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Research Article

Economic and Labour Market Implications of Climate Change on the Fisheries Sector of the Maltese Islands

L. Knittweis*[1]
[1] *Department of Biology, University of Malta, Msida, Malta*

Abstract. Climate change has been predicted to have large and rapid impacts on the Mediterranean Sea. Impacts of increasing mean annual sea temperatures, more extreme climatic events and changes in oceanographic parameters will affect the distribution, productivity and resilience of commercially targeted stocks. This study uses data on the Maltese fishing industry, collected through the EU fisheries data collection system by the Government of Malta, to develop our understanding of how climate change may impact the Maltese fisheries sector. The most important fleet segment contributing to the overall productivity of the Maltese fishing industry, both in terms of total biomass landed and total generated income, was comprised of vessels using hooks in 2009-2011. These vessels mainly used drifting surface longlines to target large pelagic species. In 2011, this fleet segment accounted for the largest number of full time employment positions, and was the most important fleet segment in terms of total investment. Available information on species targeted by this fleet segment suggests that the impact of climate change may in fact be positive. However, limited information is available on stock status as well as on the potential impacts of climate change on several important target species such as swordfish, dolphinfish and bluefin tuna. In order to ensure the continued competitiveness of the Maltese fishing fleet in light of this uncertain situation, it is suggested that an emphasis is placed on ensuring that the industry is flexible and able to effectively market and promote new products as and when they emerge. This could be achieved by developing fishers' skills accordingly, and placing an emphasis on diversifying activities.

Keywords: climate change, fisheries, economic impacts, fisheries management, Mediterranean Sea

1 Introduction

In 2011, the Maltese fishing fleet consisted of 1,087 registered vessels and employed 155 full time fishers. A large proportion of the fleet consisted of artisanal vessels with a length of 12 m or less, and the mean age of fishing vessels was 26 years. The size of the Maltese fishing fleet declined between 2008 and 2012, with the number of vessels decreasing by 20% (STECF-13-15, 2013).

The total volume landed in 2011 was 1.8 thousand tonnes, with a value of €11.3 million (STECF-13-15, 2013). The small-scale fleet accounted for around one third of the volume of landings. Swordfish generated the highest landed value (€2.9 million) by the national fleet, followed by common dolphinfish (€1.6 million), bluefin tuna (€1.1 million), giant red shrimp (€1 million) and red mullets (€0.6 million). Overall in 2011, the Maltese fishing sector generated €6.1 million in gross value added (GVA), however a generally deteriorating economic development trend has been evident over time for several years (STECF-13-15, 2013). Several factors including the effects of rising fuel prices and overfishing are likely to have contributed to this trend. In view of such an uncertain economic climate it is clearly important to understand and anticipate the potential impacts of climate change the Maltese fishing industry may be facing in the near future.

It has been predicted that the impacts of climate change on the Mediterranean Sea will be both large and rapid due to the small size of the basin, its oligotrophic nature, and high levels of species diversity and endemism (Lejeusne, Chevaldonné, Pergent-Martini, Boudouresque & Pérez, 2010; Calvo et al., 2011). Data collected to date shows steadily increasing mean annual surface as well as water column sea temperatures (e.g. Rixen et al., 2005, Calvo et al., 2011, Raitsos et al., 2010, Macias, Garcia-Gorriz & Stips, 2013), and there

**Correspondence to*: L. Knittweis (leyla.knittweis@um.edu.mt)

is concern about future changes in climate-driven thermohaline circulation patterns which would affect the entire Mediterranean basin, including deep water habitats (Calvo et al., 2011). Extreme sea conditions and disease outbreaks among marine organisms are becoming more common (Coma et al., 2009; Danovaro, Umani & Pusceddu, 2009; Lejeusne et al., 2010), non-native species are spreading (Evans, Barbara & Schembri, 2015; Azzurro, Soto, Garofalo & Maynou, 2013; Raitsos et al., 2010; Coll Piroddi et al., 2010; Ben Rais Lasram & Mouillot, 2009) and the distribution of native Mediterranean fauna is shifting (Albouy, Guilhaumon, Araújo, Mouillot & Leprieur, 2012; Azzurro, Moschella & Maynou, 2011; Psomadakis, Bentivegna, Giustino, Travaglini & Vacchi, 2011). The consequences of climate change will eventually affect ecosystem functioning as a whole, especially when functional consequences of climate change affect key or engineering species (Lejeusne et al., 2010). An overview of the expected effects of climate change on the Mediterranean Sea and its biological resources is presented in Table 1.

When assessing potential impacts on fisheries as an economic activity, it is difficult to distinguish between changes occurring due to climate change and those which are due to other pressures such as for instance loss of habitats, overfishing and pollution. Potential synergies between the various stressors acting on marine ecosystems are as yet unknown (Calvo et al., 2012). Nevertheless, whilst the impacts of climate change have to be evaluated in the context of other anthropogenic pressures, it is clear that as climate change increases in importance in coming decades, the distribution, productivity and resilience of fish stocks, and thus fisheries productivity, will increasingly be affected.

The main aim of this review is to (i) develop an understanding of how climate change may be impacting the Maltese fisheries sector, (ii) identify which fleet segments of the Maltese fishing fleet are most likely to be affected, and (iii) analyse the economic implications of climate change on employment, product growth/decline, capital investment, competitiveness and skills/educational development.

2 Materials and Methods

2.1 Product Growth/Decline

The product of the Maltese fishing industry can be defined as the quantity of species landed (i.e. species caught minus non-retained by-catch/discards) by each fishing activity. Fishing activity was defined as outlined in Commission Decision 2008/949/EC (Appendix IV: Fishing activity (metier) by region).

Data on species landed by Maltese fishing vessels was extracted from the capture production database of the General Fisheries Commission for the Mediterranean (GFCM). Species were ranked in terms of the mean total weight landed in 2009–2011. The percentage contribution to total mean landings during this time period was computed per species, and the most important species sustaining the Maltese fishing industry were thus identified.

In order to identify the potential impact of climate change on these commercially important species, a comprehensive literature search was carried out. Ultimately, climate-driven changes in stocks will result from a number of (interlinked) mechanisms affecting the life cycles of species targeted by the fishing industry, including (i) physiological responses, (ii) behavioural responses, (iii) changes in population dynamics, (iv) ecosystem level changes (Rijnsdorp, Peck, Engelhard, Mollmann & Pinnegar, 2009).

Changes in productivity of the fishing industry (growth/decline) due to climate change can thus be monitored by comparing actual changes in landings of fishing activities which target species for which there is evidence of being affected by climate change, to the projected trajectory of change. However, such assessments of changes in landings also have to take into account:

(i) Fishing effort parameters (e.g. days at sea or engine strength); only changes in standardised catch per unit effort (CPUE) data will allow inferences to be made on the true abundance of target species at sea (see Maunder and Punt, 2004 for details).
(ii) Species stock status; where available catch forecast scenarios based on analytical stock assessments need to be taken into account.

Information on fishing effort parameters were extracted from fisheries-dependent data supplied by the Department of Fisheries and Aquaculture of the Government of Malta. Information on species stock status and catch forecast scenarios was extracted from relevant reports of the EU's Scientific, Technical and Economic Committee for Fisheries (STECF).

2.2 Employment

Data on employment in the fishing sector is collected by the Maltese authorities at the fleet segment level; classification into fleet segments is done on an annual basis based on two factors: (i) gear used and (ii) vessel length class.

A matrix showing the contribution of the fishing techniques to species catches was constructed in order to relate climate change impacts on individual species to impacts on fleet segments. The majority of vessels in the Maltese fishing vessel register use a number of different gear types which change on a seasonal basis and from one year to the next. Similarly, target species vary between seasons and years. For the purpose of identi-

Table 1: Overview of the expected effects of climate change on the Mediterranean Sea and its biological resources. Key references: Boero (2013), Sterftaris and Zenetos (2006), Sala, Kizilkaya, Yildirim and Ballesteros (2011), Rijnsdorp, Peck, Engelhard, Mollmann and Pinnegar (2009), Calvo et al. (2011).

A – Effects on the Geophysical Environment and Oceanographic Parameters
• Increase in mean annual surface as well as water column seawater temperature, in particular at shallower depths above the thermocline. • Gradual salinization of seawater esp. in intermediate and deep layers due to increases in evaporation and decrease in both terrestrial runoff and direct precipitation in the Mediterranean. • Alteration in marine circulation patterns due to changes in salinity and temperature altering water density and thus deep water formation. Changes in thermohaline circulation patterns will affect transport of nutrients in and out of the euphotic zone and hence primary production/food webs, as well as other processes linked to current patterns such as migration movements and dispersal of marine species. • Increased stability of the water column leading to increased stratification and decreased vertical mixing of water masses, hence leading to more oligotrophic surface waters and deeper thermoclines with associated impacts on biota (e.g. mass mortalities of gorgonians). • Increased absorption of CO_2 leading to ocean acidification with impacts on calcifying organisms such as mussels, species of zooplankton, and ecosystem engineers such as scleractinian corals and coralline algae. • Increase in frequency of extreme storm events may lead to changes in wave events affecting coastal marine ecosystems impacted by wave action (e.g. seagrass meadows). • Increase in droughts and overall reduction in rainfall leading to a reduced supply of nutrients from land-based sources, reducing overall primary productivity (i.e. phytoplankton growth, which is the basis of the oceanic food chain). • Decrease in seawater oxygen saturation and increase in the frequency of extreme events of anoxia and toxic algal blooms, in particular where more pronounced and stable water stratification occurs.
B – Effects on Marine Organisms
• Changes in environmental parameters will impact physiological rates, for instance changes in pH will affect metabolism, reproductive potential and mortality levels of organisms. • Survival of early life stages in coastal nursery areas will be affected by changes in their physical environment (e.g. increased storm frequencies). • The spread of diseases may be facilitated by increased mean annual sea temperatures, affecting organisms, including species of commercial value (e.g. commercially harvested sponges). • Behavioural responses will lead to shifts in breeding periods and distribution areas, including shifts in annual migrations to feeding/spawning grounds through active temperature preference of some species. • Population dynamics (recruitment, growth and mortality): changes in recruitment rates may occur as a result of mismatches between the timing of reproduction and the production of larval food; changes in temperature will affect growth rates; high temperature conditions may increase mortality rates; changes in ocean currents may affect the transport of eggs and larvae from spawning sites to nursery areas. • Trophic changes in food webs will affect the entire structure of the ecosystem, resulting in changes in the productivity and distribution of populations. • Entry and spread of new species that did not previously occur may cause shifts in ecosystem structure and function (e.g. the creation of rocky barrens by the alien herbivorous fish *Siganus* spp. through grazing).
C – Effects on Fishing
• Shifts in distribution areas of commercial target species will change susceptibility of species to particular fishing gears and fishing fleets. • Protective capacities of existing closed-areas designed to protect nursery and/or spawning areas may no longer be effective, increasing the vulnerability of critical life stages. • Climate change may make species more vulnerable to overexploitation, and conversely overfished populations may become more vulnerable to climate change. • Predator-prey relationships shifting as a result of trophic changes in food webs may be further affected by the impact of fishing on population size structures, with potentially detrimental synergistic effects. • Higher sea surface temperatures and ocean stratification in the open sea promote the development of jellyfish swarms, which in turn increases predation on ichtyoplankton (i.e. fish larvae and eggs) to the detriment of fisheries. • Alien species and range expanding species may replace native species. This may have a positive or negative impact on fisheries, depending on the relative commercial value of the native and replacing species in question. • Blooms of certain planktonic species may be detrimental to fisheries. Gelatinous plankton (i.e. jellyfish) blooms may impair fishing activities by clogging nets; toxic algal blooms may cause mortalities.

fying potential short to medium term trends in the impact of climate change on employment, calculations were based on the mean values of the three most recent years' data available for fleet segments identified when assessing projected product growth/decline.

Information on employment in the fishing industry was extracted from fisheries-dependent data supplied by the Department of Fisheries and Aquaculture of the Government of Malta.

2.3 Capital Investment

Changes in investments are monitored in terms of improvements to existing vessels or gears during the given reference year; data available for the Maltese fishing sector thus refers to investments in physical capital. For the purpose of identifying potential short to medium term trends in the impact of climate change on capital investment, calculations were based on the mean values of the three most recent years' data available for fleet segments identified when assessing projected product growth/decline.

Information on investments was extracted from fisheries-dependent data supplied by the Department of Fisheries and Aquaculture of the Government of Malta; for a list of economic parameters which are monitored see Commission Decision 2008/949/EC (Appendix VI: List of economic variables).

2.4 Competitiveness & Skills/Educational Development

Proposed measures to improve the competitiveness as well as the skills base of the Maltese fishing industry are outlined in the Fisheries Operational Programme for Malta, and in Malta's National Strategic Plan for Fisheries. Both policy documents were drafted for the period 2007–2013; however, several of these measures have yet to be implemented. The planned actions outlined in the two strategic documents were assessed in terms of potential impacts of climate change.

3 Results

3.1 Product Growth/Decline

Fifteen species/species groups accounted for 84% of mean total landings recorded for the Maltese fishing fleet in 2009–2011. The remaining 16% of landings were composed of over 130 other species.

Potential future climate change impacts on different classes of commercially important target species exploited by the Maltese fishing fleet which have to date been identified in the scientific literature are presented in Table 3; a summary of potential trends due to climate change as well as available information on stock status and short term landing forecasts are shown in Table 4.

Taking dolphinfish (*Coryphaena hippurus*) as an example, an increase in abundance is expected as a result of climate change since this is a thermophilic species. No stock assessment or landing forecasts are available for this species, but a recent analysis of the available data has shown a decline in CPUE in 2005–2012. The negative effects of stock overexploitation could in the long term be balanced out by the positive effects of climate change but further research is required on this aspect.

Overall it is clear that further research on (i) stock status and (ii) the impact of climate change is required to accurately predict the impact of climate change on the productivity of the Maltese fishing sector, especially in quantitative terms.

3.2 Employment

Fishing techniques vary depending on species characteristics. In 2009–2011 large pelagic species were mainly caught by vessels using hooks (bluefin tuna, swordfish) and other active gears (dolphinfish); over 70% of landings declared by vessels using hooks were caught using drifting longlines. Demersal species were targeted mainly by bottom otter trawlers (giant red shrimp and red mullets).

In terms of employment, the vast majority of full time positions were generated by vessels using hooks, followed by vessels using other active gears and demersal trawlers in 2011. Climate change impacts on species fished with gears using hooks will thus have the largest impact in terms of employment.

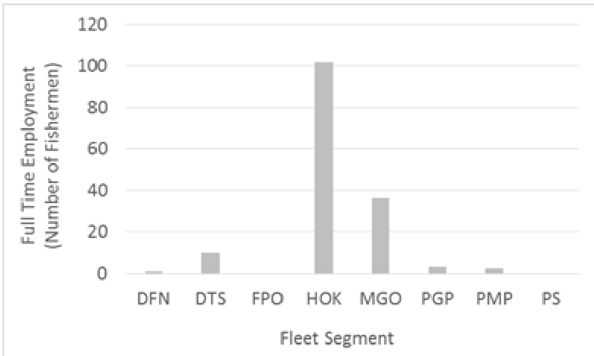

Figure 1: Full time employment according to fishing technique as recorded for the Maltese fishing sector in 2011. Gear codes refer to the following: DFN-Drift and/or fixed netters; DTS-Demersal trawlers and/or demersal seiners; FPO-Vessels using pots and/or traps; HOK-Vessels using hooks; MGO-Vessel using other active gears; PGP-Vessels using polyvalent passive gears only; PMP-Vessels using active and passive gears; PS-Purse seiners.

Information available in the scientific literature suggests that climate change will have positive impacts on both bluefin tuna and dolphinfish (Bombace, 2001; Azzurro et al., 2011); provided the populations will not decline due to overfishing, environmental change in isolation could in fact positively impact employment in the

Maltese fishing industry.

3.3 Capital Investment

According to the official data collected by the Maltese authorities, total capital investments by the Maltese fishing fleet amounted to €1.6 million in 2011. In relation to 2010, this represents an overall increase of 14%. In 2011, the highest investments were recorded for vessels using hooks, followed by vessels using other polyvalent passive gears and vessels using other active gears.

As was the case for employment, investing in vessels using hooks may prove to be a good strategy since the available information indicates potential positive trends related to climate change for species caught by this gear type.

3.4 Competitiveness, Skills and Educational Development

The specific objectives outlined by the Maltese authorities to increase competitiveness of the sector, and to upgrade and diversify professional skills of Maltese fisheries, summarised from the Maltese Fisheries Operational Programme and Malta's National Strategic Plan for Fisheries for 2007–2013, are listed below.

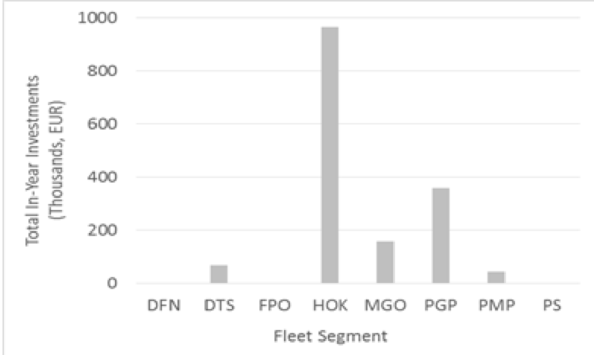

Figure 2: Total in-year investment according to fishing technique as recorded for the Maltese fishing sector in 2011. Gear codes as per Figure 1.

Specific objectives to increase the competitiveness of the fisheries industry in Malta.

- To improve port infrastructure including landing and storage facilities in different ports across the country to increase quality of fish and to enable fishers to supply fish at competitive prices;
- To enhance the efficiency of the operations of enterprises involved in processing and marketing of fish products;
- To enhance product quality and presentation;

Table 2: Fifteen highest ranked species/species groups in terms of mean total landings recorded for the Maltese fishing fleet in 2009–2011. The names of the five species which generated the highest landed values in 2011 (STECF-13-15, 2013) are highlighted in bold.

Scientific Name	Common Name	Mean Landings 2009–2011 (t)	St. Dev. (t)	% of Mean Total Landings 2009–2011
Coryphaena hippurus	**Dolphinfish**	424.5	94.2	23.8
Xiphias gladius	**Swordfish**	406.9	133.7	22.8
Thunnus thynnus	**Bluefin tuna**	185.8	66.7	10.4
Scomber spp.	Mackerels	135.9	83.4	7.6
Mullus spp.*	**Red mullets**	63.3	16.5	3.6
Boops boops	Bogue	54.9	49.2	3.1
Scorpaena spp.**	Scorpionfish	39.0	9.7	2.2
Octopus vulgaris	Common octopus	38.3	14.4	2.1
Aristaeomorpha foliacea	**Giant red shrimp**	36.1	7.6	2.0
Sepia officinalis	Cuttlefish	28.0	8.1	1.6
Trachurus spp.***	Jack mackerels	16.0	6.0	0.9
Parapenaeus longirostris	Deep-water rose shrimp	15.6	7.4	0.9
Pagrus pagrus	Red porgy	15.6	6.4	0.9
Raja clavata	Thornback skate	15.2	7.9	0.9
Pagellus erythrinus	Common pandora	14.7	4.9	0.8

* Species: *Mullus barbatus*, *Mullus surmuletus*
** Species: *Scorpaena notata*, *Scorpaena porcus*, *Scorpaena scrofa*
*** Species: *Trachurus mediterraneus*, *Trachurus trachurus*

Table 3: Potential future climate change impacts on different classes of commercially important target species exploited by the Maltese fishing fleet.

Climate Change Impact	Potential Mechanism	Reference
Large Pelagic Fish		
Bluefin tuna (*Thunnus thynnus*)	Increased length of stay in central Mediterranean waters due to changes in species migration patterns	Bombace (2001)
Dolphinfish (*Coryphaena hippurus*)	Possible increase in abundance since the species is thermophilic	Azzurro, Moschella and Maynou (2011)
Small Pelagic Fish		
Bogue (*Boops boops*)	Reduction in numbers through competition by exotic invasive species (*Siganus* spp. have been observed to outcompete native herbivorous fish such as *Boops boops* along the Libyan coast and in the S.E. Aegean)	Papaconstantinou (1987); Galil (2007)
Demersal Fish		
Red mullet (*Mullus barbatus*)	Reduction in numbers through competition with exotic invasive species (e.g. *Upeneus moluccensis* in the Levantine Basin)	Ben Rais Lasram and Mouillot (2009)
Demersal Crustaceans		
Giant red shrimp (*Aristaeomorpha foliacea*)	Decrease in abundance correlated with an increase in warmer, more saline waters and reduced dissolved oxygen	Cartes et al. (2011)
Deep-water rose shrimp (*Parapenaeus longirostris*)	Stock abundance positively correlated with rising sea surface temperatures and decreasing wind circulation	Ligas, Sartor and Colloca (2011)
Demersal Mollusc		
Octopus (*Octopus vulgaris*)	Decrease in abundance correlated with warm anomalies, possibly due to shifts in larval distribution and/or primary productivity caused by changes in ocean circulation	Vargas-Yanez et al. (2009)

Table 4: Summary of available information on predicted climate change impacts and catch trajectories for the most commercially important species harvested by the Maltese fishing sector.

	Potential Climate Change Impact*	**Stock Status****	**Short Term Landings Forecast with Unchanged Fishing Mortality*****
Bluefin tuna	Increase	Recovering[1]	Unknown: species managed through annually negotiated quota system
Dolphinfish	Increase	Unknown; declining CPUE[2]	Unknown: no stock assessment
Giant red shrimp	Decrease	Subject to overfishing[1]	Unknown: projections only till 2013[3]
Red mullets	Decrease	Subject to overfishing[1,2]	*Red mullet* - Unknown: projections only till 2013[3] *Striped red mullet* - Increase 2014 to 2015[2]
Swordfish	Unknown	Overfished[1]	Unknown: degree to which stock is overfished is uncertain[1]

* See Table 3 for potential mechanisms and references.
** Status definitions refer to standard terminology as defined by the General Fisheries Commission for the Mediterranean (GFCM).
*** Status quo fishing mortality (F_{stq}) as calculated by the most up to date stock assessment available.
[1]STECF-13-27 (2013)
[2]STECF-14-08 (2013)
[3]STECF-13-05 (2013)

Table 5: Mean percentage contributions of different fishing techniques to catches of the five economically most important species targeted by the Maltese fishing industry in 2009–2011. Gear codes are as per Figure 1 above.

	Mean % Contribution to Landings (2009–2011)				
Fishing Technique	**Bluefin Tuna**	**Dolphinfish**	**Giant Red Shrimp**	**Red Mullets**	**Swordfish**
DFN	0	0	0	0	0
DTS	0	0	100	84	0
FPO	0	0	0	0	0
HOK	62	25	0	2	82
MGO	3	52	0	0	2
PGP	0	7	0	10	10
PMP	11	14	0	4	7
PS	24	2	0	0	0

- To improve public health and hygiene conditions;
- To develop and market new products;
- To support the marketing of products originating from less saleable local landings;
- To improve working conditions of people employed in the sector;
- Ensuring that the work environment is conducive to equal access by men and women to the industry;
- To improve the management and use of by-products and waste;
- To establish Producer Organisations to enable fishers to obtain better results in marketing their produce.

Specific objectives to upgrade and diversify professional skills of Maltese fishers.

- The diversification of activities by fishers;
- The upgrading of professional skills through lifelong learning, targeting in particular skills in navigation, communication and seamanship;
- The provision of training to fishers for occupations outside sea fishing;
- The promotion of equal rights for men and women in the fisheries industry;
- The continued and increased participation of young (< 40 years old) fishers.

Some of the planned actions are more relevant than others with regards to managing the potential impacts of climate change, and should thus be given priority when attempting to address climate change. With regards to maintaining competitiveness, experience in the Eastern Mediterranean (e.g. Carpentieri et al., 2009) has shown that a focus on improving the development and marketing of new products, and supporting the marketing of products originating from less saleable local landings, may be the most effective in helping the local fishing industry to cope with climate change. Having effective marketing strategies in place for such products might increase the sector's competitiveness by capitalising on catches of new, previously unknown or uncommon species which may in future be found in the Sicilian Channel as a result of climate change.

With regards to skills and educational development, it may be beneficial to place an emphasis on the diversification of activities fishers are engaged in, in order to help the sector cope with climate change. Since it is difficult to predict the impacts of climate change on the product growth/decline of the Maltese fishing industry with precision, fishers should be empowered to become more flexible so they are able to shift their activities to the most profitable alternatives resulting from climate change as and when they arise.

4 Discussion and Conclusion

The most important fleet segment contributing to the overall productivity of the Maltese fishing industry, in terms of total biomass landed and total generated income, is comprised of vessels using drifting surface longlines. In 2011 this fleet segment generated the largest number of full time employment positions, and was the most important fleet segment in terms of total investments. Available information on species targeted by this fleet segment suggests that climate change may in fact lead to an increase in fish abundance in the waters surrounding the Maltese Islands. Impacts of climate change on the Maltese fishing industry as a whole may thus be positive.

Emerging information on the implications of climate change on commercially targeted fish stocks in the Mediterranean, as well as results of stock assessments, however need to be continuously assessed and updated in the coming years. For instance, there is currently no information on the potential impact of climate change on swordfish, a species which contributed 23% to total landings by weight made by vessels using hooks in 2009–2011, and conclusive catch trajectory forecasts based on analytical stock assessments are lacking for both dolphinfish and swordfish, which together contributed 47%

of landings by weight made by vessels using hooks in 2009–2011. Such information is vital when attempting to predict the impacts of climate change on fisheries in the Maltese Islands. Overall, it is clear that considerable uncertainties and research gaps remain, in particular with regards to the effects of synergistic interactions among stressors such as fishing, pollution and climate change. The abilities of marine organisms and communities to adapt to the changes and evolve, as well as the role of critical thresholds are not well understood. Increased research on the projected impacts of climate change on marine fish and fisheries is thus essential to implement successful coping strategies (Hollowed et al., 2013).

In order to ensure the continued competitiveness of the Maltese fishing industry in light of this uncertain situation, an emphasis should be placed on ensuring the industry is flexible and able to effectively market and promote new products as and when they emerge. This may in future include adjusting fishing techniques to effectively target new potentially important species resulting from changes in the distribution of commercial (i.e. edible) species in the Mediterranean. Such changes in fishing patterns are ongoing in other parts of the Mediterranean; for instance in Southern Lebanon 37% of the total landing by weight are now composed of Lessepsian species, and non-indigenous species have become important components of Lebanese fisheries (Carpentieri et al., 2009).

The recent Marine Strategy Framework Directive (MSFD) Initial Assessment report on Non-Indigenous Species (NIS) for Malta (MEPA, Malta Environment Planning Authority, 2014), which builds on a previous review by Sciberras and Schembri (2007), reveals that 56 NIS have to date been recorded in the Maltese Islands. MEPA, Malta Environment Planning Authority (2014) list 10 species of phytobenthos and macroalgae, 33 species of crustaceans, echinoderms and molluscs, and 13 species of fish. Of these species 52% have become established in the wild with free-living, self-perpetuating populations that are independent of anthropogenic influences. Although the great majority of these species have no direct implications for the Maltese fishing industry, there are three species which have on occasion been offered for sale at the Marsaxlokk fish market: the dusky spinefoot (*Siganus luridus*), the bluespotted cornetfish (*Fistularia commersonii*) and the spotted scat (*Scatophagus argus*) (MEPA, Malta Environment Planning Authority, 2014). All three species have been mainly caught with gill and trammel nets set in shallow waters (Deidun & Germanà, 2011; Zammit & Schembri, 2011; Schembri, Deidun & Falzon, 2012). However it is doubtful whether *S. argus* is still established in Maltese waters since no recent records exist (Evans et al., 2015). *S. luridus* and *F. commersonii* are also not sufficiently abundant to have any important implications on the Maltese fishing industry.

Although non-indigenous species are not abundant enough at present to constitute new target species as is the case in other parts of the Mediterranean, the industry would benefit from developing fishers' skills to increase the sector's flexibility. In this manner fishers' ability to cope with likely future changes in stock distribution and target species' abundances would be increased. An emphasis should also be placed on generally diversifying the activities of the Maltese fishing industry. Such diversification could, for instance, be achieved by developing and marketing new or value added products, for which detailed commercial feasibility studies should be carried out with the involvement of local fishers' cooperatives. Increased marketing of products from less saleable local landings may be beneficial to increase the resilience of the Maltese fishing industry; local consumer education could be one way of creating demand for species which are not consumed traditionally or are less well known.

The Fisheries Operational Programme for Malta and Malta's National Strategic Plan for Fisheries were drafted for the period 2007–2013. Several of the measures identified therein would have assisted in increasing the flexibility and adaptability of the Maltese fishing industry. The Maltese authorities are currently drafting a new Operational Programme under the European Maritime and Fisheries Fund (EMFF; Regulation (EU) No 508/2014), which will cover the period 2014–2020. This could be a further opportunity to prioritise measures that would increase the sector's resilience to climate change.

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