with regard to provenance and certification.

31. Market research should be conducted to identify specific opportunities for value-added products from Malta, considering the mix of product, target market and distribution logistics.

32. It is recommended that marketing budgets are spent on researching customer needs, identifying competitive advantage and the supporting actions necessary to exploit these.

33. With regard to amberjack, it is recommended that a marketing study be carried out to identify the product attributes likely to realise the best returns.

Improving the image of aquaculture

34. In order to counteract negative views of aquaculture, compliance with both statutory operating conditions and a publicly available COGP should be demonstrated.

35. All means of promoting the positive aspects of aquaculture and educating the public, including farm open days, school visits, and the use of aquaculture facilities as tourist attractions, should be utilised.

8.3 Proposals for updating aquaculture policy

The most important requirement for a sustainable industry is a clear and unequivocal national policy on aquaculture, in particular setting out the role aquaculture has to play in the national economy, what priority is to be afforded it, and what resources, in particular sites, are to be made available for it.

As previously recommended, the 2004 policy document should be reviewed and amended to reflect the findings of this study and in particular the issues that have been identified, especially on the question of sites and licenses. In particular, the following policy positions are proposed:

Tuna

- Industry to be supported but not at the expense of CCS culture
- ICCAT and all other regulations to be strictly observed

- Sites further offshore to limit adverse impacts of baitfish feeding (>50m depth, >1nm)
- Option to use tuna sites for other species in future e.g. large amberjack and closed cycle tuna
- Clarify that tuna penning may take place in areas other than SE Zone providing sites can be found
- Keep options open for future development subject to availability of stocks and strength of markets

CCS
- CCS such as bream, bass and other species already commercially cultured have an important role to play
- Existing sites in less than 50m water depth only to be used for CCS (this would require MFF, F&F, and AJD tuna sites to be moved further out, keeping their existing sites for CCS)
- Future potential lies with alternative species e.g. amberjack
- Support R&D into closing the cycle for amberjack, bluefin tuna and other species
- Support development of new hatchery and R&D centre

Zoning
- New zones for new sites to be set up on same basis as SE Zone, but in less exposed locations and with more favourable terms
- New zones to be established around existing sites as appropriate e.g. off Il Hofra to include MFF and F&F
- Agree standard concession terms acceptable to all operators
- Each zone to have an Area Management Agreement (AMA)
- Encourage Good Management Practice through COGP prepared by industry in consultation with MRRA/others

R&D
- Supportive R&D position
- Priorities for R&D to be stated
- Funding sources stated
- Support PPP model; encourage industry participation

Environment
- Improved monitoring system specified
- Mechanism for review and refinement of carrying capacity models
- Farms must operate within agreed carrying capacity guidelines

Market development
- Support market development initiatives e.g. branding, certification

8.4 Strategic objectives, required action plans and delivery

The proposed strategy for aquaculture in Malta is based on the present status and realistic future potential for the industry, the external competitive environment, and the constraints and issues surrounding it. Taking all these factors into account, and in particular the outcome of the consultation exercise summarised in Table 11, four over-riding strategic objectives for the industry have been identified, together with desired outcomes, as set out in Table 28 below.

Table 28. Broad strategic objectives and desired outcomes

Strategic objective	Desired outcome
Improved regulation	Streamlined regulatory environment under one MRRA Directorate, with a clear policy on site locations, minimal conflict with other users, and standard conditions for all operators
Improved operation	Efficient, profitable farms operating according to the principles of best management practice, complying with their operating consents, causing no nuisance to other coastal users, and with a positive public image
Improved environmental monitoring	A system that recognises the link between biomass and impacts, specifies limits to what constitutes adverse impact (EQS), over what area such impacts are acceptable (AZE), and is proportionate, practical and cost effective
Better innovation	Facilities, funding and human resources to allow high quality applied research for the benefit of all industry operators

The realisation of these objectives will be achieved by formulating specific action plans in response to the issues identified in Table 11 and the recommendations in Section 8.2 arising from the conclusions made in Section 7. A summary of the action plans required is given in the table below, and such plans should form part of an operational programme going forward. The timescale for individual action plans will depend on the relative priority and the resources available.

Table 29. Action plans for inclusion in the operational programme of the aquaculture strategy

Key issue	Action plans needed	Related recommendations (NB refer to list in Section 8.2)	Responsibility	Priority
Regulatory issues				
	Updating National Aquaculture Policy	4, 9,12, 16, 29	MRRA	H
	Improving relationship with MEPA (liaison officer, working group)	17, 18	MEPA, industry, MRRA	H
	Identifying and applying for new aquaculture sites/zones	8, 10	MRRA, industry	H
	Standardisation of concession conditions	11	MRRA, industry	M
	Preparation of AMAs	26	Industry	M
	Preparation of a disease contingency plan	27	MRRA	L
Operational issues				
	Hatchery development	6	MRRA, industry	H
	Baitfish feeding practices	1, 2, 14, 20	MRRA, industry	H
	Production of COGP	15, 34	Industry	M
	Enforcement of operating conditions inc. site marking	13	MRRA	M
	Improving the image of aquaculture	34, 35	Industry	M
	Market development	30, 31, 32, 33	Industry	M
	Review of tuna offal disposal	3	MRRA, industry	L
	Improved fish disease diagnostic capability	28	MRRA	L
	Vocational training forum	25	MCAST, MQA, industry	L
Environmental issues				
	Independent review of environmental monitoring system	24	MRRA, MEPA	H
	Develop EQS and AZE criteria	24	MRRA, industry	H
Innovation issues				
	Amberjack research	5	MRRA, industry	H
	Hatchery/R&D centre PPP model and business plan	6, 21, 22, 23	MRRA, industry	H
	Alternative tuna feeds	20		M
	Review of research priorities and funding	19	MRRA, industry	M

Priority: H=high M=medium L=low

Delivery of the desired outcomes and implementation of related action plans should be made the responsibility of a Strategy Management Group (SMG) representing key stakeholder interests and chaired at Ministerial level. Such an SMG should meet every 6 months to review, amend and agree action plans. Individual SMG members should be given specific responsibility for overseeing actions relating to the 4 key priority themes of regulation, operation, environment and innovation, reporting to the SMG every 6 months or as appropriate. The SMG should liaise closely with the AWG established under the relevant action plan and recommendation 18.

8.5 Summary of potential production scenarios and related impacts

As has already been stated, the strategy for aquaculture in Malta must consider the tuna and CCS sectors separately given the different constraints facing both, although clearly there are significant areas of overlap. The future production of tuna based on the capture of wild stock is constrained primarily by ICCAT quotas, whilst the future production of CCS is constrained primarily by availability of inshore sites i.e. those lying within the 1 nm and 50m depth limits. The tables below summarise the overall picture for both sectors in terms of potential production scenarios, assumptions, constraints, economic impacts, employment levels, and funding requirements.

The scenarios for penned tuna (Table 30) assume that penned tuna farming i.e. using wild caught stock, takes place mostly at sites beyond the 1 nautical mile limit in 50m water depth or more, in line with Government policy. In Scenario 3, it is assumed that the AJD tuna site is exchanged for CCS production assuming AJD agrees to grow tuna on an alternative site further offshore.

The production targets and timeframes can be viewed as milestones by which certain levels might be achieved, or as stand alone outcomes. In reality, Malta has no control over the status of wild stocks or ICCAT quotas so it is impossible to predict what future production levels might be. Even if the cycle is closed for tuna and hatchery stock becomes available, it is likely that cage culture will mainly be of 1-2kg fish grown on inshore sites rather than on the offshore sites currently used for the much larger (70kg plus) wild caught tuna, although some growers may choose to ongrow some stock to larger sizes on offshore sites.

The scenarios for CCS (Table 31) assume that farms are mainly on sites within the 1 nautical mile limit in 50m water depth or less. Some sites further offshore in 50-60m depth and outside the 1nm limit may also be suitable for larger CCS e.g. large amberjack or hatchery produced tuna >6kg. The achievement of production targets within the suggested timeframes will be dependent mainly on the availability of sites and the carrying capacity agreed for those sites, and secondarily on the future viability of CCS culture generally.

It must be emphasised that the achievement of the 2020 and 2025 scenarios, especially for CCS, will only be achieved if the Government ensures that increased site capacity is made available.

Table 30. Strategy summary table – the penned tuna sector

	Section reference				
Timeframe		**2010 (est.)**	**By 2015**	**By 2020**	**By 2025**
Production scenario	Table 17	Baseline	1	2	3
Production targets (t)		3,520	2,000	4,500	7,000
Main assumptions	6.5.1		Reduced quotas, minimum financially sustainable level	Stocks increase moderately, quotas increase	Stocks increase significantly, quotas and production return to 2007 levels
Environmental constraints	6.1.1		None expected	None expected	Some new sites overlap maerl beds and are also in proposed MPA
Other constraints	6.1.1		F&F/MFF site amendments would need change to bunkering area 4	As 1, plus NE Zone overlaps trawl zone, wind farm, bunkering area	As 2, plus potential navigational & other constraints for possible new sites
Impact of constraints on potential production level			None, providing flexibility in which sites are used	None, providing flexibility in which sites are used	None, providing flexibility in which sites are used
Economic impact	Tables 11, 20				
Total GVA (€'000)		36,667	20,833	46,875	72,917
Direct employment		117	67	150	233
Total employment		609	297	667	1,038
Total household income (€'000)		8,991	5,108	11,494	17,879
Composition of human resources required					
Managerial staff	Note 1		3	8	12
Manual workers			64	143	221
Funding requirements					
Ongrow & shorebase capex (€ million)	Note 2		8.26	18.59	28.91

<u>Notes</u>

1 Managerial staff 5% of direct employees

2 Capex assumes up-front cost not allowing for facilities already installed. Based on depreciation of €0.59/kg and 7 years average life, capex=€4130/t.

3 F&F= Fish and Fish, MFF=Malta Fish Farming, MPA=Marine Protected Area, GVA=Gross Value Added

Table 31. Strategy summary table – the closed cycle species sector

	Section reference				
Timeframe		**2010 (est.)**	**By 2015**	**By 2020**	**By 2025**
Production scenario	6.5.2	Baseline	1	2	3
Production targets (t)		1,925	2,500	5,000	10,000
Main assumptions	6.5.1		Mostly existing sites, amendment of F&F/MFF sites to move tuna penning further offshore, CCS capacity 500t/site, P2M unchanged	As scen. 1, but NE Zone and associated rationalisation approved, CCS capacity 1000t/site, P2M unchanged	As scen. 2, but AJD SPB used for CCS, more new sites approved, P2M unchanged
Environmental constraints	6.1.1		None expected	NE Zone in proposed MPA, increased CCS site capacity needs to be verified	As 2, plus some new sites ovelap maerl beds and are also in proposed MPA
Other constraints	6.1.1		F&F/MFF site amendments would need change to bunkering area 4	As 1, plus NE Zone overlaps trawl zone, wind farm, bunkering area	As 2, plus potential navigational & other constraints for possible new sites
Economic impact	Tables 11, 27				
Total GVA (€'000)		3,068	16,653	26,555	46,359
Direct employment		71	168	266	464
Total employment		115	324	518	906
Total household income (€'000)		1,705	5,625	8,791	15,122
Composition of human resources required					
Managerial staff	Note 1		8	13	23
Manual workers			160	253	441
Funding requirements					
Hatchery - approx. capex (€ million)	Annex 14		8.50	8.50	8.50
Ongrow & shorebase capex (€ million)	Note 2		2.98	5.95	11.90

Notes

1 Managerial staff 5% of direct employees

2 Capex asssumes up front cost not allowing for facilities already installed. Based on depreciation of €0.17/kg and 7 years average life, capex=€1190/t.

3 AJD=AJD Tuna, CCS=closed cycle species, F&F= Fish and Fish, GVA=Gross Value Added, MFF=Malta Fish Farming, MPA=Marine Protected Area, SPB= St Paul's Bay

8.6 Strategy roadmap

The scenarios presented above are seen as sequential milestones that could be realistically reached by the indicated date based on the assumptions given. However, there are clearly economic incentives for moving faster, the economic impact of increased output is cumulative, so the earlier targets are reached, the greater the total benefit for Malta over the next 15+ years. Alternatively, progress may be slower and if new sites are not authorised, development may be restricted to scenario 1 or 2. If the tuna penning industry does not show prospects for recovery within the next 5 years it may be desirable to place greater strategic focus on CCS and the potential use of offshore sites for the culture of larger amberjack for instance.

There are therefore many variables that affect the timetable for implementing the identified actions. An attempt to map the actions against time is shown in Tables 33 and 34. However, in most cases, earlier action is desirable. The urgency of others (e.g. market development) will depend on the rate that production increases, or the competitive pressures faced by the producers.

The highest priorities for immediate action are the updating of the aquaculture policy and adoption of the aquaculture strategy and investment in better marine hatchery facilities and associated research and development.

Table 32. Indicative roadmap of actions for the penned tuna sector

	2011	2012	2013	2014	2015
Regulatory Issues		Updating National Aquaculture Policy Improving relationship with MEPA	Identifying and Applying for New Aquaculture Sites / Zones		Standardisation of Concession Conditions Preparation of Area Management Agreements
Operational Issues		Baitfish Feeding Practices	Production of Codes of Good Practice Enforcement of Operating Conditions incl. Site Marking	Production of Codes of Good Practice Market Development	Improving the Image of Aquaculture Improved Fish Disease Diagnostic Capabilities
Environmental Issues		Independent Review of Environmental Monitoring Programme	Develop Environment Quality Standards and Allowed Zone of Effects Criteria		
Innovation Issues			Review of Research Priorities and Funding	Alternative Tuna Feeds	

	2016	2017	2018	2019	2020
Regulatory Issues		Preparation of a Disease Contingency Plan	Identifying and Applying for New Aquaculture Sites / Zones		
Operational Issues	Review of Tuna Offal Disposal Vocational Training Forum		Market development		
Environmental Issues					
Innovation Issues		Review of Research Priorities and Funding			

	2021	2022	2023	2024	2025
Regulatory Issues					
Operational Issues					
Environmental Issues					
Innovation Issues		Review of Research Priorities and Funding			

Table 33. Indicative roadmap of actions for the closed cycle species sector

	2011	2012	2013	2014	2015
Regulatory Issues		Updating National Aquaculture Policy Improving relationship with MEPA	Identifying and Applying for New Aquaculture Sites / Zones		Standardisation of Concession Conditions Preparation of Area Management Agreements
Operational Issues		Hatchery Development	Hatchery Development	Hatchery Development	Hatchery Development
			Production of Codes of Good Practice	Production of Codes of Good Practice	Improving the Image of Aquaculture
			Enforcement of Operating Conditions incl. Site Marking	Market Development	Market Development
					Improved disease diagnostic facility
					Vocational Training Forum
Environmental Issues		Independent Review of Environmental Monitoring Programme	Develop Environment Quality Standards and Allowed Zone of Effects Criteria		
Innovation Issues		Amberjack Research	Amberjack Research	Amberjack Research	Amberjack Research
		Hatchery / R&D Centre PPP Model and Business Plan	Hatchery / R&D Centre PPP Model and Business Plan		
			Review of Research Priorities and Funding		

	2016	2017	2018	2019	2020
Regulatory Issues	Preparation of Area Management Agreements	Preparation of a Disease Contingency Plan	Identifying and Applying for New Aquaculture Sites / Zones		
Operational Issues	Hatchery Development				
	Vocational Training Forum				
	Market Development	Market Development	Market Development	Market Development	Market Development
Environmental Issues					
Innovation Issues	Amberjack Research	Review of Research Priorities and Funding			

	2021	2022	2023	2024	2025
Regulatory Issues		Identifying and Applying for New Aquaculture Sites / Zones			
Operational Issues					
Environmental Issues					
Innovation Issues		Review of Research Priorities and Funding			

References

Agius, F., 2006. Successful fertilization and hatching of amberjack eggs in Malta. The Malta Independant Online (17 July 2006). http://www.independent.com.mt/news.asp?newsitemid=35748

Agius, F., 2006. Rearing the amberjack in captivity. TimesofMalta.com, 27 March 2006. http://www.timesofmalta.com/articles/view/20060327/opinion/rearing-the-amberjack-in-captivity

Applied Economics Consulting Ltd. 2009. The Economic Impact of Aquaculture Activity on the Maltese Economy. Report for the Federation of Maltese Aquaculture Producers.

Aquaculture Development Council, 2007. An Opportunity Study of an Open Ocean Aquaculture Project in Western Australia. Prepared by: Ordnexia, chartered accountants & TAFEWA, Government of Western Australia (http://finfish.org/wp-content/uploads/open-ocean-project-report-131207-final-draft-2.pdf).

Barazi-Yeroulanos, L (2010) Synthesis of Mediterranean finfish aquaculture – A marketing and promotion strategy. General Fisheries Commission for the Mediterranean, Studies and Reviews No. 88. Food and Agriculture Organisation of the United Nations.

Basurco, B. & Abellán, E. 1998. Finfish species diversification in the context of Mediterranean marine fish farming development. Results of the Survey on Finfish Diversification in the Mediterranean carried out within the framework of the CIHEAM Network on Technology of Aquaculture in the Mediterranean (TECAM). CIHEAM. http://ressources.ciheam.org/om/pdf/b24/99600183.pdf

Chopin, T., Sawhney, M., R. Shea, E. Belyea, S. Bastarache, W. Armstrong, G.K. Reid, S.M.C. Robinson, B. MacDonald, K. Haya, L. Burridge, F. Page, N. Ridler, A. Justason, J. Sewuster, F. Powell and R. Marvin. 2007. AN INTERDISCIPLINARY APPROACH TO THE DEVELOPMENT OF INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA): THE INORGANIC EXTRACTIVE COMPONENT. Aquaculture 2007 – Meeting Abstract, World Aquaculture Society. https://www.was.org/Meetings/AbstractData.asp?AbstractId=13724

Cleanseas website, 2011. Tuna. http://www.cleanseas.com.au/fish/tuna.html

EC, 2011. Fisheries and Aquaculture in Europe, No 52, August 2011, p8

FAO, 2011. Fishery and Aquaculture Country profiles. Malta. Fishery and Aquaculture Country Profiles. In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 5 August 2004. [Cited 19 October 2011]. http://www.fao.org/fishery/countrysector/FI-CP_MT/en

FAO. © 2005-2011. National Aquaculture Sector Overview. Malta – Profiles home. National Aquaculture Sector Overview Fact Sheets. **Text by Vassallo-Agius, R.** In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 12 November 2010. http://www.fao.org/fishery/countrysector/FI-CP MT/en

FAO. ©2005-2011. Cultured Aquatic Species Information Programme. Argyrosomus regius. **Text by Stipa, P.; Angelini, M.** In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 10 April 2005. [Cited 8 April 2011]. http://fao.org/fishery/ culturedspecies/Argyrosomus regius/en

FAO. ©2005-2011. Cultured Aquatic Species Information Programme. Seriola quinqueradiata. **Text by Dhirendra P.T.** In: *FAO Fisheries and Aquaculture Department* [online]. Rome. Updated 13 January 2005. [Cited 9 April 2011]. http://fao.org/fishery/culturedspecies/Seriola quinqueradiata/en

FAO. The State of World Fisheries and Aquaculture 2010. *FAO Fisheries and Aquaculture Department.* Rome. 2010.

FAO. Seabass and seabream – February 2011. *Globefish Commodities Reports.*

Forristal, A. 2010. Is amberjack the next salmon? Seafood News Aquaculture, SeafoodSource.com. http://www.seafoodsource.com/newsarticledetail.aspx?id=4294990665

GFCM, 2011. Report on the Intersessional Activities for 2010, Recommendations and 2011 Workplan of the CAQ and its Subsidiary Bodies. General Fisheries Commission for the Mediterranean. 35th Session, Rome. 9-14 May, 2011. GFCM:XXXV/2011/7.

GFCM, 2011: GFCM:CAQVII/2011/Inf.13: REPORT OF THE WGSC - SHoCMed MEETING ON ENVIRONMENTAL QUALITY STANDARDS FOR MARINE FISH FARMS. St. George's Bay, Malta, 23-25 November 2010.

IUCN, 2009. Guide for the Sustainable Development of Mediterranean Aquaculture 2. Aquaculture site selection and site management, IUCN, Gland, Switzerland and Malaga, Spain. VIII + 303 pages.

Kinki University, Fisheries laboratory. 2011. Aquaculture: Completely farm-raised bluefin tuna. http://www.flku.jp/english/aquaculture/tuna/index.html

Marine Scotland, 2009. A Fresh Start: The renewed Strategic Framework for Scottish Aquaculture

MEPA, 2006. Environmental Impact Statement for the Construction of an urban wastewater treatment plant at Ta' Barkat, l/o Xghajra. PA 06974/06

Monfort, M.C. Present market situation and prospects of meagre (*Argyrosomus regius*), as an emerging species in Mediterranean aquaculture. *Studies and Reviews. General Fisheries Commission for the Mediterranean*. No.89. Rome, FAO. 2010. 28p.

MRRA, 2009. A proposal for an offshore windfarm at Is-Sikka L-Bajda. Project Description Statement.

Mylonas, C. C,. Papandroulakis, N., Smboukis, A., Papadaki, M. & Divanach, P., 2004. Induction of spawning of cultured greater amberjack (*Seriola dumerili*) using GnRHa implants. Aquaculture 237, 141-154.

National Statistics Office, Malta. Aquaculture 2009. Compiled by Unit B3: Agricultural and Fisheries Statistics. News release 19 November 2010.

National Statistics Office, Malta. Aquaculture 2008. Compiled by Unit B3: Agricultural and Fisheries Statistics. News release 13 November 2009.

National Statistics Office, Malta. Aquaculture 2007. Compiled by Unit B3: Agricultural and Fisheries Statistics. News release 13 January 2009.

Papandroulakis, N., Mylonas, C.C., Maingot, E. & Divanach, P., 2005. First results of greater amberjack (*Seriola dumerili*) larval rearing in mesocosm. Aquaculture 250, 155-161.

Perez, O.M., Telfer, T.C., and Ross, L.G., 2005. Geographical information systems-based models for offshore floating marine fish cage aquaculture site selection in Tenerife, Canary Islands. Aquaculture Research, 2005, 36, 946-961

Pierre, S., Gaillard, S., Prevot-d'Alvise, N., Aubert, J., Rostaing-Capaillon, O., Leung-Tack, D. & Grillasca, J-P. 2007. Grouper Aquaculture: Asian success and Mediterranean trials. Aquatic Conservation: Marine and Freshwater Ecosystems. In press. http://eb2m.univ-tln.fr/PAGES/PUBLICATION/grouper.pdf

Planning Authority, 1994. Policy & Design Guidance: Fishfarming. Malta Planning Authority.

Sawada, Y., Hattori, M., Iteya, M., Takagi, Y., Ura, K., Seoka, M., Kato, K., Kurata, M., Mitatake, H., Katayama, S and Kumai, H., 2006. Induction of centrum defects in amberjack *Seriola dumerili* by exposure of embryos to hypoxia. Fisheries Science 72, 364-372.

Sawada, Y., Okada, T., Miyashita, S., Murata, O. & Kumai, H. 2005. Completion of the Pacific bluefin tuna *Thunnus orientalis* (Temminck & Schlegel) life cycle. *Aquaculture Research.* Vol.36, Issue 5, 413-421.

Scottish Executive, 2003. A Strategic Framework for Scottish Aquaculture

Seafish, 2009. 2008 Survey of the UK Seafood Processing Industry. ISBN: 978–1–906634–11–7

Seafish Economics, 18 Logie Mill, Logie Green Road, Edinburgh EH7 4HS.

SELFDOTT, 2010. SELFDOTT public website. http://sites.google.com/site/selfdottpublic/

Reference web sites

http://europa.eu/legislation_summaries/maritime_affairs_and_fisheries/fisheries_sector_organisation_and_financing/l66004_en.htm

http://ec.europa.eu/regional_policy/funds/feder/index_en.htm

http://cordis.europa.eu/erawatch/index.cfm?fuseaction=prog.document&uuid=C6DC0220-E893-629B-9CC82E88A3A73A2E

http://www.mcst.gov.mt/files/uploaded/R& Istrategy .pdf

(http://support.maltaenterprise.com/Documents/R&D-TaxCredits/Guidelines.pdf)

http://cordis.europa.eu/erawatch/index.cfm?fuseaction=ri.content&topicID=329&parentID=50&countryCode=MT

http://ec.europa.eu/fisheries/reform/index_en.htm

www.stirlingaqua.com