Overview of the evolution of the assessment and management of the Northern European skate and ray fishery.

Author; William Lart

December 2014

SR674

ISBN no 978-1-906 634-80-3

Seafish Responsible Sourcing

Author: William Lart
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Summary:

The management of skate and ray fisheries has changed radically in the past 6 years with the implementation of Total Allowable Catches (TAC) in the Celtic Sea and West of Scotland as well as the North Sea and stock assessments using the ICES Data Limited Assessment methods.

The purpose of this document is to outline and discuss the main trends in the assessment and management of stocks of skates and rays and the fisheries of them in the North Sea, Celtic Sea and West of Scotland over recent years.

The assessment and management of these fisheries is discussed in the context of how science, government, fishers and the supply chain could contribute to the management of skate and ray fisheries thereby reducing the necessity for cuts across all stocks of these species.

This report summarizes some of these advances and it discusses possible further work in these fisheries. The main issues are;

- **The proposal by the EU to reduce TACs by 20%** for both the North Sea and Celtic Sea irrespective of species for 2015. During this year (2014) the TACs for both these areas were limiting catches, so we should expect a reduction in TAC of 20% to further limit landings, but not necessarily catches since these species are caught as part of a mixed catch in many demersal fisheries. Hence, discarding is likely to increase, this will lead to more uncertainty on the level of mortality that the fishery imposes on the stocks.

- **Improved stock assessment methods**. There is a need to refine the use of the precautionary buffer; this is a 20% reduction in catches which is advised under the ICES Data Limited Stock method when the sock status is uncertain. There is a particular problem where the assessment is only based on catch and expert judgment. This is because it is difficult to show a recovery of stocks if there is no fisheries' independent survey to track changes in the biomass.

- **Risk Assessment**. There are differences between stocks based on data limited assessments; some stocks appear to be growing, whereas others appear to be decreasing. It would be useful to use data on seasonal and spatial differences in

catches and include other factors such as survival rates, to make further comparative assessments on these stocks in order to guide management. Here industry information would be useful since it is likely to be at a higher resolution than Research Vessel survey data.

- Further research and discussion of **spatial management**. It is clear from WGEF that there are substantial quantities of data which could help to inform on locations of ecologically important areas for skates and rays. There is a need to draw on fishers' knowledge to find out more on these aspects and the implementation of a management plan by the NWWAC, including voluntary closed areas are examples of this approach.

- There is a need for guidance on the **use of size limits** and the utility of **minimum and maximum landing sizes**. Fishermen in North Devon have implemented a voluntary measure for minimum landing sizes. Maximum landing sizes to conserve breeding stock have been suggested as being suitable for these stocks because there is evidence that they survive discarding. However, most of the published evidence is based on survival of skates and rays based on tank based experiments. There is a need to examine survival in the wild.

Defra is currently progressing the Shark, Skate and Ray Plan, which includes a number of collaborative initiatives between fishers and scientists designed to improve knowledge of skate and ray stocks. Further information can be found at;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224294/pb14006-shark-plan-review-20130719.pdf

http://webarchive.nationalarchives.gov.uk/20130505040140/http://archive.defra.gov.uk/environment/marine/documents/interim2/shark-conservation-plan.pdf

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Overview of the evolution of the assessment and management of the Northern European skate and ray fishery.

1. Introduction

The management of skate and ray fisheries has changed radically in the past six years with the implementation of Total Allowable Catches (TAC) in the Celtic Sea and West of Scotland as well as the North Sea and assessments using the ICES Data Limited Assessment methods.

The most recent scientific advice on these stocks called for a 20% precautionary reduction in total allowable catches for some stocks and now the European Commission proposes a reduction in Total Allowable Catches of 20% for all stocks of these species.

This is of concern because a reduction in TAC of 20% will limit landings, but not necessarily catches since these species are caught as part of a mixed catch in many demersal fisheries. Hence, discarding is likely to increase leading to more lost revenue for the fishing industry and uncertainty in the level of mortality which the fishery imposes on the stocks.

2. Purpose

The purpose of this document is to outline and discuss the main trends in the assessment and management of stocks of skates and rays and the fisheries on them in the North Sea, Celtic Sea and West of Scotland over recent years.

The assessment and management of these fisheries is discussed in the context of how science, government, fishers and the supply chain could contribute to the management of skate and ray fisheries thereby reducing the necessity for cuts across all stocks of these species.

3. Biology

Skates and rays comprise a large group of fish, which includes the true skates (Order Rajiformes) and species such as electric ray and stingray. The main commercial species within northern European waters are the true skates, which have common names that generally distinguish the large species with long snouts (skates), from the smaller species with short snouts (rays).

The most abundant species in inshore waters are thornback ray (*Raja clavata*), blonde ray (*Raja brachyura*) and spotted ray (*Raja montagui*). Cuckoo ray (*Leucoraja naevus*), shagreen ray (*Leucoraja fullonica*) and common skate (actually two biological species: *Dipturus intermedia* and *Dipturus flossada*) are found further offshore, with long-nosed skate (*Dipturus oxyrinchus*) and sandy ray (*Leucoraja circularis*) occuring along the edge of the continental shelf.

In the central and northern North Sea, starry ray (*Amblyraja radiata*) occurs, although it is of little commercial importance due to its small size. Smalleyed ray (*Raja microocellata*) and undulate ray (*Raja undulata*) are most frequently found in the Bristol and English Channels respectively. White (*Rostroraja alba*) skate occur in coastal and shelf seas and black skate (*Dipturus nidarosiensis*) in fjords and deeper waters further offshore although both these species are currently considered rare. Long nosed skates (*Dipturus oxyrinchus*) occur in deeper waters of the continental slope.

Skates and rays are elasmobranchs, that is, fish with a cartilaginous skeleton. These fish are slow growing and with a late age at maturity. There are differences in the growth of these species: smaller-bodied species such as spotted ray and cuckoo ray grow to about 70–80cm in length; thornback ray and blonde ray grow to 110–120cm, whilst common and white skate grow to more than 200cm.

Skates typically mature at between five and 10 years of age, with the smaller-bodied species maturing at an earlier age. Male and females are easily identified, as males have a pair of claspers (used in copulation) alongside the pelvic fins. The females lay fewer than 100 eggs per year, on the sea floor (compared to cod, for example, which may each shed millions of eggs every year), and these hatch after four to six months (Ellis & Shackely, 1995).

Figure 1 Egg cases (left to right) of blonde, thornback and spotted ray

The juveniles of inshore species (such as thornback, spotted, blonde and small-eyed rays) occur in bays and coastal waters and move into deeper water as they grow Nursery grounds for offshore species are less well known. Adult fish move over wider areas, though they may return to certain areas to feed or breed (Hunter et al, (2005) Hunter, et al, (2005b)). They feed primarily on the sea floor; juveniles eat small crustaceans, and the larger species eat shrimps, crabs and fish (Ellis et al, 2005)).

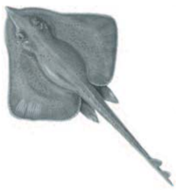
<table>
<tr><td colspan="2">Thornback ray</td><td>Cuckoo ray</td><td>Spotted ray</td><td>Blond ray</td></tr>
<tr><td colspan="2"></td><td></td><td></td><td></td></tr>
<tr><td>Undulate ray</td><td>Small-eyed ray</td><td>Shagreen ray</td><td>Sandy ray</td><td>Common skate</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
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Figure 2 Main species of skates and rays in Northern European waters

4. Stock Assessment

The assessment of skates and ray stocks has evolved over the past 5 years. Prior to 2009 all skates and rays were landed under a single code (SKA) in most European countries. In 2008-9 the authorities required recording of these species separately, and this has been achieved for 90%+ of landings since 2011.

In 2012 ICES implemented a Data Limited Stock (DLS) assessment methodology which included different categories dependent on the level of data available. In addition the implementation of the Marine Strategy Framework Directive (EC 56/2008) has stimulated research into indicators to examine ecological indicators and Project Inshore has assessed the feasibility of certifying inshore fisheries around England under the Marine Stewardship Council framework.

4.1. Risk Assessment

In the absence of full stock assessments, risk assessment or risk screening methods use expert judgement to highlight which species are most at risk from fishing and therefore those species are priorities for further assessments and management.

The Productivity and Susceptibility (see Appendix I) risk assessment method has been used by McCully et al, (2013) to risk assess North East Atlantic stocks. This method relies on being able to use information on the biological characteristics of the stocks to make an assessment of **Productivity**; highly productive species are likely to be able to recover from fishing whereas less productive stocks are likely to take longer so potentially at higher risk. Growth rates, reproduction in terms of fecundity and other features of the stock are assessed and scored.

Susceptibility relates to spatial and temporal factors in relation to the fishery encountering the stock and the intensity of the interaction. Species which are highly susceptible to fishing are those whose distributions overlap with the fisheries' distributions and where there is intense interaction; that is they are easily caught.

The two scores a combine to give a relative **Vulnerability score**. McCully et al, (2013) scored 86 species; 57 teleosts (bony fish) and 29 elasmobranchs in Northern European fisheries.

They found that skates and rays scored in the top 17 species for vulnerability. Blonde ray was estimated to be the most vulnerable ray ranked third overall behind spurdog and tope shark, with thornback, sandy, shagreen and undulate rays ranked just below blonde ray.

Skates and rays are vulnerable to trawl gears at a relatively early age and they mature at a relatively late age and have low fecundity (few young). In general, scores indicated that skates and rays' vulnerability was mostly related to their biological characteristics; that is slow growth and low fecundity whereas teleosts were likely to have a greater susceptibility to fisheries.

However, blond and thornback rays were scored as susceptible to fishing on a par with other valuable or target species (e.g. saithe, hake, lemon sole, sole, sea bass, turbot and john dory), and but below that of the main target species (cod, haddock and whiting).

Considering these characteristics it is perhaps surprising that skate and ray populations survive at all. The larger species such as white skate and common skate have disappeared from large parts of their former range and the range of the commercial species is relatively restricted compared with earlier in the 20th century.

However, fishing activity is not evenly distributed over the seabed; studies using VMS (Vessel Management Systems) tracking devices, which are compulsory on fishing vessels over 12 m, show that fishing is concentrated in certain areas, leaving many areas relatively lightly fished (Jennings & Lee, 2011). There would be scope for skates and rays to inhabit the lightly fished areas, and therefore avoid capture.

The role of these risk assessments is to enable expert opinion to be formalised into scoring of risk, thereby enabling resources to be focussed on those species and stocks most in need of assessment and management. It does not imply that the stocks scored as most at risk cannot be exploited sustainably. For example, the US West Coast limited entry groundfish trawl fishery includes the longnose skate (*Raja rhina*) in its list of MSC certified species.

4.2. ICES Data Limited stock (DLS) assessment

The assessment of skates and ray stocks has been carried out using the ICES Data Limited stock assessment guidelines. For skates and rays the methods used correspond to categories 3, 5 and 6;

- **Category 3**: uses an index of abundance usually derived from research vessel survey data. The trend in abundance is applied to the current catch level to estimate next year's catches.

- **Category 5**: For these stocks only landings (or catch) data are available. In most of the ray assessments the mean catch for the previous 3 years was calculated and the precautionary buffer of -20% was applied to derive the advised TAC for 2015

- **Category 6**: This category includes stocks where there are negligible landings. For skates and rays these would include the common skate and undulate ray, in these cases risk assessments are based on expert judgments and advisory catches are derived on a precautionary basis.

ICES WKLIFE has evolved the current methodology over the past 3 years. ICES WGEF has also innovated in this field. The current survey based methods (category 3) are designed to keep stocks at equilibrium for periods of 3 to 5 years, but there is a need to move to more target based methods aiming at Maximum Sustained Yield (MSY), otherwise stocks, particularly depleted stocks, are likely to decrease.

Precautionary Buffer

In the ICES Data Limited Stock (DLS) Guidance (ICES, 2012) a 'precautionary buffer (PA buffer)' or 'precautionary margin' is defined as a reduction of -20% in the advised catch applied after the 20% 'uncertainty cap' or 'change limit'.

The PA buffer is designed to make advice based on uncertain information more precautionary. The DLS method requires the calculation of the indicated increase or decrease in catches based on the method for the appropriate category; changes in survey indices, catches or other method.

The uncertainty cap is then applied, limiting the advised change to ±20% prior to the application of the precautionary buffer. The precautionary buffer is then applied, which would reduce the resulting catch by a further 20%. Thus the maximum reduction in advised catch could be up to 36%, after application of the 20% uncertainty cap to an estimated decrease in catches ≥20%, followed by the precautionary buffer of -20%. The minimum decrease in catches would be 4% after application of an uncertainty cap of 20% to an indicated increase in catches of ≥20% followed by a precautionary buffer of -20%.

After the implementation of the precautionary buffer the intention is to monitor the stock for a period (duration) to see if there is some improvement in the status of the stocks before further control measures such as further reduction in TACs are required. See Appendix II for a hypothetical example.

The precautionary buffer is applied when there is uncertainty in relation to the stock status. Exceptions to this rule have been made where expert judgement determines that the stock is not reproductively impaired, and where there is evidence that stock size is increasing or that exploitation has reduced significantly.

In the case of skates and rays in 2012, advising on the catches for 2013 the main advice from WGEF (Working Group on Elasmobranch Fisheries) was;

> "ICES considers the generic TAC, at best, as an ineffective measure, regulating overall outtake [catch] from the assemblage [skates and rays]. ICES advises that a suite of species- and fishery-specific measures be developed to manage the fisheries on commercial species and achieve recovery of the depleted species. Such measures should be developed by managers involving all stakeholders; ICES could assist in the process.
>
> Management measures should be framed in a mixed-fisheries context, considering the overall behaviour of demersal fleets, and the drivers for such behaviour. Because these species are mainly caught in mixed fisheries, when the TAC is exhausted, catches continue to take place, but are discarded. In order to achieve optimal harvesting of the commercial species, and to assist recovery of the depleted species, a suite of measures should be put in place.
>
> Closure to fishing of spawning and/or nursery grounds, and measures to protect the spawning component of the population (e.g. maximum landing size) are powerful tools to protect rays and skates. In some cases, single-species TACs may be appropriate, especially for easily identified species, and/or discrete stocks in limited distribution areas."

Calculations were performed applying the DLS method (in 2012 for catches during 2013) for assessments for individual stocks (species within areas; stock structure is uncertain for many of these species). However, the results were only expressed in terms of percentage increase or decrease of catch, because the time series of catch data were of limited duration and not fully reliable. It was not intended to revisit these assessments until 2014 at the earliest; in the meantime (during 2013) ICES investigated, at the request of the EU, the broad range of possible management measures for skates and rays in European waters.

The main conclusions of the special request were that because of the regional differences in skate and ray species and fisheries, management measures would best be developed on a case by case basis in with the participation of the fishing industry.

In 2014 the stocks of skates and rays in Celtic Sea and West of Scotland (ICES sub area VI and VII (excluding VIId)) were assessed using ICES Data Limited Stock methods. The advice is given on the basis of species and area. For the North Sea Skagerrak and Eastern English Channel (ICES Sub area IV and Divisions VIId and IIIa) the assessments made in 2012 are considered to be valid and no further changes in catches are advised.

4.3. Marine Stewardship Council Certification

Project inshore has examined the main inshore (inside 6 mile) fisheries for blonde, cuckoo, small-eyed, spotted and thornback rays as pre assessment under the Marine Stewardship Certification criteria. They used Productivity and Susceptibility analysis and found broadly similar results to those described above; that these species scored high risk under this analysis.

They identified the main gaps in the stock assessment as being;

“There is inadequate information, no apparent harvest strategy and the stock status is unknown. The application of the Risk Based Framework indicates fisheries posing a high risk on the productivity of the species.”

Their view was the these stocks lacked a precautionary harvesting strategy, and suggested that;

“The harvest strategy for the ray species should include more technical measures based on the considerable knowledge that exists on their ecology. Spatial, seasonal, and technical measures can be used to improve stock status and regulate fishing mortality because rays have defined spatially discrete life history stages and stock–recruitment relationships.”

4.4. Ecological assessments

Skates and rays are large predatory fish and as such would be expected to be important components of the food web. The Marine Strategy Framework Directive of the European Union (EC 56/2008) designates two descriptors of Good Environmental Status for demersal fish communities, the Large Fish Indicator (LFI), and the Large Species Indicator (LSI).

These indicators are calculated from Research Vessel Surveys and relate to the quantity of either fish larger than a given size (LFI) or the quantity of fish of species capable of growing larger than a given size (LSI).

With their relatively large size skates and rays are likely to be contributors to both these indices. The theory is that the more fish of larger size or species capable of growing to that size in the fish community, the more stable and healthy the ecological community is likely to be.

Thus conservation of skates and ray stocks can be considered a measure likely to improve ecological stability and contribute to the achievement of ‘Good Environmental Status’ under the EU Marine Strategy Framework Directive.

5. Management

These are divided into input controls and technical measures which relate to the behaviour of the fisheries, spatial management, effort and gear used and output controls which relate to quantities caught.

5.1. Input controls and technical measures

These are measures concerned with regulation of fishing effort, such as spatial measures relating to conserving essential habitat for skates and rays, closing areas that are ecologically important or form nursery and/or breeding areas or act as refuge for prohibited species. These measures also include minimum and/or maximum landing sizes, mesh size and other regulations and concerning fisheries behavior; for example soak time of gear.

Spatial measures

ICES (2013) discuss the relevance of spatial measures. Closing areas to protect spawners or juveniles is potentially effective because there is a strong stock-recruitment relationship in these stocks. That is there is a good relationship between the number of adults and the number of young recruited into the stock. This is in contrast to teleost populations, which broadcast large quantities of fertilized eggs of which only a few survive with a high variability from year to year.

ICES (2014) has mapped out the locations of potential spawning and nursery areas based on fisheries observer programme data. Areas where mature females were caught in quarter 2 (March, April, May, June) were mapped as potential spawning areas and areas where fish smaller than 15 cm were found were mapped as potential nursery areas. There is also evidence of increased abundance of rays in areas of low fishing effort (Shephard et al, 2012). This type of information, together with information on fishing effort has potential for designation of ecologically important areas for skates and rays conserving spawning stock, providing refuges for prohibited species and young growing fish.

However, such plans need to be developed in collaboration with stakeholders. The North West Waters Advisory Council (NWWAC) has a management plan for skates and rays in the Irish Sea (ICES Div VIIa, and Celtic Sea ICES Div VIIg) which includes voluntary closed areas. The plan has been developed with the collaboration of scientists, but has not yet been evaluated by ICES.

Minimum and Maximum Landing sizes

Minimum and maximum landing sizes are designed to protect certain parts of the population. Minimum landing sizes, which ideally coincide with the selectivity of the gear, are designed to protect young, growing fish so that potential growth of the population is optimised. Maximum landing sizes are designed to protect the larger breeding fish in the stock.

This concept is used in lobster fisheries where larger egg bearing females are protected. Also larger female spurdog have been protected in European Waters in the past through a maximum landing size, although currently no spurdog are landed. Apart from localised areas, where either IFCAs have introduced statutory measures or voluntary measures are in place (eg North Devon), neither measure is in place for the overall skate and ray fishery.

Most skate and rays are caught in mixed fisheries with other species and the mesh size used is determined by the catch composition and, as discussed above, mesh sizes used (at least in trawl fisheries) tend to render many of the species vulnerable from a small size.

Therefore the use of minimum and maximum sizes is mainly reliant on the survival of discarded fish. However, there is also potentially a deterrent to targeting larger or smaller fish through the implementation of these measures. Care is needed, because a minimum landing size by itself could incentivise targeting larger fish with a potential detrimental effect on the breeding stock.

There is evidence that rays survive discarding, and that their survival is related (amongst other factors) to the bulk of weight of the cod end and the duration of the haul. Enever et al, (2009) found that a maximum of 55% of rays survived 2 days in tanks on deck. Another factor is size, as larger fish survived better (Enever et al, 2010).

Although selection of skates and rays is not likely to be significantly affected by mesh size, selectivity of the gear is important because it has a direct effect on the bulk of the catch. Enever et al, (2010) showed an increase in potential survival (based on observations from holding tanks) from a maximum of 56% survival from cod end mesh sizes of 80 mm to 59% from 100 mm and 65% survival from 100 mm cod end mesh turned through 90^{o} (T90) to improve its selectivity.

However survival for further periods is uncertain. The fish lack a robust skeleton to protect their internal organs, but skin thickness is also considered a factor; species with thicker skins are considered better survivors than those with thinner skins. Defra is currently progressing the Shark, Skate and Ray Plan to improve understanding of the factors affecting survival in different fisheries

Prohibited listing
Common and black skates, and undulate rays are protected as prohibited species under the European Fisheries legislation and white and long nosed skates are protected under the UK Wildlife and Countryside Act. It is proposed that starry rays are added to the prohibited species list in 2015.

This means that the landing of these species is prohibited and they should be replaced in the sea if captured. Obviously, this approach is reliant on the survival of the captured fish on when returned to the sea, but it also deters the targeting of these species.

Other measures
Soak time of static nets varies between fisheries and is regulated in some areas. Tow duration in trawl fisheries is variable dependent on conditions. Enever et al, (2009) showed that survival was significantly related to tow duration in trawl fisheries. Whilst these practices are difficult to regulate (although there are some regulations governing soak time in static net fisheries), the information from Enever

et al, (2009) and subsequent work under Defra's shark, skate and ray plan should be useful in discussing strategy perhaps for localised measures designed to improve survival of discarded skates and rays.

5.2. Output controls; Total Allowable Catches

Figure 3 and Figure 4 show time series of catches of skates and rays over recent years together with agreed TACs. These results show that whilst the North Sea and Eastern Channel catches have been just above the TAC level for the past five years, the catches in the Celtic Sea have been below the TAC level until 2014, when the TAC and catches have become in alignment. From October 2014 the UK quota has been almost completely used up, and the fishery is not likely to be reopened in 2014, with the exception of the Welsh Inshore fleet.

Therefore for both areas the TAC is limiting catches this year. The EU has proposed a 20% reduction in TAC in 2015. If the 20% reduction in TAC is implemented, this implies that catches will be further limited next year (2015).

Table 1 and Table 2 outline the results of these assessments and proposed changes in TACs for skates and rays during the period 2013 to 2015. For 2015 (advice given in 2014) the advice for Celtic Sea and West of Scotland was based on data limited assessments, calculating the percentage increase or decrease in catches and applying these results to reported landings data.

Figure 5 and Figure 6 show the proportions of the most recent catch results by advised change in catches for the two TAC areas. These results illustrate the varying advice between the two TAC areas. Whilst 61% of the stocks in the North Sea Skagerrak and Eastern Channel are advised an increase in catches only 30% of stocks are advised for an increase in catches in the Celtic Sea and West of Scotland.

However, the proposal from the European Commission was for an overall reduction in TAC of 20% for all stocks. Several issues arise from this approach;

- There is no discrimination between stocks which are assessed as in relatively good condition and those perceived to be declining so this measure will not necessarily protect the declining stocks.

- The time series of landings data where skates and rays have been reported by species only dates back to 2009 at the earliest, which has implications for the reliability of the assessments based on catch (category 5 as opposed to survey data for category 3 stocks).

- The data limited stocks method requires that the change in TAC is applied then a period of observation in which the abundance is observed. For category 5 and 6 stocks and non-commercial components where there is no biomass index available to judge the effectiveness of the precautionary buffer on the recovery of the stock (see Appendix II). Therefore the above framework is not easy to apply unless some other index of stock health can be ascertained.

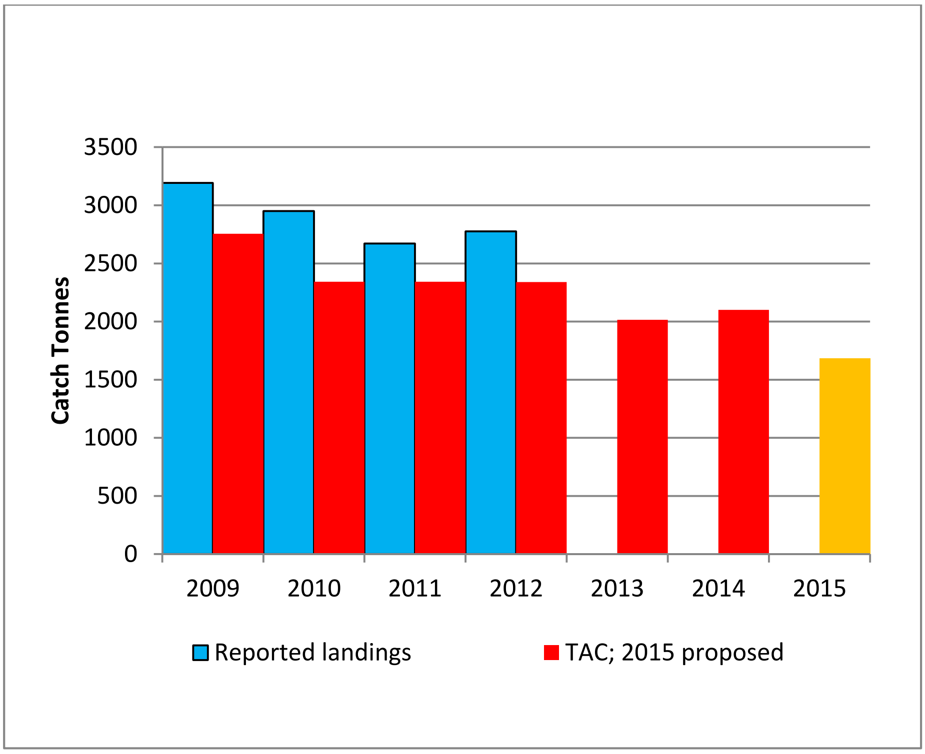

Figure 3 North Sea, Skagerrak and Eastern English Channel (ICES Sub area IV and Divisions VIId and IIIa) skates and rays reported landings and Total allowable catches (TACs) 2009 to 2015

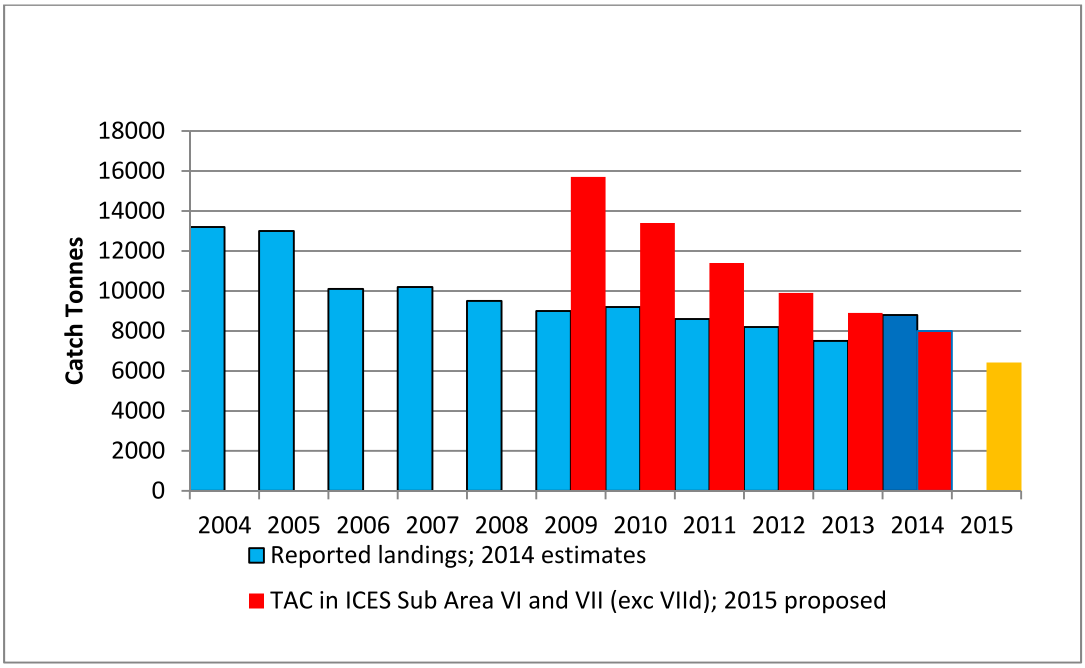

Figure 4; Celtic Sea and West of Scotland (ICES sub areas VII (ex VIId)); skates and rays reported landing s and TACs 2004-2015

Table 1 Data Limited Stock (DLS) categories, application of the PA buffer, TAC change corresponding to the assessment, percentage TAC change during 2013 and 14 and proposed TAC change during 2015 for skates and rays stocks in the North Sea, Eastern Channel and Skagerrak. NTF=No targeted fishery

Stock definition		**2013**				**2014**		**2015**	
Species	**Area**	**DLS cat**	**PA Buffer applied Y/N**	**%TAC change based on DLS**	**TAC % change**	**TAC change based on DLS**	**TAC % inc/dec**	**%TAC change based on DLS**	**Proposed TAC % inc/dec**
North Sea, Eastern Channel and Skagerrak									
Thornback ray	IV,VIId,e,IIIa	3	No	+20	-14	0	+4%	0	-20
Thornback ray	IV,VIId,IIIa			NA		0		0	
Spotted ray	IV,VIId,IIIa	3	No	+20		0		0	
Cuckoo ray	IV,VIId,IIIa	3	No	+20		0		0	
Blonde ray	IVc,VIId,e	5	Yes	-20		0		0	
Blond ray	VIIc,VIId	5	Yes	Inc above		0		0	
Small-eyed ray	IV,VIId,IIa	5	Yes	-20		0		0	
						0		0	
Other	IV,VIId,IIIa	5	Yes	-20		0		0	
Starry ray	IIa,IV,IIIa	5	Yes	-36		0		0	Zero TAC; Prohibited species
Undulate ray	VIId,e	6		NTF	Zero TAC	NTF		NTF	
Common skate	IV and IIIa	6	NA		Zero TAC				

Table 2 Data Limited Stock (DLS) categories, application of the PA buffer, TAC change corresponding to the assessment, percentage TAC change during 2013 and 14 and proposed TAC change during 2015 for skates and rays stocks in the Celtic Sea and West of Scotland NTF=No targeted fisherie

		2013		2014		2015			
Area	**Species**	**%TAC change based on DLS**	**TAC % change**	**TAC change based on DLS**	**TAC % inc/dec**	**DLS cat**	**PA Buffer applied Y/N**	**%TAC change based on DLS**	**Proposed TAC % inc/dec**
Celtic Sea and West of Scotland									
Blonde ray	VI	-20		0				Not Assessed	
Blonde ray	VIIafg	-20		0		5	Yes	-20	
Blonde ray	VIIe	Inc.above				5	Yes	-20	
Thornback ray	VI	+20		0		3	No	+20	
Thornback ray	VIIafg	+20		0		3	No	+20	
Thornback ray	VIIe	NA				5	No	0	
Small-eyed ray	VIIfg	-36		0		3	Yes	-36	
Small-eyed ray	VIIde					4	Yes	-20	
Spotted ray	VI	-23		0			NA	NA	
Spotted ray	VI & VIIbj	NA	-10		-10	3	Yes	-11	-20
Spotted ray	VIIafg	+20		0				NA	
Spotted ray	VIIa, e-h					3	Yes	-4	
Sandy ray	VI,VII	-20		0		5	Yes	-20	
Shagreen ray	VI,VII	-20		0		5	Yes	-20	
Cuckoo ray	VI,VIIa-c,e-j	-36		0				NA	
Cuckoo ray	VII,VII & VIIIabd	NA				3	Yes	-34	
Other rays	VI & VII ex VIId					5	Yes	-20	
Undulate ray	VIIj	Inc below		NTF	Zero catch				
Undulate ray	VIIbj					6	NA	NTF	Zero catch
Common skate	VII, VII	NTF		NTF	Zero catch	6	NA	NTF	

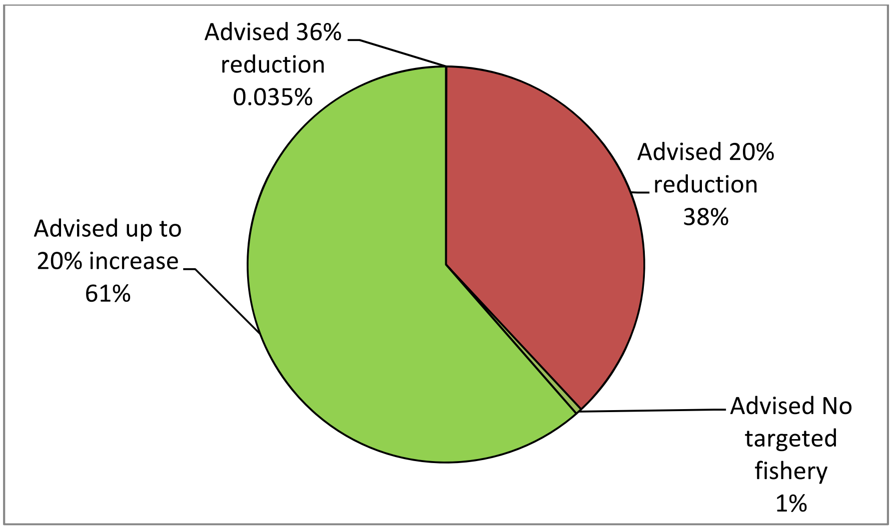

Figure 5 North Sea, Skagerrak and Eastern English Channel (ICES Sub area IV and Divisions VIId and IIIa). Proportions of landed catch in 2011 by ICES advice in 2012; Total landings accounted for 2869 Tonnes in 2011

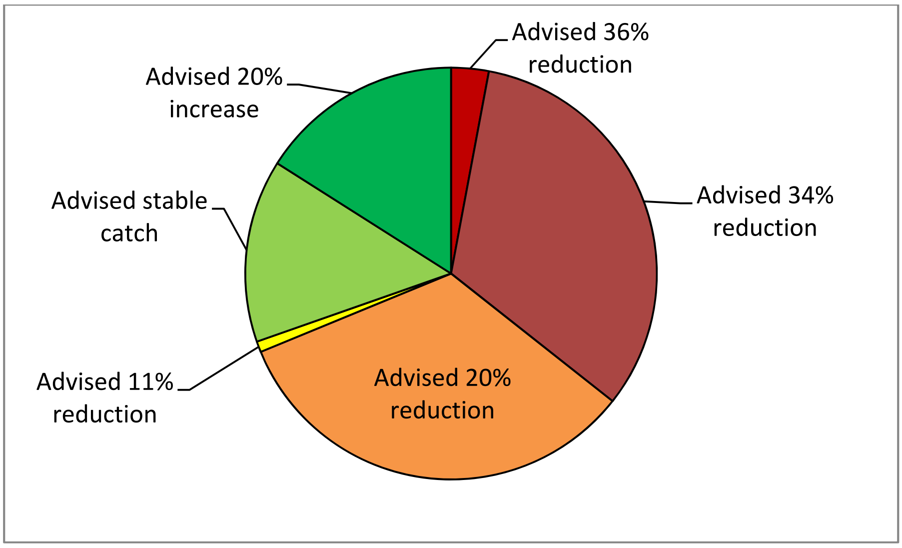

Figure 6 Celtic Sea and West of Scotland: ICES Sub Area VI and VII (excluding VIId); Proportion of landed catch in 2013 by ICES advice in 2014

6. Discussion and Further work

There is a need to establish an approach to skate and ray fisheries which enables not only fishers, managers, scientists and conservationists but also other members of the supply chain such as processors and buyers to contribute to their management. To this end there is a need for research and guidance in the following areas;

- **Risk Assessment**; Although the risk assessment places skates and rays at relatively high risk, there are some ray stocks, most notably thornback and cuckoo rays that appear to be growing in certain areas (Table 1 &Table 2). In contrast other species such as blonde rays, the biomass appears to be decreasing and a reduction in catches is advised. It would be useful to examine carefully these different species and see if there were any differences between them that would help to guide management. For example;

    - Are there differences in their survival rates post discarding?
    - Are there seasonal or spatial differences in their availability which exposes them to different levels of fishing effort?

  For these purposes industry input and data would be invaluable, since this information would be at a higher resolution than the Research Vessel surveys.

- As most of these stocks are caught in **mixed fisheries,** analysis of the gears, fisheries and with which species skates and rays are most likely to be caught with would be useful in examining the effects of catch limits such as TACs and quotas.

- **Improved stock assessment methods**; There is a need to refine the use of the precautionary buffer. This is a 20% reduction in catches which is advised when the stock status is uncertain. There is a particular problem where the assessment is only based on catch; category 5 stocks and where they are based on expert judgment; category 6 stocks;. This is because it is difficult to show a recovery of stocks if there is no fisheries independent survey to track changes in the biomass.

- Further research and discussion of **spatial management**. It is clear from WGEF that there are substantial quantities of data which could help to inform on locations of ecologically important areas for skates and rays. There is a need to draw on fishers' knowledge to find out more on these aspects. Such an approach could be combined with tagging and genetic studies to assess site fidelity and relationships between populations.

  Shephard et al., (2012) provides an example of how scientific and fishermen's data can be brought together to improve knowledge on the spatial distribution of these stocks and the implementation of a management plan by the NWWAC including voluntary closed areas are examples of this approach.

- There is a need for guidance on the **use of size limits** and the utility of **minimum and maximum landing sizes**. Fishermen and buyers have expressed an interest in implementing voluntary measures for minimum landing sizes and maximum landing sizes have been mooted as being suitable for these stocks. There is also a growing body of evidence on survival; however there is a need to understand more about survival in the natural environment.

  There is also a need to model the effects of different size limit strategies taking into account known characteristics of the species There is a need to use local knowledge to develop and implement viable measures in the context of the overall management of skate and ray stocks in the region.

  There are also opportunities to include the supply chain, including retailers in defining size limits for the fishery. To this end, Seafish is developing the means (in prep; using a spreadsheet) which buyers can use to monitor the size distributions of the fish from which their filleted ray wings are sourced. However, there is a need for guidance on the appropriate size limits to set for improved management of these stocks.

There is a need to use local knowledge to develop and implement viable measures in the context of the overall management of skate and ray stocks in the region. Defra is currently progressing the shark, skate and ray plan, which includes a number of collaborative initiatives between fishers and scientists designed to improve knowledge of skate and ray stocks.

Further information can be found at;

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224294/pb14006-shark-plan-review-20130719.pdf

http://webarchive.nationalarchives.gov.uk/20130505040140/http://archive.defra.gov.uk/environment/marine/documents/interim2/shark-conservation-plan.pdf

7. Conclusions

There is scope for a regional approach to the management of skate and ray fisheries using input controls to reduce the reliance on catch limits as the main management measure. This would be based on information from a variety of sources including science, the fishing industry, government and the supply chain.

This approach would be based on collaboration across industry and government, as is the approach of the Defra Shark, Skate and Ray Plan, and there are several initiatives such as the work of the North West Waters Advisory Council in designating voluntary closed areas in the Celtic Sea and other localised initiatives in North Devon where a voluntary approach to minimum landing sizes and no fishing zones has been initiated.

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9. Other Sources

European Commission
Total allowable catches (TACs) or fishing opportunities, are **catch limits** (expressed in tonnes or numbers) that are set for most commercial fish stocks. The Commission prepares the proposals, based on scientific advice on the stock status from advisory bodies such as **ICES** and **STECF**.
http://ec.europa.eu/fisheries/cfp/fishing_rules/tacs/index_en.htm

ICES
ICES WGEF is responsible for providing assessments and advice on the state of the stocks of sharks, skates, and rays throughout the ICES area.
http://www.ices.dk/community/groups/Pages/WGEF.aspx

ICES WKLIFE I - IV
A series of workshops on the Development of Quantitative Assessment Methodologies based on Life-history traits, exploitation characteristics and other relevant parameters for the ICES Data-limited Stocks
http://www.ices.dk/community/groups/Pages/WKLIFE4.aspx

North Western Waters Advisory Council; NWWAC
The North Western Waters Advisory Council (NWWAC) is a representative and legitimate EU fisheries stakeholder body which is legally recognised as an organisation aiming an European Interest.

It is established in Ireland and it produces regular advice on its own initiative or at request of the European Commission and the concerned Member States on all relevant matters related to fisheries management in the EC offshore waters within the EEZ of Ireland, part of United Kingdom and France (ICES areas Vb, VIa and VII).
http://www.nwwac.org/english

Project Inshore
Project Inshore is to utilise the Marine Stewardship Council (MSC) pre-assessment framework to develop Strategic Sustainability Reviews to feed into management plans for each Inshore Fisheries & Conservation Authority (IFCA). These plans will facilitate English inshore fisheries moving towards a level judged sustainable against the globally recognised MSC standard.

http://www.seafish.org/industry-support/fishing/project-inshore/about-the-project

Appendix I Productivity and Susceptibility Analysis.

Each point on the graph shown in represents a stock affected by fishing. Productivity is plotted from high to low on the horizontal axis (hence from low risk to high risk, when moving from left to right on the horizontal axis); Susceptibility from low to high on the vertical axis (hence from low risk to high risk, when moving upwards on the vertical axis). Those in the top right hand section of the graph highest distance from the origin represent stocks at highest risk due to the effects of fishing hence have the highest vulnerability score.

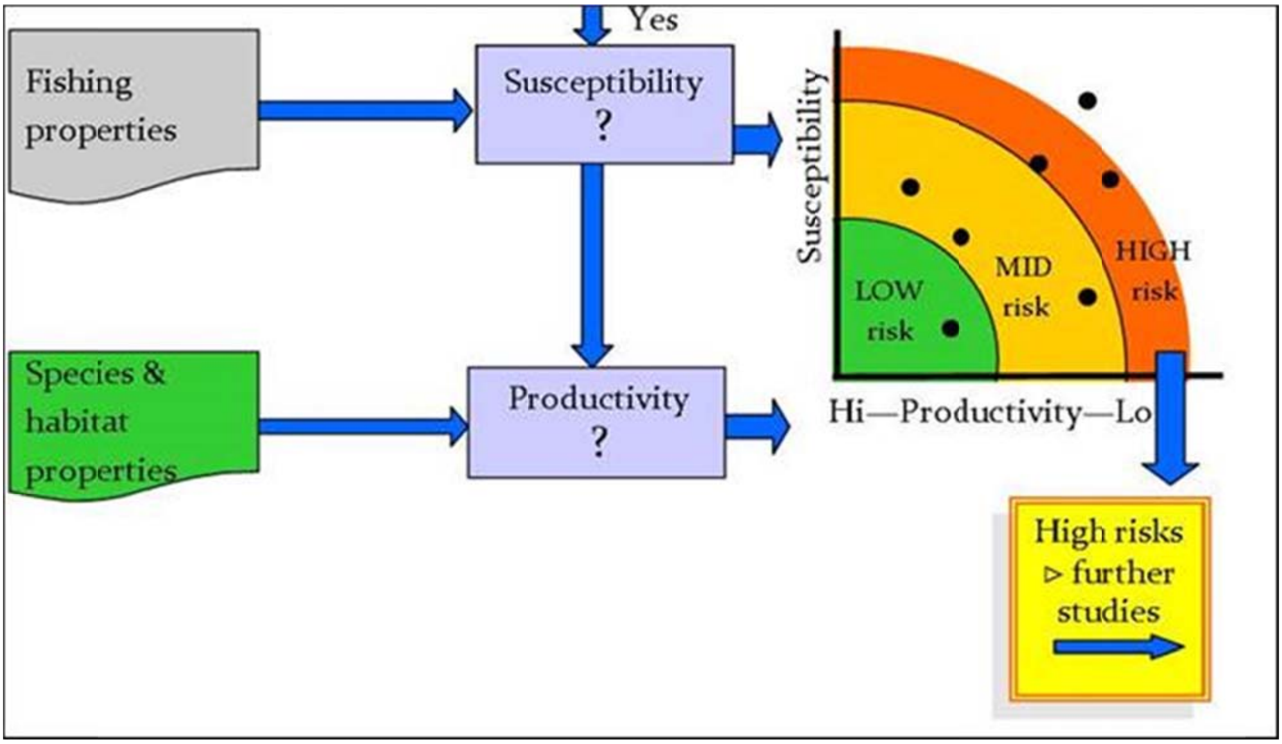

Figure 7 Illustration of Productivity and Susceptibility analysis; modified from (Cotter & Lart, 2011).

Appendix II; Hypothetical application of the precautionary buffer;

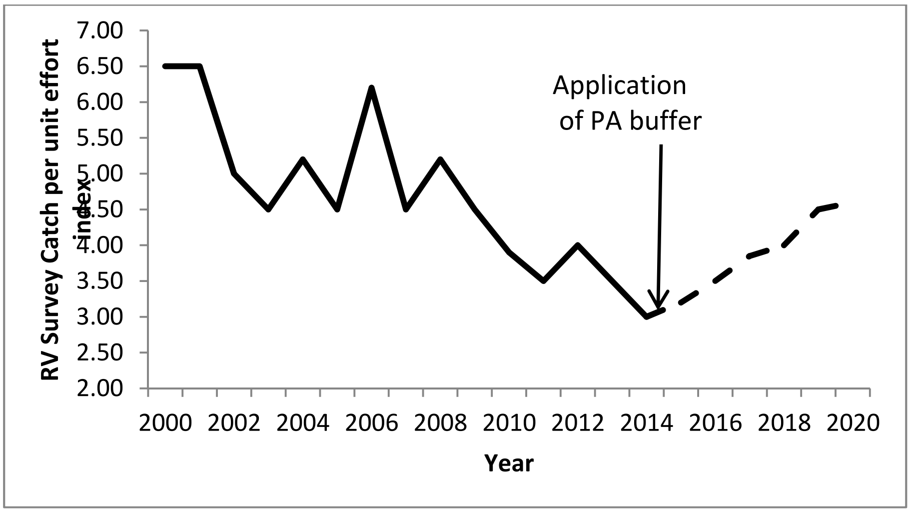

Figure 8 Illustration of the hypothetical application of the precautionary buffer on the Research vessel Catch per unit effort index.

Where catches are reduced in 2015 and the stock abundance is monitored using RV survey data; in this case the stock responds with an upward trend in abundance. Further assessments would be made biannually or at longer intervals. Advice for further application of the buffer would not be made unless there was a further trend downwards. The intention is to avoid repeated annual application of the precautionary buffer. The buffer would be applied and see if the stock responds over a period which is consistent with its possible growth rate.

Appendix III ICES Assessments using the Data Limited Stocks guidelines

Thornback ray (*Raja clavata*) in Divisions VIIa,f,g;

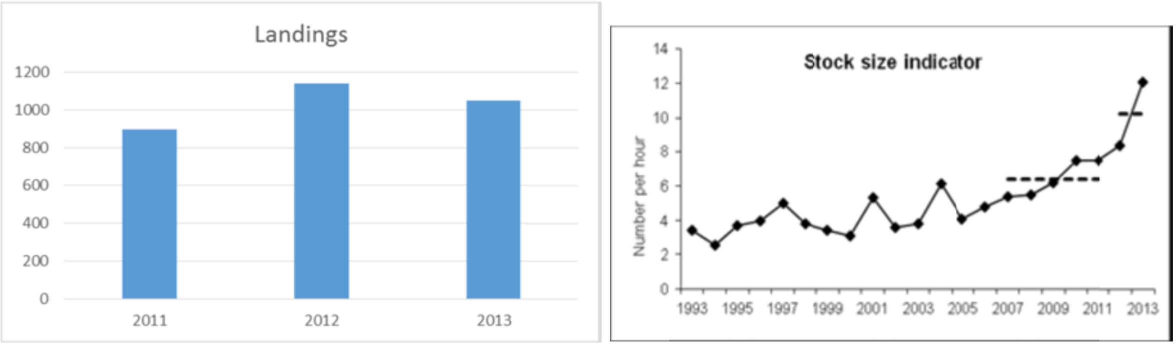

Figure 9 Data limited assessment using a category 3 survey based method for Thornback ray (*Raja clavata*) in Divisions VIIa,f,g (Irish and Celtic seas).

The assessment reads;

"For data-limited stocks for which an abundance index is available, ICES uses as harvest control rule an index-adjusted status quo catch. The advice is based on a comparison of the two most recent index values with the five preceding values, combined with recent catch or landings data. Knowledge about the exploitation status also influences the advised catch.

For this stock the abundance is estimated to have increased by 60% between 2007 and 2011 (average of the five years) and 2012–2013 (average of the two years). This implies an increase in catches of at most 20% in relation to the last three years' average, corresponding to landings of no more than 1235 t in each of 2015 and 2016.

Considering that there has been a consistent increase in stock abundance over time and there is evidence that the stock is not overexploited, no additional precautionary reduction is needed. Discarding is known to take place but cannot be quantified, and there is some discard survival; therefore, total catches cannot be calculated.."

Application of the change limit or uncertainty cap of 20% implies an increase in catch of 20%. Considering that there has been a consistent increase in stock abundance over time and there is evidence that the stock is not overexploited, no additional precautionary reduction is needed. So no precautionary buffer is applied.

Blonde ray (*Raja brachyura*) in Divisions VIIa, f, g (Irish and Celtic seas);

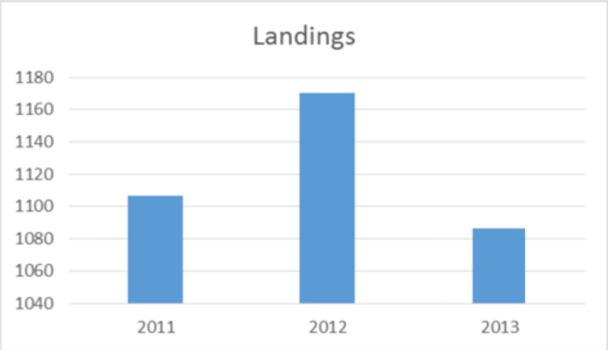

Figure 10 Data limited assessment using a category 5 catch based method for Blonde ray (*Raja brachyura*) in Divisions VIIa, f, g (Irish and Celtic seas). The assessment reads;

“ For data-limited stocks without information on abundance or exploitation ICES considers that a precautionary reduction of catches should be implemented, unless there is ancillary information clearly indicating that the current exploitation is appropriate for the stock.

For this stock, ICES advises that catches should be decreased by 20% in relation to the last three years’ average, corresponding to landings of no more than 897 t in each of 2015 and 2016.”