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Guidance on Promoting Survival of Discarded Fish

1. Executive Summary

The EU Common Fisheries Policy (CFP) is, through the Landing Obligation, attempting to minimise wasteful use of living resources by discouraging the release of potentially dead and dying unwanted catches back to the sea. However, there are several situations in which the release of animals from commercial fishing operations will still be permitted (Art. 15 of EU Reg. 1380/2013):

- Protected species
- Unregulated species
- High survival exemptions
- *De minimis* derogations

Commercial fishing practices can cause injuries and stress that will compromise the survival¹ of any animals that are caught and subsequently released. To promote the survival of these released animals it is necessary to understand what stressors an animal may experience during a particular capture process, and how these stressors can be avoided or minimised. The nature and severity of these stressors will be dependent upon the animal, the capture and handling methods, and the environment in which the animal is caught. As such, practical solutions for promoting survival will be dependent upon these factors, and some specific examples are provided in this report.

The primary solution to reducing discard mortality is to avoid catching unwanted animals in the first place. This can be achieved by **modifying fishing practices** to either:

- **avoid unwanted catches** by not fishing in areas or at times associated with substantial quantities of unwanted animals (e.g. Gullestad et al, 2014), or by
- **improving gear selectivity** to promote the escape of any unwanted catch before the gear is retrieved (e.g. Wileman et al, 1996; Holst et al, 1998).

Where unwanted catches cannot be avoided, simple modification of fishing practices can improve the survival likelihood of any released animals, for example:

- 1) **Limited duration of fishing operations** (i.e. tows duration, soak-times) will limit the exposure of each animal to capture related stressors, and so they are

¹ Survival: the proportion of animals that do not die following a stressful event (e.g. catch and release) for a specified period of time. Ideally, the animals should be observed for any resultant mortality rate to have stabilised or reached asymptote.

- more able to cope with the stressors experienced during retrieval, handling and release.
- 2) **Smaller catch volumes** are likely to result from limited fishing times, or using catch control devices, but they will also be of benefit to the unwanted catch by reducing the risk of injury and/or asphyxiation. Also, the crew will process smaller catches more quickly, thus reducing exposure to emersion related stressors.
 - 3) **Handled with urgency and care:** at all stages of retrieval, sorting and release the catch should be processed as quickly and carefully as possible, to reduce the risk injury and further stress.
 - 4) **Avoid direct sunlight:** the catch should be kept out of direct sunlight to avoid potential stress and injury from bright light. Particularly important for deep-water organisms.
 - 5) **Avoid emersion:** where practical, the catch should be retained in freshly supplied, oxygenated water during retrieval and while sorting to minimise any effects from emersion.
 - 6) **Avoid seabird predation:** as soon as an animal has been selected for release, it should be released into the water with care and via a route that promotes its escape from the surface, and minimises likelihood of further injury and encounters with predators (e.g. a discharge pipe).
 - 7) **Appropriate release location:** where practical and safe, unwanted catch should be released in a location where they will quickly find a suitable habitat for shelter and food (i.e. ideally close to where they were first caught).
 - 8) **Assisted recompression:** animals suffering from physical barotrauma (i.e. excessively swollen or ruptured swimbladder), which would be unable to swim away from the surface, could be assisted using a device that enables recompression.

Some of these mitigation measures (for example i. to iv.) could be applied immediately by communicating these recommendations directly to the fishers. However, further research will be required to further develop others (for example v. vi. & viii). Examples of the methods and analysis to undertake the survival assessments required for this development work are presented in MINOUW Deliverable Report D2.16.

2. Introduction

The EU Common Fisheries Policy (CFP) is, through the Landing Obligation (Art. 15 of EU Reg. 1380/2013)(see appendix 1), attempting to minimise wasteful use of living resources by discouraging the release of unwanted catches back to the sea, on the reasonable assumption that many of those released animals are likely to be dead or dying (Borges, 2015; Salomon et al, 2014). However, there is growing scientific evidence to suggest that some of those animals may not be dying (e.g. Revill, 2012), furthermore there are several situations in which the release of animals from commercial fishing operations will still be permitted and /or necessary:

- Protected species – endangered and protected species identified by the European Habitats Directive (Annexes II & IV) must be released.

http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

- Non-regulated species – the Landing Obligation currently only applies to regulated species. That is, species for which there are TACs (Total Allowance Catch, and so called quotas) or, in the Mediterranean, species which have a MCRS (minimum conservation reference size).

http://ec.europa.eu/fisheries/cfp/fishing_rules/discards_en

- High survival exemptions – fishery specific regulations may exist for some species for which it has been demonstrated there is scientific evidence of “high survival”² when they are released from commercial fishing operations, in accordance with the CFP, Article 15, paragraph 4b.
- *De minimis* derogations – fishery specific regulations may exist which permit the release of small quantities (<5%) of total annual catches under certain circumstances, in accordance with the CFP, Article 15, paragraph 5c.

Thus there will be an ongoing need to consider the welfare and promote the survival of animals released from commercial fishing vessels.

Benefits of Good Catch Welfare

Good animal welfare during capture is important to prevent unintended mortality for animals that are to be released from fishing gears, but is also important for good quality fish products. The stress experienced during the capture process can induce significant mortality amongst any released catch (e.g. Revill, 2012). Furthermore, acute stress immediately prior to slaughter has been demonstrated to reduce flesh quality in a number of fish species, including Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), Atlantic cod (*Gadus morhua*), turbot (*Scophthalmus maximus*), sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*).

The capture, handling and release processes are not benign, as fish are exposed to a range of dynamic stressors. Stressors act upon the fish to elicit a stress response. The stress response is the naturally occurring sum of all physiological and behavioural

² see appendix 2 for more details on the High Survival Exemption.

modifications made in the face of a stressor, as the organism attempts to re-establish allostasis.

Thus “Catch Welfare” is more than just an ethical issue – it can potentially ensure good product quality from the catch and promote the survival of any unwanted catch, contributing to reduced fishing mortality, which is essential for a sustainable fishery sector. These and the ethical concept of “good welfare” will promote confidence in the consumer with respect both the quality of the product and sustainability of the fishery, which will give added value to the final product.

Report Objectives

This report (constituting Deliverable 2.15) aims to provide simple and pragmatic guidance to promote the survival of animals that are returned to the sea (or discarded) after being unintentionally caught during commercial fishing operations. It will provide a brief explanation of what mechanisms during the capture and discarding processes can stress and kill animals. It will then discuss some practical solutions for addressing these stressful mechanisms to not only promote the survival of any released animals, but also to potentially improve the quality of the retained catch.

This guidance will be based on the scientific literature, as well as the experience and knowledge gained by the researchers collaborating in Project MINOUW (H2020 - 634495). So, while this guidance aims to be generally applicable to most commercial fishing operations, there will also be examples and advice that are particularly relevant for Southern European and Mediterranean fisheries.

What kills discarded animals?

The capture and subsequent release of unwanted catches from fishing operations is known to kill some discarded animals (e.g. Revill, 2012, Breen & Catchpole, 2017). Before addressing how to promote the survival of animals being released from fishing operations, it is first necessary to understand what processes can lead to post-release mortality.

Why animals die?

Every animal has critical biological systems that maintain its vitality throughout its life. If any one of these systems permanently fails, the animal will die (Hillman, 2003). For a fish, these systems include the cardio-vascular, respiratory and neurological systems; the loss of any one of which will rapidly kill the fish (Roberts, 2012; Ellis *et al.*, 2012). There are other critical systems that if severely disrupted will significantly increase the likelihood of the fish dying, but maybe over a longer period (i.e. hours to days), including: the osmoregulatory, metabolic, immunological, endocrinological and behavioural systems, for example (Roberts, 2012; Ellis *et al.*, 2012). Failure of these systems, or components of them, can happen for many different reasons, including: traumatic injury, physiological disruption, disease, and senescence (aging); or any combination of these.

Under normal circumstances, every animal has a finite metabolic capacity which is allocated to both the basal functions (i.e. the critical biological systems) and non-basal functions (i.e. locomotion, digestion and growth) (McKenzie et al, 2016). If the animal is faced with a life-threatening situation, i.e. a stressor (e.g. a predator, injury, change in environmental conditions, disease), this metabolic capacity will be directed to the most appropriate functions to counteract the stressor and keep the animal alive, commonly referred to as a stress response (Cooke et al, 2012). However, if there is insufficient metabolic capacity for the animal to counteract the stressor (or combinations of stressors) and maintain its basal functions, it will likely die. Individual animals will have different metabolic capacities, depending upon various factors, including: age, size, physical condition and sex. Therefore, what simply manifests as the death of an individual can have numerous possible causes, mechanisms and time-frames.

Stressors encountered during capture, handling & release

Hypoxia

Insufficient oxygen, hypoxia, is an important and potentially fatal stressor for all aerobic organisms, including fish and other aquatic animals (Hugues, 1975; Domenici et al, 2012). In the context of fish capture, it can be caused by: low oxygen (hypoxic) concentrations in the water around the animal (for water breathing animals); a reduced functionality in the animal's ability to breath (asphyxia) due to injury or constriction; and/or complete emersion from the animal's breathing medium (i.e. water breathing animals, e.g. fish, crustaceans; or air-breathing animals, e.g. mammals and amphibians). Tolerance of hypoxia will vary between species, and will be modulated by various environmental parameters, including temperature (Domenici et al, 2012; Rogers et al, 2016). However, prolonged hypoxia will eventually lead to cell death and the failure of critical biological systems (Hugues, 1975).

Fatigue & Exhaustion

As part of the capture process (e.g. in trawls), while struggling to free themselves from a fishing gear (e.g. hooks and gillnets), or while on deck of the fishing boat, captive animals may become fatigued or exhausted due to excessively strenuous activity. Exhaustive swimming can cause fatalities in some fish (Beamish, 1966; Black, 1958; Breen et al, 2004), due to physiological disruption from a build-up of lactate and other metabolic acids in the blood (Wood et al, 1983). Even if not fatal, the oxygen debt associated with exhaustion can limit an animal's metabolic capacity and compromise their ability to cope with other stressors. The effects of exhaustion will exacerbate, and in turn be exacerbated by, hypoxia (see above).

Decompression & Barotrauma

A rapid ascent from depth will cause a reduction in hydrostatic pressure that can cause injury and stress in some aquatic animals via two related mechanisms; physical and physiological barotrauma. Physical barotrauma is due to a rapid and uncontrolled expansion in closed air spaces within the animal's body (e.g. physoclistous swim-bladders) in accordance with Boyle's Law (Brown et al, 2012). This rapid expansion can cause the swim-bladder wall to rupture, releasing gas into the abdomen, which with

further expansion can cause internal organs to be everted through the mouth or anus (Feathers and Knable, 1983; Rogers et al, 1986). Effects are most damaging at depths greater than 40 m, where reduction in ambient hydrostatic pressure can cause greater than five-fold expansions in swim-bladder volumes. Physiological barotrauma is due to dissolved gases coming out of solution in the animal's blood and tissue fluids in accordance with Henry's Law (Brown et al, 2012). This is synonymous with the condition referred to as "the bends" in divers, and causes bubbles to form in the blood and tissues, which can impede blood supply and disrupt the functionality of some critical systems, especially the neurological system. In fish, symptoms include the appearance of bubbles in the fins and eyes of affected animals (Brown et al, 2012).

Temperature Shock

Most aquatic animals are ectotherms (except mammals), that is their body temperature is dependent on the ambient environmental temperature. If there are rapid changes in the ambient temperature this can cause disruption of the animal's metabolism called "temperature shock", which can sometimes result in death (Davis & Olla, 2001, 2002; Davis et al, 2001; Donaldson et al, 2008; Gale et al, 2013). Animals captured in fishing gears are most likely to experience stressful temperature changes during the retrieval of the gear, when they are likely to ascend through thermoclines, and in particular when exposed to ambient air temperatures, which could be far in excess of fatal temperature thresholds (e.g. less than -10 °C in the Barents Sea during winter; or greater than 30 °C in the Mediterranean in the summer).

Osmoregulatory Distress

Many animals need to maintain, "osmoregulate", an optimal concentration of dissolved salts in their blood and other tissue fluids for their metabolism to function effectively. This can be particularly challenging for water-breathing aquatic animals, which continually exchange water and dissolved ions across their respiratory surfaces (Greenwell et al, 2003). This challenge is heightened when the animal is stressed because one of the key stress responses is to increase blood circulation to the respiratory surfaces, to increase the potential uptake of dissolved oxygen from the water; but which consequently increases water/ion exchange leading to haemoconcentration in marine species and haemodilution in freshwater species (e.g. Wedemeyer et al, 1990; Barton, 1997; Cooke et al, 2013). A substantial change in salinity of the ambient water, i.e. by passing through a halocline during the retrieval of the gear, has been observed to cause osmoregulatory distress in some species (e.g. Harris & Ulmstrand, 2004). Furthermore, injuries that result in blood loss and/or increased exchange of water and dissolved ions could disrupt osmoregulation and consequentially reduce metabolic capacity to cope with other stressors (Smith, 1993; Greenwell et al, 2003).

Crowding

Confinement and crowding can induce stress, injury and mortality in captive aquatic animals (Portz et al, 2006; Huse & Vold, 2010; Tenningen et al, 2012). Although, crowding in itself will be stressful for many aquatic animals, it will also increase the likelihood of injury due to physical contact with the catch and fishing gear, as well as hypoxia if the biomass is sufficiently large and/or dissolved oxygen supply is restricted. As such, it can be considered as a collective stressor (see also "emersion").

Physical trauma & injury

The potential for physical trauma during the capture, handling and release of animals is considerable and likely to result in wide range of injuries, including: skin abrasion, lacerations, puncture wounds, blunt force trauma and crushing. Moreover, many aquatic animals, particularly pelagic species, have evolved relatively delicate integuments (skins) and are not well adapted to physical contact with hard and abrasive surfaces (Elliot, 2011; Kitsios, 2016). In addition to loss of functionality in the target organ, wounds from physical trauma may lead to the loss of blood and other tissue fluids, increase the likelihood of infections, and cause discomfort and distress for the animal.

Light Exposure

Natural light levels are greatly reduced by attenuation at typical fishing depths in comparison to the surface (Johnson, 2012). At very low light levels, at these fishing depths, it has been observed that some animals may have a reduced responsiveness to approaching fishing gears (Glass & Wardle, 1989; Olla and Davis, 1990; Ryer and Olla, 1998; Olla *et al.*, 2000), which could result in increased risk of injurious contact particularly with towed gears. At the surface, light intensity during the day will be many orders of magnitude higher than the animals are adapted to in their normal habitat. This is likely to cause disorientation and bleaching of sensory pigments in the eye (Pascoe, 1990), leading to short-term or permanent blindness in some species (Frank and Widder, 1994; Chapman et al, 2000). In addition to visible wavelengths of light, aquatic animals brought to the surface will be exposed to potentially damaging UV light, which has the capacity to burn exposed tissues, as well as induce melanoma (Sweet et al, 2012).

Emersion

Removal from the water, “emersion”, will present an aquatic animal with a disorientating and potentially stressful array of novel stimuli. For example, lack of the supportive, hydrostatic properties of the water will mean that many animals will experience their own weight-in-air for the first time. Furthermore, these novel stimuli will be compounded with an array of other stressors: hypoxia/asphyxiation, desiccation, temperature shock and light exposure. As such, it is common for “emersion” to be used as a collective term for the combined effect of all of these stressors.

Displacement

The location where the animal is released may not be close to where it was originally caught; particularly if caught using a towed gear (e.g. trawl); this is called displacement. This new location may provide an inappropriate habitat for the released animal, with regards to environmental parameters (e.g. depth, water currents, temperature, salinity), as well as the provision of shelter and food sources. This is likely to further reduce the survivability of an already compromised animal.

Predation

The stressed and weakened state of discarded animals is likely to lead to behavioural impairment, which may decrease the likelihood of them being able to avoid predators (Olla et al. 1997; Ryer, 2002, 2004; Cooke and; Ryer et al. 2004; Raby et al, 2013).

Furthermore, predators are known to preferentially target sick or weakened individuals (Miller et al. 2014). The likelihood of being preyed upon will be dependent on many factors, in addition to the animal's vitality, including: its size and body form, the prey preferences of the predator, the composition and size of the assemblage of predators; and the availability of suitable shelter in the receiving habitat (Raby et al, 2013; Breen & Catchpole, in press). Seabirds are likely to present one of the most prevalent predators of discarded animals because they forage at or just below the sea-surface, are known to follow fishing boats to specifically prey on discards, and therefore present one of the first predatory threats to discarded animals, at the point when most discarded animals will be at their most vulnerable (Breen & Catchpole, in press).

Pain

Evidence is growing that fish, and possibly crustacea, have the neuro-physiology and anatomy to sense damaging stimuli (e.g. Sneddon et al, 2014). However, it is currently debated whether they are capable of perceiving those stimuli as "pain" (e.g. Rose et al, 2014). While this debate is informative in context with considering the philosophy underlying good animal welfare practices, it should not distract us from defining pragmatic guidance for promoting the survival of released animals for commercial fishing operations. It is clear that the survivability of an animal that is injured and/or experiencing other life threatening stressors is likely to be compromised, at whatever cognitive level it is capable of perceiving that trauma. Therefore, to promote their survival, if released, and to generally improve the welfare of animals during the capture process, a pragmatic solution is to identify where during the capture process these stressors occur and attempt to minimize their impact upon the captive animals, where practical.

3. The capture and discarding processes

Before discussing potential solutions to the stressful and potentially fatal mechanisms that can occur during the capture and subsequent discarding of an animal, it is necessary to have an overview of the capture and discarding process in order to put those mechanisms in context. The capture and discarding process can be broadly categorised as a four-step process:

1. Capture
2. Retrieval
3. Handling (and sorting the catch)
4. Discharge / Return to the sea

1. Capture

There are many different fishing methods with different modes of operation and varying effects on the animals encountering them. The FAO International Standard Statistical Classification of Fishing Gear (ISSCFG), based on construction and mode of operation, recognises 58 different gear types, in 11 broad categories: surrounding nets, seine nets, trawls, dredges, lift nets, falling gear, gillnets and entangling nets, traps, hooks and lines, grappling and wounding, harvesting machines; not including: miscellaneous gear, recreational fishing gear, and gear not known/specified (FAO, 1990).

To make an effective capture, all fishing gears are dependent on the behaviour of the target animals to some degree. With regards to the impact that a capture method can have upon the target and incidental catches, it can be informative to consider both their mode of operation and how they interact with the behaviour of the target animals. To this end, we will consider four different gear types, which have been investigated as part of case studies within project MINOUW:

Trammel nets (CS 3.1, 3.2, 3.4 & 3.5): are multiple sheets of netting suspended vertically in the water between a float-line and a weighted ground-rope. The netting layers will typically consist of a small mesh inner layer, with larger mesh outer layers. They rely on the natural migratory and/or foraging behaviour of fish to capture them as they attempt to swim through the low visibility netting. There are a variety of ways a fish can become entangled in the net. A fish may swim partially through, only to become trapped by the restricted girth of the net around its body. It can be restricted from retreating from the mesh by the netting becoming trapped under its gill covers; referred to as “gilling”. An animal, particularly crustaceans, can also become entangled via an appendage or limb in the netting material. Fish not entangled by the outer layer of net, can swim through and encounter the inner net. If too large to be entangled or “gilled” by the inner net, they can push this net through a larger mesh of the outer net, forming a pocket in which they can become entangled. Dead and dying animals in the net may also act as an attractor to scavenging animals, which in turn become entangled.

Once an animal is entangled, it will inevitably struggle to escape, which will eventually fatigue/exhaust it. In soft-bodied animals, like fish, attempts to struggle free can lead to abrasive injury. In addition, the restricted movement and constriction, particularly if

gilled, can suffocate some animals. The survival of animals released from gillnets and trammel nets is highly variable depending on various factors including tolerance to hypoxia, taxa, animal size and soak time (see Uhlmann & Broadhurst, 2015, for review).

Purse seine (CS2.2 & CS3.3): purse seines are surrounding nets that are deployed, or set, around natural aggregations of pelagic fish. They are essentially a wall of netting, up to 1000 m in length and 200 m deep, that is deployed from a moving vessel to encircle the target school of fish. Although. In southern Europe and the Mediterranean, purse seines are typically smaller: ~800m long and 120m deep, or less (see Mediterranean Regulation 1967/2006, Annex II). Once the school is encircled, a purse-wire on the bottom of the net is hauled in, closing the bottom of the net. Then the net is hauled in, gradually reducing the volume of the net until the catch is concentrated close to the fishing vessel and the catch can be taken on board, using either landing net, or “brails”, or pumping systems. The scale of these operations can vary greatly from fishery to fishery, with some gears and catches being small enough to be hauled by hand, while larger gears require mechanical winches and net haulers and can take single catches of 100s of tonnes.

The capture process starts to become stressful and injurious for the catch once the volume of the net has been reduced to the point at which the movement of the school becomes restricted and they start to become crowded in densities that they would not naturally encounter. At this point, there is an increased risk of physical contact with either the netting or other fish in the school. Physical contact can be particularly injurious for pelagic fish, which generally have delicate and easily damaged skin. As the volume of the net gradually decreases, and the crowding density increases, this risk of physical injury increases. Crowding can become so dense that the catch is pressed against the netting with animals being exposed to compression and crushing injuries, as well as constricted movement preventing effective ventilation of the gills, which could lead to asphyxiation. In larger catches, this can be exacerbated because the large biomass of fish can quickly deplete the surrounding water of oxygen. Furthermore, crowding can also induce “escape” responses in some species, which will rapidly beat their tails in a vain attempt to swim away from the threatening stimuli. This can quickly lead to exhaustion and further exacerbates the risk of hypoxia and asphyxiation. Experiments have demonstrated a strong correlation between crowding density and mortality if fish released from purse seines (Huse & Vold, 2010; Marçalo et al, 2010; Tenningen et al, 2012).

Pots (CS3.7) are a trap that uses an attractor, typically bait, to entice target fish inside the trap. The entrances of the pot are generally designed to ensure the route of entry is easier than the route of escape, and thus retain most animals that enter the gear. The behavioural interactions with the target animals can be complex, particularly before the animal enters the pot. However, fundamental to the capture process is that the animal enters voluntarily. Thus, at least until the animals has entered the pot, the capture process can be assumed to be non-stressful.

Once caught, the animal risks injury from contact with netting and frame of the pot, as well as physical interaction with other captive animals. There may also be stress responses as a result of confinement. However, behavioural observations of fish caught in pots show that after some initial escape attempts, the fish simply swims

around in the available space inside the pot, feeding off the bait, if they can get access (Anders, 2015; Meintzer et al. 2017). Crustaceans are known to interact aggressively with each other and other catch, causing injuries and fatalities. Large animals, including fish (i.e. conger eel), octopus, crabs and lobsters, are also known to prey on smaller animals in the pots. However, it is generally believed that the most stressful and injurious part of the capture process in pots begins at the point of retrieval (see later), which is confirmed by the generally high survival of animals caught and released from pots (table 1).

Table 1. Survival of animals caught and released from pots

Species	Survival	Reference
Norwegian lobster (<i>Nephrops norvegicus</i>)	>96%	Wileman et al, 1999
Blue crab (<i>Callinectes sapidus</i>)	81%	Darnell et al, 2010
Deepwater red crab (<i>Chaceon quinquegens</i>)	95%	Tallack, 2007
Cod (<i>Gadus morhua</i>)	79-96%	Humborstad et al, 2016

Demersal Trawls (CS1.2, 1.4, 1.5 & 1.6/1.8) are a complex gear, consisting of a conical net that is towed behind a fishing vessel, using long wire warps, at speeds of typically 2-3 knots, but sometimes faster. The net is held open vertically by a combination of a weighted ground gear and a buoyant headline, and laterally by trawl “doors” that are spread apart by hydrodynamic forces as the net is towed through the water. For non-mobile species, the trawl simply acts as a sieve collecting animals in the water column and on the seabed in its path. However, for more mobile and active species the behavioural interactions with a trawl can be complex and potentially injurious. Initially animals will be alerted to the approaching trawl by the noise of the vessel, which can cause fish in the water to descend into the path of the trawl. Fish may also be guided into the path of the trawl by the approaching trawl doors, and the sand-clouds they create. Fish and other animals can be progressively guided/herded into the mouth of the trawl, by the doors (sand-clouds) and the wires connecting them to the trawl. Once in the mouth of the trawl, many fish will turn and try to swim ahead of the net. Eventually the fish become fatigued and begin to turn and fall back into the net. Further into the net they may turn again in an attempt to swim in the direction of the towed net again, only to tire and drop back further into the net. Eventually they fall back into the codend at the end of the net where, if they are unable to escape through the codend meshes or other selective device, they ultimately become part of the catch amassing there.

As the fish progress in this way into the net, they become increasingly fatigued and, as the net narrows, their risk of injurious contact with the netting increases. Injurious contact can also be made by animals in the mouth of the net, as they strike some component of the gear or pass under the ground gear. Fish collecting in the codend are exposed to further risk of injurious contact with other animals in the catch and, as

they become compressed within the catch, they may become constricted and as a result asphyxiated. The likelihood of fatigue and injury in a trawl is likely to be influenced by an individual's ability to swim, which can be dependent on many factors including: size, swimming mode, physical condition, temperature, towing speed and light levels (Suuronen, 2005). The survival of trawl caught animals, both discarded and escaping, has been observed to be significantly correlated with size (length) in several species (e.g. Sangster et al, 1996; Suuronen, 2005) supporting the hypothesis that swimming ability is an important survival trait. Other factors linked with survival are: towing duration, catch size & composition, codend construction and mesh size.

2. Retrieval

During this phase, the fishing gear and its catch are retrieved from the fishing depth and brought aboard the vessel. From the perspective of potential stressors for the captive animals, there are two key steps, which will compound additional stressors with those already experienced as part of the capture process:

- 1) Ascent to the surface as the fishing gear is hauled to the surface the captive fish will experience a rapid reduction on hydrostatic pressure, which for some species, i.e. with a closed swim-bladder and/or caught at great depths, can cause barotrauma (see Decompression & Barotrauma). In addition, this journey through the water column can also cause other stressful changes in environmental conditions including water temperature (see temperature shock), salinity (see osmoregulatory distress) and light intensity (see Light exposure).
- 2) Retrieval from the water in addition to the environmental changes experienced during the ascent through the water column, as the gear is retrieved from the water so the catch becomes emersed and no longer has access to the dissolved oxygen they require for respiration (see Hypoxia). Also, temperature changes and exposure to light (particularly damaging ultra-violet) are likely to be exacerbated. Furthermore, movement of the gear (particularly in poor weather conditions) during this transition is likely to increase the risk of physical injuries as the fish come into contact with the gear, the boat and other components of the catch. The lack of the supportive, hydrostatic properties of the water will mean that many animals will experience their own weight-in-air for the first time, which in large catches will be compounded with the weight of the catch around them and may lead to crushing injuries.

3. Handling

- 1) Removal from Gear the stressors experienced at this stage will depend upon the type of gear, how the catch is retained in that gear and the body-form and size of the animal. For example, trawl codends can generally be opened quickly

and the catch efficiently emptied out. Gears using hooks will require some means of removing the catch from the hook; this is generally by hand but gaffing and mechanical devices may also be used (e.g. Farrington et al, 2008). Gill and trammel nets can be challenging to remove the entangled catch quickly and without injury, particularly crustaceans. In purse seines the catch is usually removed from the net directly using pump systems or landing nets or “brails” while the net remains in the water concentrating the catch in a limited volume.

- 2) Containment once removed from the gear, if the catch is mixed and requires sorting, it is generally deposited either on the deck or into a container of some form. The nature of this containment will have important implications for the stressors experienced by the animals waiting to be sorted. If simply lying on deck, the fish is at additional of physical injury, including being stood on by the crew, as well as exposure to the desiccating effects of sunlight and wind. When in a catch bin or “hopper”, these risks are reduced for the animals lying within the body of the catch, but in large catches there may be increased risk of injury from crushing and contact with other animals.
- 3) Sorting this is usually done by hand by the crew, but mechanical size sorting systems (typically grids) are used in some fisheries, as well as conveyor belts to extract the catch from the hopper. All may induce physical injury and trauma to varying degrees. How long the animals are exposed to the compounded stressors of emersion, temperature shock and sunlight will depend on the size of the catch and the efficiency of the crew. Crews are generally very efficient at sorting through a catch quickly, but they are less likely to be invested in handling the catch carefully, and so avoiding further physical trauma and injury; particularly in the unwanted catch.

4. Discharge/Release

The exit route for an animal selected to be discarded can vary between simply being thrown over the side of the vessel to being directed through a purposely designed hole or chute in the side of the vessel, by a conveyor belt or water flow/jet. In some large factory vessels, it has been known for the discarded catch to be directed into macerators (normally used for mechanically breakdown offal from the processing plant) to disguise the fact that they are discarding.

If the animal is still alive at the point of release, it is now exposed to a new hazard – predation; typically by seabirds at the surface, but also by other predators attracted to the fishing vessel, e.g. cetaceans and seals. Furthermore, the animal’s journey back to a suitable habitat, where it can find refuge and recover, may be considerable; particularly if the fishing vessel has moved away from the area where the animal was originally caught (see displacement).

4. Promoting Good Catch Welfare & Survival of Discarded Animals

General principles

The primary solution to reducing discard mortality is to avoid catching unwanted animals in the first place. This can be achieved by **modifying fishing practices** to either:

- **avoid unwanted catches**³ by not fishing in areas or times associated with substantial quantities of unwanted animals (e.g. Gullestad et al, 2014), or by
- **improving gear selectivity** to promote the escape of any unwanted catch before the gear is retrieved (e.g. Wileman et al, 1996; Holst et al, 1998).

Although it has been shown that some animals may die as a result of being caught and escaping from fishing gears (e.g. Breen, 2004; Suuronen, 2005; Breen et al, 2007; Broadhurst et al, 2006), by comparing the likely path taken by an escaping animal to that of a discarded animal, it can be logically deduced that the escaping animal is likely to encounter fewer and less extreme stressors. This would suggest that escaping animals are more likely to survive an encounter with fishing gear than discarded animals, which is supported by the few comparative trials that have tested this hypothesis (e.g. Wileman et al, 1999).

Even where unwanted catches cannot be avoided, simple modification of fishing practices can still improve the likely survival on any animals that are going to be released, for example:

- **Limit duration of fishing operations** (i.e. towing duration, soak-times) will limit the exposure each animal has to capture related stressors, and so they are likely to have more capacity (i.e. better vitality) to cope with the stressors experienced during retrieval, handling and release.
- **Smaller catch volumes** are likely to result from limited fishing times, or from using catch control devices, but they will also be of benefit to the unwanted catch. The risk of injury and/or asphyxiation is likely to be reduced in smaller catches in trawl codends, for example. Also, smaller catches will mean the fishing crew will process the catch more quickly, thus reducing exposure to emersion related stressors.

1. Capture

Trawl

Trawl selectivity can be improved by simply increasing codend mesh sizes (e.g. Hunt et al, 2014) and by including selective devices like square mesh panels (e.g. Graham et al, 2003) and selection grids (e.g. Larsen & Isaksen et al, 1993). Species selection can also be improved by modifying the trawl entrance and main body, for example separator panels (e.g. Ferro et al, 2007) and topless trawls (e.g. Krag et al, 2015). To promote the

³ In MINOUW, this approach is promoted in the context of the project in D.1.2 producing spatio-temporal maps of juvenile recruitment areas.

survival of escaping animals from trawls, it is best to employ the selective device as early in the capture process as possible (Breen, 2004; Suuronen, 2005; Breen et al, 2007). Although, the introduction of selective technical measures into a fishery may be resisted by the industry, if they anticipate the loss of marketable catch. This is particularly true in the Mediterranean, where many exploited, but unregulated, species have small mean sizes.

Limiting **towing duration** is a practical option for reducing the exposure to capture related stressors, and has been demonstrated to improve discard survival (e.g. Uhlmann and Broadhurst, 2007). However, this is unlikely to be acceptable to fishers if catch sizes are already small, although on the other hand shorter tow durations usually produce better quality fish in trawls (e.g. Wagner, 1978; Digre et al, 2010).

Controlling catch size in trawl operations has also been made more practical with a range of recent innovations which limit the volume of the catch held in the codend, and then automatically release any excess (see Grimaldo, 2014 and ICES, 2015 for examples).

Codend construction and materials can also be modified to avoid injuries to captive animals by using non-abrasive materials, e.g. knotless netting (e.g. Barthel et al 2003) and alternative mesh configurations e.g. "T90" (Digre et al, 2010).

Lined codends have been used to reduce water flow in codends, and thus reduce exhaustion and injury, to collect specimens for experiments (e.g. Breen et al, 2007). This has recently been developed further in commercial trawls to protect the catch and promote selectivity (e.g. Adams, 2013).

Gill & Trammel Nets

This project has identified that the survival of animals released from trammel nets is likely to be very low, due to the rough handling practices for removing the animals from the nets, as well as the relatively long soaking times that effectively kill all vertebrates in set nets. (see Deliverable 2.16). Therefore, to promote survival of unwanted animals the primary option will be to avoid capturing them.

Selectivity in gill- and trammel-nets can be modified by changing a range of gear related parameters, including netting material, mesh size, hanging ratio, etc. (Holst et al, 1998; Uhlmann & Broadhurst, 2015). Furthermore, acoustic pingers have been successfully used to reduce bycatch of marine mammals (e.g. Carretta et al, 2008; Dawson & Sooten, 2005). In project MINOUW, three case studies (CS 3.2, 3.4 & 3.5) have included an additional panel at the bottom of the net, a "greca" or selvedge, in a variety of materials, to successfully reduce catches of unwanted crustaceans and other benthic invertebrates, as well as lessen predation on commercial catches by crabs and predatory snails. However, in some fisheries the capture of bycatch over extended soak times (>24 hours) is an important part of the capture process, to generate bait to attract the target animals, e.g. spiny lobsters (CS 3.2). In such cases, the use of bait sourced from previous catches and other fisheries and placed in bait bags, as well as shorter soak times, is suggested as a possible alternative.

Purse Seine

Pre-catch characterisation: Purse seine are generally considered non-selective fishing gear. However the capture process can be highly selective, when the fishers have sufficient information about the catch to decide whether to take or not in the early part of the fishing process (Breen et al, 2012). For example, in the MINOUW Project (CS 2.3) very low bycatches have been reported for a purse seine fishery targeting sardine and anchovy in the north Aegean Sea. This fishery uses multiple floating lights to attract the sardine and anchovy and, during the collection of these lights by a rowing boat, if it can be seen that the proportion of bycatch species is too high the catch is abandoned before the net is set. Methods of pre-catch characterisation are also being developed in Norwegian purse seine, using hydro-acoustics to estimate the biomass and species of a target school and small canon deployed trawls for taking samples, during the early capture phases, to determining size distribution and quality (Breen et al, 2012).

Slipping practices: if the pre- and early catch characterisation shows the catch is unsuitable or too large, practices are now being developed to allow catches to be safely released from the net with minimal risk of mortality (Vold et al, 2017). In project MINOUW (CS 2.2), it has been demonstrated that the survival of sardine can be significantly improved, if the school is allowed to escape through a purposely formed opening in the net, rather than crowding the fish and slipping them over the floatline.

Pots

Selectivity in pots can be achieved through modifications to the mesh size (to release small fish), introduction of escape gaps (to release small benthic animals) and by limiting entrance dimensions and shapes, to prevent large predators (e.g. seals) from entering (Thomsen et al, 2010; Uhlmann & Broadhurst, 2015). Pots can also be floated to prevent unwanted benthic animals, e.g. crustacea, from entering the pots (Furevik et al, 2008).

Materials: as with trawl codends, the risk of injury to captive animals can be reduced by using non-abrasive netting materials, as well as ensuring there are no sharp edges, etc.

Pot Size: having a large enough size of pot to accommodate the catch, will reducing crowding effects. Moreover, there is evidence to suggest that it can also increase catch rates (Meintzer et al. 2017).

2. Retrieval

Controlled decompression: Scientific protocols have been developed for decompressing fish with closed swim-bladders at rates that avoid both physical barotrauma and to some extent temperature shock (e.g. Breen et al, 2007). However, it would be unreasonable/unrealistic to expect fishermen to haul their gear at these slow rates because to haul from just 100 m would take many hours. So in reality the stressors associated with the environmental change during retrieval are practically unavoidable. The only practical solutions at present are to address the consequences and symptoms of these stressors (see Handling & Sorting, and Release).

Retrieval from water:

With urgency and care: the catch should be retrieved from the water as quickly and carefully as possible, to avoid risk of injury and predation in the surface waters, while avoiding striking the vessel and/or deck equipment.

Splitting catches: in trawl codends, it may sometimes be necessary to split the catch, using a “lifting becket”, for the vessel to safely lift the codend and its contents aboard the vessel, and limit crushing effects inside the catch. However, the remainder of the catch remains in the water, inside the trawl extension, where it is at continued risk of abrasive injury and seabird predation. The benefits to the welfare of the catch will be dependent on several factors, including the size and composition of the catch, the surface conditions and the skill and efficiency of the crew in conducting the procedure.

Retain/retrieve in water: retaining the catch in a small volume of water is frequently used to obtain viable, uninjured samples for scientific investigation, e.g. tagging, by avoiding emersion related stressors. It can be achieved by partially lining the codend with an impermeable liner, to retain some water with the catch, as it is lifted aboard.

3. Handling & sorting

Avoid emersion/Hold in water: where practical, the catch should be transferred from the fishing gear directly into water, where it should be held during the sorting process (e.g. Broadhurst et al, 2009). The first advantage of this is that direct transfer into water will help avoid injuries due to contact with hard surfaces or other components of the catch. Furthermore, provided the conditions within the water tank are suitable, this treatment will alleviate the effects of emersion. The water container should have a continuous supply of water with a temperature, salinity and dissolved oxygen content that will minimise effects of temperature shock, osmo-regulatory stress and hypoxia. Ideally, the water should be supplied from the bottom of the container, via a network of small holes, to ensure that hypoxic zones do not develop in the tank where animals are most likely to aggregate. The most practical water source will be the surface waters immediately adjacent to the boat, so may be different from the ambient waters from where the animals were removed, however this is comparatively still favourable to the effects of emersion. Although, air pumps and diffusers, as well as heat exchanges, could be used to address these issues.

Where it is impractical or even unsafe to install a water filled holding tank on the vessel, the receiving/holding should attempt to minimise the effects of physical/abrasive contact and try to spray the catch with a constant water supply. Even a water-soaked cloth covering the catch on the deck will help alleviate some effects of emersion.

Avoid direct sunlight: wherever the catch is being held during sorting, it should be kept out of direct sunlight to avoid potential stress and injury from bright light.

With urgency and care: the catch should be sorted and handled as quickly and carefully as possible, to avoid risk of injury and further stress. With an efficient and conscientious crew, sorting by hand has some benefits over mechanical sorting with respect to this. However, with large catches this may need to be traded off with

reducing sorting time and thus minimising emersion exposure; where mechanised sorting (e.g. grids) may be more beneficial.

Prioritisation: the sorting and release of unwanted catch, should be prioritised over the processing of the landed catch; specifically to ensure emersion times are minimised. In particular, protected and vulnerable animals should be dealt with first.

Vitality Assessment: it may be advantageous, or even a regulatory requirement, to assess the vitality of the discarded components of the catch to ensure that any released animals do indeed have the potential to survive. These assessments need not be complex or time consuming, and may simply be based upon an informative categorical scale (see table 2); for more details see Breen & Catchpole (2017). This process will be facilitated by holding the catch in water because it will be easier to identify active, more vital, animals, well as those with barotrauma and unable to leave the surface of the water.

Table 2. Example description of the codes used by onboard observers to score the pre-discarding vitality of individual fish (from Benoît *et al.*, 2010).

Vitality	Code	Description
Excellent	1	Vigorous body movement; no or minor ^a external injuries only.
Good/ Fair	2	Weak body movement; responds to touching/prodding; minor ^a external injuries.
Poor	3	No body movement, but fish can move operculum; minor ^a or major ^b external injuries.
Moribund	4	No body or opercular movements (no response to touching or prodding).

4. Discharge / Release

With urgency and care: as soon as an animal has been selected for release, it should be released into the water quickly and with care, via a route that promotes its escape from the surface, and minimises likelihood of further injury and encounters with predators.

Appropriate release location: where practical and safe, they should be released in a location where they will quickly find a suitable habitat for shelter and food (i.e. ideally close to where they were first caught).

Assisted recompression: animals suffering from physical barotrauma (i.e. excessively swollen or rupture swimbladder) which would be unable to swim away from the surface, could be assisted using a device that enables recompression. Effective solutions to this problem have been developed by recreational fishers, and such devices could be developed for releasing animals from commercial fisheries; particularly if they are protected or endangered species. This device could be a simple cage containing the compromised animals which can be lowered to a sufficient depth to relieve their symptoms. For example, lowering an affected animal to 50 m will

reduce an equilibrated gas volume to one sixth of its volume at the surface. For examples of recompression devices see NOAA (2017).

Discharge pipe: to give released animals some protection from predatory birds, they could be released via a pipe, with a constant flow of water through it, to a depth of around 5 m. While some diving birds can swim to this depth, most gulls cannot. Moreover, the small increase in hydrostatic pressure will assist fish with barotrauma (reducing the gas volume to 2/3).

5. Summary & Conclusions

The EU Common Fisheries Policy (CFP) is, through the Landing Obligation, attempting to minimise wasteful use of living resources by discouraging the release of potentially dead and dying unwanted catches back to the sea. However, there are several situations in which the release of animals from commercial fishing operations will still be permitted (Art. 15 of EU Reg. 1380/2013):

- Protected species
- Unregulated species
- High survival exemptions
- *De minimis* derogations

Commercial fishing practices can cause injuries and stress that will compromise the survival of any animals that are caught and subsequently released. To promote the survival of these released animals it is necessary to understand what stressors an animal may experience during a particular capture process, and how these stressors can be avoided or minimised. The nature and severity of these stressors will be dependent upon the animal, the capture and handling methods, and the environment in which the animal is caught. As such, practical solutions for promoting survival will be dependent upon these factors, and some specific examples are provided in this report.

The primary solution to reducing discard mortality is to avoid catching unwanted animals in the first place. This can be achieved by **modifying fishing practices** to either:

- avoid unwanted catches or
- improve gear selectivity

Where unwanted catches cannot be avoided, simple modification of fishing practices can improve the survival likelihood of any released animals, for example:

- Limited duration of fishing operations
- Smaller catch volumes
- Handled with urgency and care
- Avoid emersion
- Avoid direct sunlight
- Avoid seabird predation
- Appropriate release location
- Assisted recompression

Some of these mitigation measures (for example i. to iv.) could be applied immediately by communicating these recommendations directly to the fishers. However, further research will be required to further develop others (for example v. vi. & viii). Examples of the methods and analysis to undertake such survival assessments are presented in MINOUW Deliverable Report D2.16.

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Appendix 1. Discard Policy in Mediterranean Sea under Article 15 of EU Regulation 1380/2013

Regulation 1380/2013 of the European Parliament and of the Council of 11 December 2013 introduced articles and provisions that aimed at a gradual introduction of a “Landing Obligation” (LO), as part of a revised Common Fisheries Policy (CFP), with the banning of discarding practices being the intended effect. The provisions on the landing obligation are stated in Article 15 of the regulation, which states that all catches of species managed by quotas/catch limits and Minimum Conservation Reference Size (MCRS) should be landed.

However, there are some important differences between national and European regulation, because in many cases national regulations are more restrictive than European regulation, with a greater number of species regulated using MCRS. Hence, undersized individuals of regulated species with MCRS under national regulations are not covered under the European regulations, and must be returned to the sea. Therefore, the regulation can only apply to species listed in Annex III of Regulation (EC) No 1967/2006, even if other national regulations for minimum size exists for other species.

Implementation Schedule

These provisions are meant to enable member states (MSs) to develop timelines for bringing the different species in a fishery under the landing obligation. A summary of the time schedule for the implementation of the landing obligation in Mediterranean Sea is the following:

- From 1 January 2015:
 - small pelagic fisheries (i.e. mackerel, herring, horse mackerel, blue whiting, boarfish, anchovy, argentine, sardine, sprat);
 - large pelagic fisheries (i.e. fisheries for bluefin tuna, swordfish, albacore tuna, bigeye tuna, blue and white marlin);
- From 1 January 2017:
 - fisheries for target species in the Mediterranean, Black Sea and all other EU waters;
- From 1 January 2019:
 - for all other regulated species in fisheries in all Union waters.

Adopted Mediterranean pelagic and demersal discard plans

Discards Management Plans are to be defined for fisheries characterized by target species. The landing obligation will be applied on a case by case basis, and details of the implementation will be included in multiannual plans or in specific discards plans when no multiannual plan is in place.

At present, the obligations derived from the LO in the Mediterranean are being dealt with through a regionalized approach. The MEDAC (Mediterranean Advisory Council) is actively involved in the development of multiannual plans. For instance, 3 member states are coordinating the discard plan in the Western Mediterranean (Spain, France, Italy) in the working group “PESCAMED” coordinated by MEDAC.

To date, with the aim to obtain the *de minimis* exemption from the landing obligation, three discard plans have been introduced in EU Mediterranean waters:

1. COMMISSION DELEGATED REGULATION (EU) No 1392/2014 of 20 October 2014 establishing a discard plan for certain small pelagic fisheries in the Mediterranean Sea.

This discard plan covers all catches of species which are subject to minimum conservation reference sizes caught in small pelagic fisheries using pelagic mid-water trawl and/or purse seines (i.e. fisheries for anchovy, sardine, mackerel and horse mackerel). It shall apply from 1 January 2015 until 31 December 2017.

De minimis exemption: article 3 defines the quantity of the above species that can be discarded; it varies according to the Mediterranean sub-area.

2. COMMISSION DELEGATED REGULATION (EU) 2016/2376 of 13 October 2016 establishing a discard plan for mollusc bivalve *Venus spp.* in the Italian territorial waters.

Reduction of MCRS from 25 to 22 mm for the species *Venus sp.* It shall apply from 1 January 2017 until 31 December 2019. A reduction of a minimum conservation reference size from 25 mm to 22 mm in the Italian territorial waters is not incompatible with the length at maturity, so it should not have a significant impact on the protection of the juvenile organisms.

Member State authorities shall determine the vessels subject to the landing obligation.

3. COMMISSION DELEGATED REGULATION (EU) 2017/86 of 20 October 2016 establishing a discard plan for certain demersal fisheries in the Mediterranean Sea.

Survivability exemptions: only for 2017 and for the following species: common sole (*Solea solea*) in GSAs 17 and 18; scallop (*Pecten jacobaeus*), carpet clams (*Venerupis spp.*) and Venus shells (*Venus spp.*) in GSAs 1, 2, 5 and 6. By 1 May 2017, Member States having a direct management interest in the fisheries in the Mediterranean Sea shall submit to the Commission additional discard data for further review.

Five species that define the fisheries identified: European hake (*Merluccius merluccius*), common sole (*Solea solea*), red mullet (*Mullus barbatus*), striped red mullet (*Mullus surmuletus*) and deep-water rose shrimp (*Parapenaeus longirostris*), with the following criteria: landing obligation for these species shall apply when the total landings per vessel of all species in 2014 and 2015 consist of more than 25 % of the species above mentioned. The demersal discard plan also requires Member States to produce a list of vessels subject to the LO based on specified catch thresholds.

De minimis exemption established for 5 species that define the fisheries, as specified above. Quantities that can be discarded varies according the gear and the zone.

Appendix 2. “High Survival” Exemption under Article 15 of EU Regulation 1380/2013

In Article 15, paragraph 4(b), of the revised CFP an exemption from the landing obligation is described for *“species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem”*.

The primary objective of this exemption is to avoid management scenarios where the introduction of the Landing Obligation (LO) could prove detrimental to the sustainability of a fishery by unintentionally increasing fishing mortality, through the enforced landing of unwanted catch that would otherwise have been discarded and survived.

To support any proposal for a “high survival exemption” (HSE) for selected species or fisheries, therefore, clear, defensible, scientific evidence for high discard survival rates are required. To address this, there are two key elements of this legislation that need to be satisfied: i) obtaining suitably reliable and scientifically robust estimates of discard survival; and ii) demonstrating these estimates are suitably high to justify an exemption in a particular fishery.

Methods for Estimating Discard Survival

From the first implementation of the LO, there was an urgent need for guidelines, and identification of best practice, for undertaking discard survival assessments. In September 2013, a STECF⁴ Expert Working Group (EWG 13-16) was tasked with providing this guidance. It concluded that there were three available techniques (captive observation, tagging/biotelemetry and vitality assessment) but that each of these had specific practical and scientific limitations. It was recommended that further work was required to better define best practice in methods for estimating discard survival, as well as defining criteria for critically appraising such assessments.

In response to a request from the EU Commission, the International Council for the Exploration of the Seas (ICES) established a Workshop on Methods for Estimating Discard Survival (WKMEDS) on 1st January 2014. In readiness for the first appraisal of Joint Recommendations by the Commission and STECF (see STECF PLEN 14-02), WKMEDS published its first draft guidance in April 2014 (ICES 2014). Its main recommendations were: i) assessments should be representative of discarded catch and practices, ideally in the metier as a whole; ii) methods should avoid biasing results through observation induced mortality, and ideally demonstrated with appropriate controls; and iii) the monitoring period should be sufficiently long to observe any delayed mortality. A peer reviewed publication of this guidance was published in 2017 (Breen & Catchpole, 2017). Further to drafting this guidance, over a series of six meetings WKMEDS has provided an open forum for researchers and stakeholders

⁴ STECF (Scientific, Technical and Economic Committee for Fisheries) is a scientific & economic advisory body of fisheries for the EU Commission.

actively involved in survival assessments to discuss and develop their methods⁵. It has also developed protocols for systematically/critically reviewing survival assessments and analysing survival data (ICES 2015a, 2015b, 2016^a, 2016b and 2017).

Selection of a suitable threshold for “high survival”.

STECF have emphasised that before considering the implementation of a HSE, it should be remembered that avoidance of unwanted catch, through improved selectivity or other means, is the primary objective of the LO (STECF EWG 16-10). Clearly, determining an appropriate “high survival” threshold for a particular species and metier is complex, which will require an informed understanding of a number of key issues:

- pre-existing status of the stock, and wider ecosystem, with respect to key management criteria (i.e. MSY) and safe biological limits (i.e. recruitment, fishing mortality and spawning stock biomass);
- current discarding rates, including temporal and spatial variability;
- realistic potential for changing the exploitation pattern to avoid unwanted catches;
- potential for reducing the incentive to reduce discarding, if an exemption was implemented;
- potential to undermine compliance to the LO, if an exemption was implemented;
- scientifically validated discard survival likelihood, and its variability across the fishery; and
- likely impacts on the stock, and wider ecosystem, of the LO with and without the HSE.

Finally, STECF have concluded that the selection of a value for “high survival” is subjective and likely to be species- and fishery-specific. Furthermore, they have stated that “the decision to accept or reject an exemption proposal based on the survival value presented is for managers to decide” (STECF EWG 13-16, 13-17, 14-01, 14-11, 15-05, 15-14 and 16-10). This is because the selection of an appropriate “high survival” threshold will involve trade-offs between different management and societal objectives, which will ultimately be driven by the management priority for that fishery at that particular time (e.g. improving stock sustainability; improving financial viability; or avoiding waste).

For further discussion on the policy implications of the High Survival Exemption please refer to MINOUW Deliverable Report D4.1.

⁵ Details about ICES WKMEDS and meeting reports are available at:

<http://www.ices.dk/community/groups/Pages/WKMEDS.aspx>

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