Traits-based Assessment of Sensitivity of Marine Fish to Environmental Change.

A workshop organised as part of the COST Action FA1004 on the Conservation Physiology of Marine Fish.es

Room G31, Defra, Nobel House, Smith Square London. 9th & 10th July 2014

Local organisers: Silvana Birchenough & Julian Metcalfe.

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1. Introduction

Assessing the response of marine fishes to climate change is considered to be a real challenge for scientists and managers. This is mainly because climate change effects on fish populations could potentially affects a number of environmental factors as well as many different levels of biological organisations (Rijnsdrorp, et al., 2009; Petitgas, et al., 2013). To date, the understanding of climate change effects (e.g. temperature changes, CO2, pH, extreme weather condition, sea level rise, etc.) and anthropogenic activities (fishing, renewable energy, dredging and disposal) have become important priorities for conservation of marine biodiversity and sustainable fisheries.

One aspect of importance is to consider how the physiological responses may be modified as an individual will get affected by temperature and/or other climate change related effects. In the past researchers have attempted to develop frameworks to anticipate the responses of fish populations to climate change, which

could integrate all life stages to assess impacts for the full life of a dedicated specie (Petitgas, et al. 2009), but in reality the use of these type of approaches are solely tested on a sub-set of species, which have commercial importance or have an important ecological significance, giving the approach only a limited use, when trying to ascertain the overall population response to these changes. Particularly, when climate change effects could affect fish assemblages on different levels, for example in relation to the distribution, structure and function (Engelhard et al. 2011).There are clear gaps in the current understanding of how climate change would affect assemblages and what species will be more sensitive to climate change, and techniques such as bio-climate envelopes have been employed to simplify life-history stages and species attributes (Cheung et al., 2008).

Given this growing body of data and understanding, are we now able to predict the relative sensitivity of any particular fish species and/or communities environmental change based solely on knowledge of their physiology, ecology and behaviour? This is the question we presented at this workshop funded as part of the EU COST Action F1004 on the Conservation Physiology of Marine Fish.

We compiled a group of multidisciplinary researchers to consider the current available information and attempt to construct a trait-based index of climate change sensitivity. The main idea was to discuss which aspects will be needed to develop such index as a tool to be tested on a specific data set later on. Will we be able to assess this index against existing community level data from observational studies at sites that have been subject to recent and documented environmental change? Finally, can the sensitivity index be used to construct simple models of species extinctions and predict the likely impact of climate change on biodiversity and community function?

2. Meeting Objectives

The aims of the workshop were dedicated to gaining information on the key ecology, physiology and behavior traits that could be used to develop a trait-based sensitive index for fish communities in response to climate change.

- Questions- discussed: what aspects of climate change do we want to concentrate on (e.g. temperature, O_2, Ocean Acidification, others?).

- Traits-info that we need (mainly concentrating on North Sea based work)

- Data set for further discussion (North Sea e.g. Engelhard et al., 2011)

The working group will summarize the main findings into a synthesis article (potential journal: Conservation Physiology) detailing a framework to undertake a BTA as a tool for combining fish, ecology, behavior and physiology information to develop a sensitivity index.

3. Discussion sessions

Plan

Session 1: Background and discussion	**Session 2: SWOT**
• Introduction and Welcome • House keeping info (e.g. Defra) • COST rules and information • Introduction to the BTA concept • BTA applications (benthic and fish) • BTA: discussions/expectations (info for data base) • BTA in relation to climate change (what is possible to achieve?) • Concentrate on 1-2 aspects of BT and climate change….	• *Sub-groups (1 hour)* • Key considerations for BTA: SWOT Analysis (Strength, Weakness, opportunities and threats) • Comparison/complementing with wider COST analysis (FARO) **Report in plenary**
Session 3: Traits and species	**Session 4 Traits and index/metric**
• Which traits are the most important to specific species? • Which life stages can we consider and code with traits? and can these traits help to determine sensitivity? • Which traits can we adopt to test which species are the most sensitive to climate change? • Can we agree on what list will be useful to develop for the purpose of COST: WP3? • Discuss on the weaknesses and strengths of the BTA for physiology approach (e.g. sources of information, limited to a sub-group of species) • Develop some recommendations on the approach to use when developing BTA and how best to add physiological responses **Report in plenary**	• Check progress on day 1 • Discuss on the best approach to include traits (e.g. metric development or single information) • Scoring traits: best way (e.g. values, fuzzy coding, broad categories) • Issues associated with data available (data sets) • Confidence issues- • Validation-best approach? **Report in plenary**
Session 5: Vulnerability and adaptive capacity climate change	**Session 6: Wrap up and way forward**
• Considerations for biodiversity conservation • Are there any specific life-traits to reflect vulnerability/ adaptive capacity? • Current issues/recommendations for conservation/issues • Gaps/issues	• Discussion on manuscript preparation/assembling the paper • Agree deadlines for input • Journal: Conservation Physiology • Trait based approach and its relevance for dissemination and impact on policy (Defra-representative?)

4. Swot Analysis

1. **Strengths** (good, internal) traits can be physiologically explicit, "ideal" traits tell you what you want to know, but may not be easy or able to measure (e.g. transfer efficiency), so use proxies and therefore need to identify proxies for ideal traits, employ physiological input to identify these. Interactions between traits, e.g. Pcrit/pH/temperature/pollutants. Can measure acclimation, rate of acclimation, physiological range. Builds on existing data, integrates a lot of information into simple analyses/metrics. Can use to forecast for future/changed scenarios, includes a mechanistic component to which physiological input is relevant, this can be tested.

2. **Weaknesses** (bad, internal). How do we deal with interactions between traits, how do we prioritise traits (which are fundamentally important)? Growth, fitness, reproductive success, GSI. Do traits need a mechanistic justification? Need to link physiological traits of other ecological function e.g. predator/prey interactions, food-webs. How do you deal with scale, how do we deal with/classify habitat heterogeneity?

3. **Opportunities** (good, external) Capacity to be policy relevant (?) or capacity to make the policy relevance explicit. A list of traits that make a species sensitive to pH, then ground truth against where fish are.

4. **Threats** (bad, external); competition from other approaches, may be wrong, bio-climate envelope modelling (e.g.) as an (the) forecast method of choice that is supported by funders. Insufficient differences between species. May not capture, or may underplay, the potential for evolutionary adaptation. Can acclimation in one species ameliorate the likelihood of invasion by an alien species?

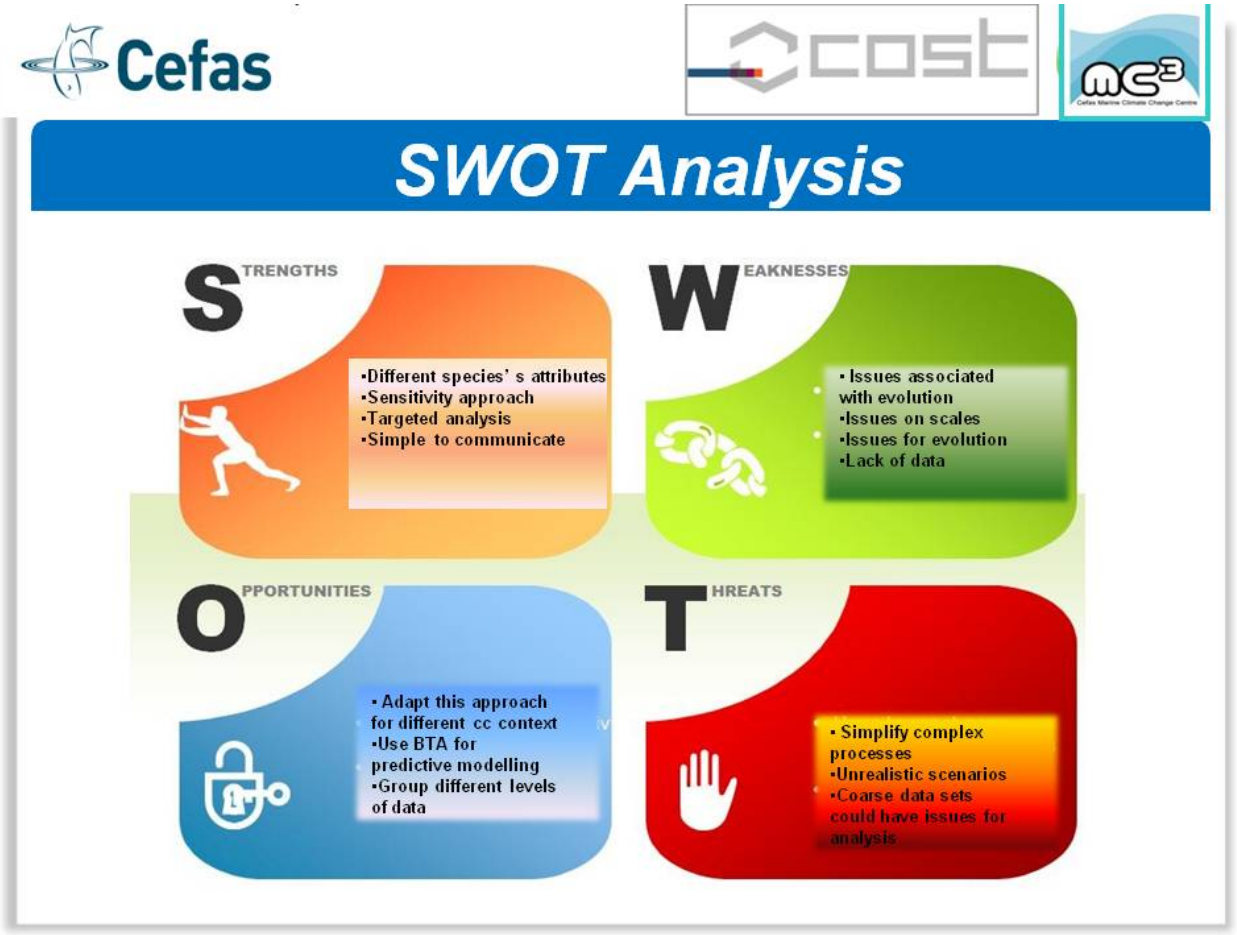

Figure 1: Summary results from the SWOT analysis.

5. Paper structure

The participants at the workshop all agreed on the need to compile a view point manuscript from this workshop. A draft manuscript is in preparation. The target journal is Conservation Physiology.

Tentative structure:

Traits-based Assessment of Sensitivity of Marine Fish to Environmental Change.

Main discussion points:

- What is the aim of a position paper? (do we want inform the physiologists – to better inform them on how their research might better inform?)
- There are societal and economic (which sum to political) requirements to assess and forecast the likely impacts of CC on marine fish and fisheries.

We will need sections for each stressor, so it is possible to discuss in relation to the traits thought to be affected/appropriate for consideration. Overall discussion of why it is thought the approach might be useful (and incoprating for example the strengths and opportunities identified through SWOT analysis (and discussing away" (!) the perceived weaknesses in consideration of the threats (but without elucidating these).

Some form of case study (CS) might be appropriate, based for example on expert opinion from the COST Action group, and assigning "level of confidence" score based on likely available data, for example. e.g. CS might help to explain approach – impact – effects and how the approach works – sensitivity to temperature might be a good starting point using an appropriate water body (Baltic, Med, NAtl) as the main thrust.

Does it list the kinds of applications – lateral thinking needed i.e. not only direct climate policy but possibly marine planning, aquaculture, other – discards listed as example where an "interesting" subject suddenly became policy relevant with the advent of new landing obligations – where there is suddenly a need for research too.

There are (and we should Identify) a priori reasons for thinking that physiological capabilities are relevant to predicting resilience/sensitivity to CC (temperature change, OA/hypoxia). But often physiologists work on individuals/problems of incorporating physiology in CC predictions and to inform advisors. Need for data that underpin conservation, ecology. Resolve this disconnect between physiology and conservation policy and intervention and help....

There is perceived to be a large body of physiological data gathered over many decades at is (believed to be) relevant to predicting the vulnerability of marine fish to climate change, but that this information is currently underutilised in the processes (other words) currently used to inform conservation policy and management interventions.

Explain why we think BTA is appropriate. Because it can be widely applied (we want something that is widely applicable – physiologists often have problems seeing where their understanding can be implemented in specific modelling approaches), unlike some other modelling approaches. Has BTA been applied to terrestrial systems and succeeded in influencing conservation policy or management interventions. For the MSFD descriptors 1, 4 and 6. WFD the French have developed an index?

Here we assess the suitability, value and feasibility of developing a BTA approach for assessing the sensitivity of marine fish to CC. We then go onto identify some specific applications where a BTA can inform conservation/management policies: MCZ designation, discard survival, aquaculture development.

Further issues for discussion: importance of intraspecific variation in an ecosystem (to be discussed at the COST Action meeting)

Linking aspects of trait based approaches with the data base, what can be done under COST? (ideas for further discussion with COST Action partners).

For the data base, there will be a further webex will be planned wiht COST action members.

Traits

A trait is a measurable attribute of a species and can include:

Migration
Escape
Size
Prey
Size @ maturity
Growth rate
Oxygen requirement
Metabolic rate
Aerobic scope
Fecundity
Longevity
Habitat preference
Resilience
pH tolerance (can tolerance to environmental variables (temperature/OA/hypoxia) be expressed in terms of physiological function/capacity duh... these are traits!)
ion regulation
Latitudinal mid-point/range
Salinity tolerance
Anaerobic capacity
Energy conversion efficiency
Hepatosomatic index
Gonadosomatic index
Swimming capacity/Ucrit
Larval development

The list of main traits was then further devleoped, adding a series of attributes, wich could be devleoped further as part of the COST Action iniciative. A summary is provided below

GROWTH/FITNESS		
	size	max length
	size @maturity	
	growth rate	
	longlevity	
	Hepato somatic index	
REPRODUCTION		
	Fecundity	
	Larval development	
	Gonad Somatic Index	
	Sexual reversal	
	Mode	Type/frequency
		Time
MOVEMENT		
	migratory	
	max escape response	
	Sustainable swimming	Ucrit
	schooling behaviour	
	demersal/pelagic	
HABITAT		
	Habitat peference	
	Latitudinal midpoint	
	Salinity midpoint	
	Diurnal rhytm	
	Territoriality	

FOOD		
	Feeding mode larvae	(and onset)
	Feeding mode adults	
	Feeding frequency	
	prey type	type/specialist/generalist
	prey size	gape
	prey location	olfaction/vision/electroreception
	energy conversion efficiency	
METABOLISM		
	Min O2 requirement	Pcrit
	Aerobic capacity	M basal
		M routine
		M max
		Aerobic scope
		Cardiavascular function
	Anaerobic capacity	
	SDA	
RESIELIENCE/TOLERANCE/SENSITIVITY		
	pH	ionoregulation
		acid/base regulation
	Temperature	Tmin/Tmax
		Topt
	Hypoxia	Pcrit
	Salinity	ionoregulation
		Min-max
Phenotypic plasticity		
Acclimation ability		

6. References

Cheung, W., Lam, V. and Pauly, D. (2008) Dynamic bioclimate envelope model to predict climate-induced changes in distribution of marine fishes and invertebrates. In: Modelling Present and Climate-Shifted Distribution of Marine Fishes and Invertebrates. W. Cheung, V. Lam & D. Pauly (eds) Fisheries Centre Research Reports 16:5–50.

Chown, S.L. (2012). Trait-based approaches to conservation physiology: forecasting environmental change risks from the bottom up. Philosophical Transactions of the Royal Society, 367, 1615-1627.

Engelhard, G.H., Ellis, J.R., Payne, M.R., Hofstede R. and Pinnegar J.K. (2011). Ecotypes as a concept for exploring responses to climate change in fish assemblages. ICES Journal of Marine Science, 68(3), 580–591. doi:10.1093/icesjms/fsq183

Petitgas, P., Rijnsdorp, A.D., Dickey-Collas, M., Engelhard, G.H., Peck, M.A., Pinnegar, J.K., Drinkwater, K., Huret, M. and Nash, R.N.M. (2013). Impacts of climate change on the complex life cycles of fish, Fisheries oceanography 22:2, 121–139.

Rijnsdorp, A.D., Peck, M.A., Engelhard, G.H., Mollmann, C. and Pinnegar, J.K. (2009). Resolving the effect of climate change on fish populations. ICES Journal of Marine Science, 66: 1570–1583.

Annex 1 – Agenda and attendees

Traits-based Assessment of Sensitivity of Marine Fish to Environmental Change
A workshop organised as part of the COST Action FA1004 on the
Conservation Physiology of Marine Fish:
9th & 10th July 2014
Venue: Room G31, Defra, Nobel House, Smith Square London.

Agenda:

Day 1: Data collation and preparation
9.00 hrs Arrival - We will start as soon as everyone is present.

9.30- Round table introduction- all participants

10.00-11.00 hrs **Session 1:** COST aims/ needs for WP3 (Julian Metcalfe)
- Introductory presentation on Biological Traits Analysis (Julie Bremner)
- Presentation on Biological Traits Analysis application: ocean acidification (Silvana Birchenough)
- Presentation on Ecotypes paper (Georg Engelhard)

11.00-11.30 hrs Coffee break

11.30-13.00 hrs **Session 2:** Discussion on what will be achieved and workshop plans
Working session- discussion on current set of information (e.g. traits, data and what is available)
Specific questions for consideration:
- Which traits are the most important to specific species?
- Which life stages can we consider and code with traits? and can these traits help to determine sensitivity?
- Which traits can we adopt to test which species are the most sensitive to climate change?
- Can we agree on what list will be useful to develop for the purpose of COST: WP3?
- Discuss on the weaknesses and strengths of the BTA for physiology approach (e.g. sources of information, limited to a sub-group of species)
- Develop some recommendations on the approach to use when developing BTA and how best to add physiological responses.

Lunch: 13:00 -13:45hrs, sandwiches and refreshments (at Defra canteen)

Session 3:

13.45-16.30 collate responses, look at potential scenarios.

19.30 Evening meal (TBC)

Day 2: Session 4:
calculation and Data Interpretation
09:00-09:30hrs – check on the progress done from day 1
09.30-10.30 hrs discuss on the potential metric development, confidence issues (scoring) / data testing
10:30-11:00hrs – coffee break (at Defra canteen)

Session 5:

11:00-12:30hrs – Hypothesis generation (question to be answered/ framework)
12:30-13:15hrs – sandwiches and refreshments to working group room
13:15-15:00hrs – draft paper key messages and start assembling paper
15:00-15:30hrs – coffee break to working group room

Session 6:

15:30-16.00hrs –Assign individual tasks for manuscript production

16.30-17.00 hrs – Wrap up session: policy colleague….info.

Attendees:

A total of 11 participants attended the workshop (See table x) and 3 colleagues (Drs. Paolo Domenici, Myron Peck and John Pinnegar) were also unable to attend but expressed an interest in the initiative. There will be opportunity to engage with these colleagues via correspondence and during the COST Action meeting in Thessaloniki.

	Name	Specialism	Country	Email
1	Julie Bremner	traits expertise, developed the trait approach, species sensitivities	UK	julie.bremner@cefas.co.uk
2	Silvana Birchenough	benthic macrofauna data (North Sea) and previous work on scaling up, OA sensitivity and traits	UK	silvana.birchenough@cefas.co.uk
3	Felix Mark,	physiologist, fish expertise (Bioacid)	Germany	fmark@awi.de
4	Martin Butzin	Modeller/ physiologist	Germany	
5	Julian Metcalfe	fish physiologist	UK	julian.metcalfe@cefas.co.uk
6	Georg Engelhard	fish/ ecotype	UK	georg.engelhard@cefas.co.uk
7	Gudrun DeBoeck	Environmental factors on energy/ metabolism	Belgium	gudrun.deboeck@ua.ac.be
8	Richard Corner	Facilitator	UK	richard@longline.co.uk
9	Mauricio Urbina	ECR, fish physiologist	UK	M.A.Urbina-Foneron@exeter.ac.uk
10	Beth Mindel (student)	Fish population ecologist	UK	
11	Nicolas Rogers	ECR, fish physiologist	UK	njr210@exeter.ac.uk

COST Action Workshop on Biological Traits Analysis for Conservation Physiology of Marine Fish
Defra, Nobel House, Smith Square, London 9th & 10th July 2014.

From left to right : Nicolas Rogers, Georg Engelhard, Mauricio Urbina, Beth Mindel, Felix Mark, Julian Metcalfe, Julie Bremner, Silvana Birchenough, Martin Butzin, Richard Corner. (missing: Gudrun DeBoeck)