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Deliverable No. D 1.1

Scoping of regional management needs

PAradigm for Novel Dynamic Oceanic Resource Assessments

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The PANDORA Project

The Blue Growth of European fisheries is at risk due to over-exploitation, unforeseen changes in stock productivity, loss of markets for capture fisheries due to aquaculture, future trade agreements opening European markets to external fleets, and fluctuations in the price of oil and other business costs. All of these risks need to be considered when providing advice needed to sustainably maximize profits for the diverse array of fisheries operating in European waters and to help safeguard the benefits this sector provides to the social coherence of local, coastal communities.

PANDORA aims to:

1. Create more realistic assessments and projections of changes in fisheries resources (30 stocks) by utilizing new biological knowledge (spatial patterns, environmental drivers, food-web interactions and density-dependence) including, for the first time, proprietary data sampled by pelagic fishers.

2. Advise on how to secure long-term sustainability of EU fish stocks (maximum sustainable /"pretty good" and economic yields) and elucidate tradeoffs between profitability and number of jobs in different fishering fleets. Provide recommendations on how to stabilize the long-term profitability of European fisheries.

3. Develop a public, internet-based resource tool box (PANDORAs Box of Tools), including assessment modelling and stock projections code, economic models, and region- and species-specific decision support tools; increase ownership and opportunities for the industry to contributute to the fish stock assessment process through involvement in data sampling and training in data collection, processing and ecosystem-based fisheries management.

The project will create new knowledge (via industry-led collection, laboratory and field work, and theoretical simulations), new collaborative networks (industry, scientists and advisory bodies) and new mechanisms (training courses and management tools) to ensure relevance, utility and impact.

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List of symbols and abbreviations

WP	Work Package
T	Task
DoW	Description of Work
MSY	Maximum Sustainable Yield
SE	Stakeholder Engagement
TAC	Total Allowable Catch

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1 Executive summary

1.1 Introduction

PANDORA is designed to fulfil the expected impacts of this research with an overarching goal of improving fisheries management under the Common Fisheries Policy. This goal will be ensured by:

- Increasing the knowledge base, share new findings, provide new tools and promote their uptake by end-users to more efficiently manage fish stocks within European waters.
- Increasing the long-term profitability of the EU fleet and increase the number of jobs in the fishing sector.
- Improving the market supply and food security in Europe by fishing sustainably at MSY.
- Contributing to adjusting fishing exploitation to levels that ensure the MSY.
- Improving the professional skills and competences of those working and being trained to work within the blue economy via workshops, training courses.

The integration with producer organisations, NGOs and policy makers in PANDORA will ensure continued participation, co-ownership and uptake of project results by these important stakeholders. Instead of the classical model of generating new knowledge and disseminating it afterwards to relevant stakeholders, PANDORA relies heavily on co-creation[2] *"allowing the end-users to co-construct the service experience to suit their context"*[3] through iterative communication in each phase of the project. An important impact of PANDORA is consequently, that the 'burden of proof' is considered shared between scientists and stakeholders, re-

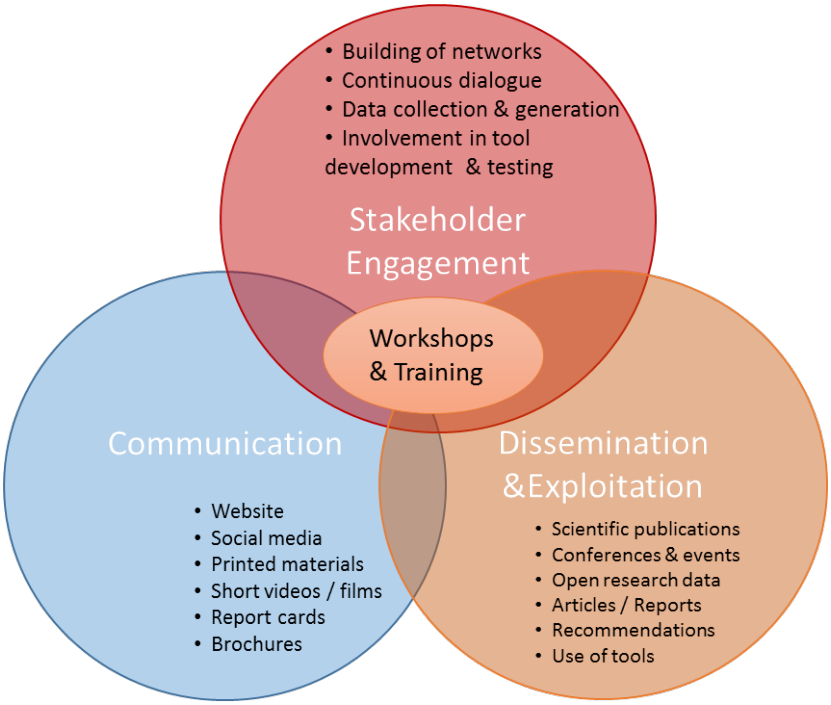

***Figure 1**: Illustration of the PANDORA Engagement Strategy and the interconnections among dissemination and exploitation, communication and stakeholder engagement with central elements (workshops and training) at the interface of these activities*

[2] https://ec.europa.eu/digital-single-market/en/news/co-creation-open-innovation

[3] Prahalad & Ramaswamy, 2004. Co-Creation Experiences, J of Interactive Marketing. Volume 18, Number 3.

sulting in a much more effective uptake of project results. This effort is possible through the consortium's existing stakeholder network, earned through long-standing successful collaboration. All partners of the consortium are devoted to generating new knowledge and decision support tools for the fishing industry and managers.

Dissemination and exploitation are inextricably linked with communication and stakeholder (fishing industry, fisheries scientists involved in stock assessment and policy makers) engagement activities (Fig. 1),

Encouraging multi-directional communication (dialog) is a key activity within PANDORA, which will be facilitated in a number of ways; through stakeholder engagement and scoping (central to WPs 1-5) via regional workshops and face-to-face interviews, an active PANDORA Advisory Board (PAB) and an informative and interactive website. This will help ensure that the project is effectively co-framed with the European fisheries industry and RFMO's (to the mutual benefit of the project and its stakeholders) and that the project remains adaptive to industry and policy trends.

1.2 Defining the Challenge

PANDORA aims to draw on broad participation from various interest groups, including large fisheries on pelagics as well as small-scale fisheries (e.g. Pêcheurs de Bretagne in relation to blackspot seabream), and for each Case Study region toorganise a series of workshops conducted with fishers, scientists and RFMOs.

The overarching goal is to scope regional management needs for biological information, for example reach an agreement on potentially upcoming new resources, and focal species showing large changes in biomass and/or distributions within recent years.

The challenge is to motivate the different stakeholder groups and individuals to participate in PANDORA, and to collect their input in a way that it actually can be applied in the core activities and during the lifetime of the project.

1.3 Approach

PANDORA applies a double path for the biological information generated in WP1. In some cases, biological information will be used directly to inform fisheries management (WP4 and WP5). Examples include changes in distributional patterns, species interactions or vital rates such as growth to be communicated via information sheets made available by PANDORA supplementing e.g. the fisheries and ecosystem summaries prepared annually by ICES. In other cases, the biological information is integrated into stock assessment models. Examples include additional state variables or quality-improved catch data from the industrial self-sampling in Kalman-filter based, retrospective estimation models (assessment *sensu stricto*) as well as short-term predictions including improved estimates of natural mortality and growth (T2.1). In addition, PANDORA will re-visit the concept of sustainability in the face of, from a biological perspective, species interactions, climate change and resulting distributional changes, and changes in carrying capacity that decouple spawning stock biomass from recruitment - the constancy of this relationship is a central paradigm in the F(msy) approach, but there is growing concern that this paradigm leads to critical bias in our perception of sustainability.

The complexity and amount of available information and avenues for processing necessitate the development of a conceptional framework and roadmap for the work in T1.2 & T1.3 as well as WP2. This framework and roadmap is going to be developed in T1.1 in close coordination with WP5.

A first important step for co-framing PANDORA and gathering input for various deliverables (especially D1.1) has beeen the **informal dialogue** in the form of face-to-face or virtual conversations among the project partners and with individuals in the existing regional stakeholer networks. Topics of conversation in this context region-specific developments in fish biology/ecology as well as gaps in current stock assessment methods and fisheries management practices. These informal consultations have been carried out at the start of the project a, but will be a continously ongoing part of the activities through which PANDORA engages with its stakeholders.

An important scoping tool are survey questionnaires that are distributed among different stakeholder groups. To increase the efficiency of this survey, two separate questionnaires have been designed and distributed; one for fishers/fisheries managers/policy- and decision-makers/NGOs in the Case Study regions focusing on biological/ecological developments and management practices (*cf*. deliverabale 5.2, Appendix 2), and second one for stock assessment scientists focusing on the stock assessment process (*cf*. deliverabale 5.2, Appendix 3).

The survey was carried out in a number of consecutive steps.

1. ***September 2018***: survey questionnaire S1 was distributed to the Case Study leaders of the PANDORA project for initial input in.
2. ***October 2018***: survey questionnaire S1 is circulated among the regional networks of the Case Study leaders for input from fishers/fisheries managers/policy- and decision-makers/NGOs in the Case Study regions.
3. ***September/October 2018***: survey questionnaire S2 is sent to the Working Group Chairs of relevant stock assessment groups within ICES and the Mediterranean for further distribution.

Results are constantly being returned to the project and collcted centrally by WP5 leader UHAM (P4). This report gives an poverview over the current state of survey returns in late October 2018. The questionnaire database will be updated constantly for the urpose of continuously adjusting PANDORA work to the needs of its stakeholders.

Finally, the consortium discussed at the project kick of the **data from the industry self-sampling** generated and collected in PANDORA, and how these will provide a means of supplementing and 'reality-checking' survey data important for the assessment.

2 Scoping for the work in WP1 and WP2 based on informal dialogue and questionnaires

The work in PANDORA is conducted in Case Studies representing the broad regional differences in available tools and data, as well as important differences in European fished stocks, their habitats and their fisheries (Table 1). In the **Mediterranean Sea**, 85% of the few assessed stocks are

currently overfished compared to a maximum sustainable yield reference value (MSY) while populations of many commercial species are characterized by truncated size- and age-structures. Rebuilding the size- and age-structure of exploited populations is a management objective that combines single species targets such as MSY with specific goals of the ecosystem-based approach to fisheries management, preserving community size-structure and the ecological role of different species. The result will be advancements transferable to most (if not all) commercially important European fisheries. In the **Bay of Biscay**, a range of species are exploited as target or bycatch in multi-species fisheries, though only a few stocks are analytically assessed. Many stocks constitute potential choke species (once quota for this species is hit, fishers have to discontinue operations due to the landing obligation), in particular while stocks rebuild. More realistic assessment models will allow reduced uncertainty buffers in Total Allowable Catches (TACs) and hence reduce their effects as choke species. The **Northwestern European Shelf** case study region in PANDORA comprises the sea areas west of Scotland and Ireland (ICES subarea 6a, 7b,c) and the northern North Sea (ICES IVa), which provide important spawning, feeding and nursery areas for some of the most abundant pelagic fish in the NE Atlantic; namely mackerel, herring, blue whiting and western horse mackerel. Priorities for conservation and managing these stocks at MSY necessitate improved understanding of the degree of mixing, fidelity to spawning areas and the ecological drivers determining their abundance, distribution and body condition. Mackerel, the single most valuable (and abundant) pelagic stock, spawns in waters of the western shelf edge, migrating north to northern Norway and west as far as Greenland during the summer and back southward in winter. The exploitation of this stock is highly valuable to many fleets of Europe, as well as Norway, Faroe Islands, Iceland and Greenland. A wide variety of commercially important species inhabits the **North Sea** leading to a complex food web structure and mixture of fisheries with strong technical interactions (more than one species are caught simultaneously and one species may be fished by different gears). Several stocks that have analytical assessments show decreasing fishing mortalities in recent years and biomass recovered above reference levels (e.g., cod, plaice, sole). However, many stocks are still categorized as data-poor, being landed primarily as bycatch and/or inadequately sampled by existing scientific surveys and/or commercial sampling programs. Management in the North Sea will benefit from improved information on sub-stock definitions (e.g. cod or Nephrops), exchange rates, spatial extent, predator-prey interactions and other factors governing dynamics, while data-poor stocks require the development of improved monitoring strategies to aid in their assessment and management. In the **Eastern Baltic Sea**, cod, herring and sprat fisheries constitute about 80% of the commercial catches. The Common Fisheries Policy foresees that these three species are managed accounting for cod predation in a multispecies approach. However, there is currently no population model for cod, since age-reading is impossible. Hence, natural mortality rates for herring and sprat have to be considered outdated. Furthermore, the invasive round goby is spreading, and its potential commercial importance is unknown.

***Table 1**: **Case Studies of species and fisheries.** Fisheries: Longline (LL), purse seiner (PS), trap (T), Ottertrawl (OT), static nets (SN), Trawl (TR), Set nets (SN), Gillnet (G), Demersal trawl (DT), Pelagic seine (PS), conventional gear (CG), pelagic trawl (PT), Beam trawl (BT). **Current management methods:** Total Allowable Catch (TAC) (1), effort (2), spatial measures (3); **Current assessment methods:** VPA-type (VPA), Data-poor (Poor), Multispecies (Mult), Statistical methods (Stat), not developed (Develop); **Current biological knowledge**: Spatial structure (S), food webs (F), density dependence (D), environmental drivers (E) indicated by traffic lights: red – poor knowledge, yellow – not implemented in current projections, green – knowledge currently used for projections.*

Case Study	Species	Fisheries	RFMO or IFO	Current-Management-method	Current Assessment method	Current Biological knowledge S F D E
Mediterranean (Lead: Patricia Reglero, IEO)	bluefin, albacore	LL, PS, T	ICCAT	1	VPA, Poor	
	hake, rose shrimp, red mullets	OT, SN, LL	GFCM	2,3	VPA	
	mackerel, jack mackerel, sea Breams	TR, PS, SN	GFCM	2	VPA	
Bay of Biscay (Lead:Verena Trenkel, Ifremner)	red seabream	LL, OT	EC	1	None	
	thornback, cuckoo, spotted & blonde rays	TR, G	EC	1	Poor	
North-western European Shelf (Lead: Chevonne Angus, UHI)	mackerel	PT	NEAFC, EC	1	VPA	
North Sea (Lead: Alexander Kempf, TI)	cod, haddock, saithe, whiting, sole, plaice, hake	OT, BT, G	EC / Norway	1, 3	VPA, Stat	
	mackerel, herring, sprat	PS, PT	EC / Norway	1, 3	VPA	
	horse mackerel, brill, turbot	-	EC / Norway	1	Poor	
	shrimps (Crangon crangon)	T	EC	-	Develop	
Eastern Baltic Sea (Lead: Rüdiger Voss, CAU)	cod	TR, G	EC	1,3	Mult, Stat	
	herring, sprat	TR, G	EC	1	Mult, Stat	
	round goby	-	EC	-	Poor	

EC= European Commission, NEAFC = North East Atlantic Fisheries Commission (RFMO), GFCM = General Fisheries Commission for the Mediterranean (RFMO), ICCAT= International Commission for the Conservation of Atlantic Tunas (IFO)

Questionnaires have been developed and distributed to the stock assessors and other stakeholders for each of the stocks in the case studies. Also stocks of the same speices in neighbouring areas were included in the distribution.

Questions addressed to stock assessors:

1. What species and stocks are you responsible for assessing?
2. What is your perception of the effectiveness and quality of current stock assessments?
3. Is there anything that you would like to change in current stock assessments?
4. From your perspective, what are the most pressing assessment issues currently?
5. Are you aware of any new fisheries developing in your region? If yes, for which target species?
6. Have you seen changes in the spatial distribution of certain fish stocks? If yes, which ones?
7. Have you observed or have you discussed (e.g. at ICES Expert Group meetings) any changes in fish biology (size, weight, feeding, behaviour etc.)? If yes, please give examples.
8. In your opinion, what are the reasons for the changes in fish biology?
9. Regarding your specific stock(s), what parameters are most uncertain and what data are most needed to reduce these uncertainties?
10. If considerable, new knowledge was available on one or more of the four processes (below), which one(s) (if any) might be most relevant to improving assessments made on the stocks you study?

    a) Density dependence b) Food web interactions
    c) Spatial distribution d) Environmental (abiotic) drivers?

11. What improvements in stock assessment models could be most easily implemented within the next two to three years?

12. Do you think it is a useful idea to develop an online tool box to improve the processes of stock assessment and fisheries management? Have people ever used an online toolbox before or would you use one in the future?

Questions addressed to other stakeholders stakeholders (e.g. fishermen associations, NGOs, policy, ministry staff):

1. What species and stocks are of greatest interest to you?
2. What is your perception of the effectiveness and quality of current stock
3. Is there anything that you would like to change in current stock assessments?
4. From your perspective, what are the most pressing management issues
   a) currently
   b) potentially in the future?
5. Is there anything that you would like to change in current management practices?
6. Are any new fisheries developing in your region? If yes, for which target species?
7. Have you seen changes in the spatial distribution of certain fish stocks? If yes, which ones?
8. Have you observed any changes in fish biology (size, weight, feeding, behaviour etc.)? If yes, please give examples.
9. In your opinion, what are the reasons for the changes in fish biology that you observed?
10. Are you currently collaborating with fisheries scientists or did you in the past? If yes, please state how.
11. Do you know any examples of how data/information from fishers are used by

fisheries scientists?

12. In your view, what data/information from fishers would be particularly valuable to fisheries scientists?
13. What challenges do you perceive in cooperation with fisheries scientists? Please give brief examples from your experience.
14. Are you aware of any initiatives to increase collaboration?
15. Additional to existing initiatives, which measures would increase cooperation between fishers and fisheries scientists?
16. May we contact you during the lifetime of PANDORA regarding an interview about your perspective on science-policy or science-industry cooperation?

The contacts established through the distribution of these questionnaires and through related informal dialogue will be maintained throughout the project. The table below give a summary of the input to the project by the returned questionnaires, status end Octber 2018.

Table 2: Case Studies and focal fish species; main results of the scoping exercise status October 2018.

Case	Species	Scoping biological knowledge for assessment and management				
		Spatial Structure	**Food webs**	**Density Dependence**	**Environmental drivers**	**Other**
Mediterranean	Hake, red mullet, deep shrimps	Knowledge about Spatial distribution is usually incorporated in the assessment process, but without implication in the analytical result of this. (Maps in the Stock assessment forms)		Growth is uncertain (k, L(inf), t(0)		Having in mind that more than 90% of Mediterranean stocks are overexploited, the effectiveness of assessment is null, basically because the management is absent. Spatial management is the future for the Mediterranean Sea.
Mediterranean	Albacore			natural mortality and growth patterns still remain a considerable source of uncertainty	further knowledge on environmental drivers would enable to estimate better abundance indices from recorded nominal catches	improvement of total catch time series and the availability of indices of abundance are key for the reduction of uncertainty
Mediterranean	Bluefin tuna	the spatial distribution is the effect of the environmental drivers as				quality and quantity of the

		well as density-dependence effect. The four process mentioned above are interrelated				input information is limited
Mediterranean	Deep-water rose shrimp, European hake, Red mullet		hake stomach contents are necessary to update the Gadget multispecies model where hake is the predator of deep-water rose shrimp		effects of abiotic drivers (e.g. temperature) areimportant to be incorporated within population processes and dynamics (e.g. growth, body condition, recruitment)	Since the management scheme will be probably based on an effort quota system, the most pressing issue is to investigate the relationship between fishing mortality and fishing effort for the different fleets exploiting the target stocks
Bay of Biscay	Black spot seabream	lacks studies on the juveniles distribution, sex proportion in the stock, migration movements. genetics for the study of connectivity among areas, specific age/length relationships, surveys for the egg abundance estimation.	Fishermen (those who target blackspot seabream) complain about biological interactions with bluefin tuna (info from the Med)	it seems that due to the fishing pressure over the biggest individuals the proportion of small ones in the population increases.		Transparent-Assessment-Framework (TAF) and the Github using R to automatize in ICES the assessment process could be very useful. Toolbox should be quite flexible so that experts could actively integrate their knowledge. BLS assessment in contradiction to fishermen obervations Fishermen would appreciate Multi-year TAC with emergency review procedures
	Several skate and shark species	Biomass index is the key parameter for some stocks. To reduce the uncertain, the biomass index of survey covering the all ecoregion are the most needed data.				
North Sea	Haddock			In haddock the sporadic large year classes have diminished in magnitude in recent years (since 2000).	regime shift to warmer temperatures especially on recruitment given the regime shift haddock seems to have	Toolbox needs to be easy to access and use and be flexible enough that it can be adapted to individual stocks. It

				new information on density dependence affects on growth, recruitment, maturity and mortality would be useful	experienced in recent years	would also be preferable to be able to customize things and explore alternative options easily and be fast
North Sea	Cod, haddock, whiting, saithe, anglerfish	We need ways to deal with North Sea cod in the different regions of the North Sea. This includes questions about stock structure and reasons for the stock developments in different regions of the North Sea. Is the further decrease in the southern part of the North Sea already a result of climate change that cannot be reverted by fisheries management? TAC areas should reflect stock areas.	Changes in predation mortality over time would need to be monitored via stomach sampling on existing surveys or with the help of the industry.	Absolute numbers of e.g., spawning stock biomass and fishing mortality are uncertain and sometimes even biased. This is expressed in jumps sometimes occurring in assessment results and advice after benchmarks and update assessments. Reasons are, e.g. uncertain survey indices, uncertainty in age determination, insufficient knowledge about natural mortality and recruitment as well as changes in model types and settings during benchmarks. So far mainly pure single species methods have been used for reference points without taking into account density dependent effects (e.g., cannibalism, reduced weight at age at high abundances)		Try to include more data available from the industry. More advanced tools are needed for reference point determination and management strategy evaluations. Strongly recovering stocks due to MSY based management may cause problems in the food web. Attempts to set up a pilot study to provide accurate catch data has been hampered by the fact that Government fisheries scientists are unable to operate with data that may demonstrate that an activity may not be complying with regulations.
North Sea	Plaice, Sole, Brill, Turbot	Plaice has a strong age-specific spatial distribution indications of the presence of potential sole subpopulations An advanced survey employing the	Turbot is a fast-growing species. Estimates of natural mortality of turbot are fixed over all ages. Improving our knowledge on food web inter-	Density dependent growth rates. Sole weights and lengths-at-age seem to be decreasing		Not enough training for young scientists on how stock assessment works, what are the statistical rational behind the management strategies

		spatial distribution of turbot may improve the quality of the survey indices	actions for turbot could improve this estimate.			
North Sea	Skates and Rays	For many elasmobranch species the population structure is not well studied and knowledge on the spatio-temporal distribution is limited.				Develop proxies for reference points using length-based indicators
North Sea	Whiting	At the moment, the assessment is done for 4 (North Sea) and 7d (eastern Channel) combined, while the TAC is given separately (7d together with 7b-k). The reasoning for a combined stock assessment rely on the fact that stock component in area 7d appears to migrate into area 4 to some degree during the year, while connectivity with the Western Channel and Irish Sea is assumed to be low.	The whiting stock is driven by natural mortality and recruitment variability. Additional knowledge on other factors driving the stock dynamics is also valuable. As more data becomes available, knowledge on foodweb interactions driving natural mortality for this stock can improve assessment	Information on density-dependence mechanisms with regard to recruitment would be most relevant	Due to the uncertainty in the prediction of recruitment, the knowledge effect of environmental drivers on the stock dynamics could potentially improve assessment	
Baltic Sea	Cod	Exchgange between the Westernand Eastern Baltic cod stock is still unclear.	The poor condition of Eastern Baltic cod and slow growth led to increased cannibalism that has to be quantified for assesment	Linkage between density dependence and environmental drivers is unclear	Environmental effect on recruitment is not employed in short term predicitons.	
	Herring	complex of several meta-populations	Predation of cod on herring needs update	Biological samples from the western Baltic have occasionally low size- and weight-at-age which have been related to mixing with the central Baltic herring stock	It is unclear if the stock productivity is under a new regime or not.	Herring mix with other large stocks such as the North Sea herring and central Baltic herring and this is reflected in both commercially and survey mixed cacthes
	Sprat	Changes in distributon towrads the North-Eastern Baltic	Predation of cod probably important for thining of sprat	Low weight at age – effect of plankton abundance unclear.	Effect of temperature on recruitment	

			in the South-Eastern Balti			

The biological knowledge on spatial distributions, foodweb processes, density dependence and environmental drivers has to be translated to operational parameters for stock assessment and management. Based on this scoping exercise, the parameters currently comprise:

- Weight-at age (or length) (W)
- Maturity (Mat)
- Predation mortality rate (M2)
- Recruitment (R)
- Distributional Range (D).

Pandora is currently in dialogue with ICES to supplement current stock assement summary sheets with this biological knowledge. A template table may look like this:

Table 3: Example of what an ecosystem table in species-specific advice may look like.

Parameter	Change	Why?	Short term forecast	Long term forecast (MSY/PGY)
W		*Explain here the reason for changes in the parameters in terms of spatial distributions, foodweb proceses, density dependence or environmental drivers,*	*Any effect on short term forecasts, e.g. on the suitable time range for averaging is listed here*	*Any effect on long term forecasts e.g. on the assumptions of stability in the relationship between stock size and reproductive potential, is listed here.*
Mat				
M2				
R				
D				

An obviously link to stock advice sheets are the sections on 'Quality of the assessment' or 'Issues relevant to the advice' , since it it here that the value of considering these parameters can be explained because they provide the context to the advice, either in the short term or long term.

The choice of parameters will be adapted during the course of the project. Furthermore, as the work in WP2-4 proceeeds, the explanation will be supplemented with model algorithms and links to the tool box which facilitate the quantitiative accounting for the changes and relevant processes.

3 Utility of industry self-sampling to existing and new information needs

The case for undertaking industry self-sampling is founded upon an identified need to either:

(i) **Improve Quality** – where the purpose is to improve the quality of data that is already routinely used to assess stocks and manage fisheries.

(ii) **Improve Understanding** – where the purpose is to provide additional data beyond that currently used to assess stocks and manage fisheries, which can be used to improve the understanding of changes in fish stocks and fishing fleet behaviour.

The crux of making industry data initiatives effective is matching what is needed with what is possible to provide and also with the incentives needed to maintain durable relationships. This means having a clear view of how it's relevant and how it will be used. In the table below, specific applications are identified and ordered in terms of their value in contributing to improvements in scientific and management information needs, and the timescale that they might be expected to make an impact. The order of these would need to be considered in detail for each target species.

Table 4. The utility potential of data collected through industry self-sampling (Timescales: short – 1-3 years, medium 2-5 years, long 5-10 years)

Application	Value to science	Time-scale for impact	Data needs
• Improve quality of stock forecast and advice on fishing opportunities	Indicators of year class strength required to improve the estimate of recruitment used in the forward projection. Providing finely resolved (lat, long) spatial information on growth rates.	Short	1. Length and weight composition of catch for every haul by lat, long. OR/AND 2. Acoustic data on fish distribution and size composition.
• Improve quality of age structure in stock assessments	Better precision and reduced bias in the size and age composition of the catch. Improved consistency in tracking year classes should help reduce the year to year variability in stock assessments, which is a key frustration that undermines people's confidence in stock assessment and the people involved in it. Particularly relevant if surveys are not undertaken annually since it provides another index of changes to track year-to-year changes.	Medium	Same as 1.

• Develop the future of stock assessments	Spatially resolved stock assessment models would have the necessary spatial data on size structure and growth rates to improve their performance.	Long	Same as 1.
• Monitor changes in the marine ecosystem	At sea measures of the length, weight fat content and gonad weight of fish provides condition and growth rate information. This can be linked to environmental variables associated with fish catches/ distribution. Changes in growth rate would affect estimates of sustainable fishing rates. At factory measurements of fat content or gonad weight	Medium to long term	Same as 1, plus 3. For every haul, record the key environmental variables such as temperature and depth. 4. Fat content measured across full range of catch sizes
• Indicators of fisheries performance	Estimate the catch per unit effort for every trip, where effort could be the amount of time or distance, fuel used searching before fishing.	Medium	5. Measure search effort. A crude indicator would be - time left port to time first haul, and times between multiple hauls (from eLog or personal record). More refined – distance sailed to first haul and between multiple hauls (from plotter track data, ideally with link to eLog system). Combined with 1 gives CPUE.
• Assist planning fisheries independent scientific surveys	Year round information on spatial distribution and biology could be used to assist in planning independent scientific surveys. For example, to establish the survey boundaries.	Short	Same as 1 & 3, plus 6. Acoustic information on fish distribution 7. Recording marks of fish that are not fished
• Fisheries dependent indices of abundance	Year round information on relative abundance and spatial distribution could provide auxiliary data to compute relative abundance indices.	Medium to Long	Same as 1 & 3, plus

	This might be particularly relevant where scientific surveys cover wide areas or encounter bad weather conditions that compromise the quality of the survey.		8. Acoustic information on fish distribution 9. Recording marks of fish that are not fished
• Evidence spatial distribution of fishing fleet to support fishing opportunities decision making.	Particularly relevant in the context of coastal state negotiations.	Short	Same as 1.
• Traceability of catch	Evidence to demonstrate the provenance of the catch – where it was caught and its quality and also	Short	Same as 1 & 4.
• Evidence environmentally responsible fishing practices	Estimation of the spatial overlap of by-catch with targeted fishing, providing information for real-time monitoring of fishing activities and decisions to fish in other areas. Evidence of avoiding undersized fish and areas where by-catch occurs.	Short to medium	Same as 1 & 7, plus 10. For every haul, record any non-retained by-catch.
• Quality of catch	Suite of metrics inform on health of fish population (see monitoring marine ecosystem)	Short	11. Same as 4, plus TVBM, Histamines and others
• Evidence of economic efficiency and environmental footprint (carbon)	Trip level data on the economic efficiency of operations	Medium	12. Economic indicators including: Fuel usage per trip, costs and landed value.
• Identify the geographical boundaries / separation of stocks and their migrations	Ability to identify stocks and migration patterns – relevant to ecology and management approaches.	Short to medium	13. Genetic samples from catches For migration studies - linked to samples taken from tagging programmes.
• Sociological snapshot of the fishing sector	A very important factor, not included in most if not all impact assessments, is the resilience of the crews and other workers dependent on fishing. This information would allow policy makers to make better informed decisions with regard to social impacts.	Medium	14. Age profile and professional qualifications of the crews, transferable skills, alternative occupations, etc.
• DNA-based stock size estimates for	In demersal fisheries, genetic Close Kin Mark Recapture population anal-	Medium to Long	15. Tissue sample for DNA extraction,

data-deficient species	ysis. Genetic structure of (sub)populations, and particularly for less abundant and data-deficient species: develop population models generating estimates of population size.		with: date and location of haul, length, sex, and photograph of top and bottom sides with size reference in frame for species ID

Key design considerations that need to be determined for each application

- Utility (is it needed, wanted, relevant and will it do the job?)
- Spatial resolution of sampling
    - By haul (sampled on vessel)
    - By landing (sampled at factory)
- Scale of sampling – the coverage of the fleet
- Quality assurance of sampling procedures
- Quality control of data
- Data Management
- Training requirements – including specific consideration of workload implications
- Conflicts of interest - Identifying and managing any conflicts of interest requires transparency in processes related to the use of data.
- Engagement and feedback mechanisms (avoid situations where fisheries are only being used to extract information from). Invest in visiting vessels and participating in research.