





### D1.3 Validation datasets for simulations in WP3 and WP4

*Richard Bellerby (UiB), Toby Tyrrell (NOCS), Laurent Bopp (CNRS), Chris Smith (HCMR), Aldo Viarengo (UPiedmont), Alessandro Dagnino (UPiedmont), Anastasija Zaiko (KU CORPI), Sergej Olenin (KU CORPI), Priscilla Licandro (SAHFOS), Italo Masotti (CNRS), Cyril Moulin (CNRS)*

Validation is a crucial part of model evaluation and the simulations in the MEECE. We have defined and created validation (meta)data sets for hydrographic, biogeochemical and bio-geographical systems targeted to support the MEECE ecosystem model evaluation, making sure they are independent of any data used in the model parameterisation and process development in Task 1.3. The scope of each dataset differs because of the temporal and spatial scales of variability, the maturity and scale of political and scientific interest in monitoring the systems in question. There may also be intellectual property challenges to address and varying rules for data access. Accordingly, there is often variability in the coverage of the individual datasets. These datasets have been created both through identifying and linking with existing datasets and through the generation of new data sets from literature searches. The datasets, when not included in the text or as external links can be found on the MEECE website at [www.meece.eu](http://www.meece.eu).

Validation will be undertaken using the datasets from WP1 by both conventional model data comparison, and multivariate analysis WP3 and WP4 to assess their performance.

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## 1. Ocean Acidification Datasets

Within the MEECE project, several groups will model ocean acidification. Datasets of observational (in-situ) carbonate system measurements are important for validating those models. In this document we review data availability for the relevant geographical areas (North Atlantic and adjacent shelf seas, Aegean Sea, Benguela Upwelling Region). Carbonate chemistry parameters (e.g. DIC, Alk, pH,  $p\text{CO}_2$ ) are not routinely measured. They generally require expensive equipment (e.g. ~40,000 euros) and skilled operators, although  $p\text{CO}_2$  can now be measured autonomously on vessels of opportunity. Overall it is non-trivial. This is why there is much less carbonate chemistry data than there is nutrient data. The scarcity of carbonate chemistry data is also particularly pronounced in certain places, for instance: “Due to the sparseness of measurements, especially in the eastern basin, little is known about the carbonate system of the Mediterranean Sea.” (Schneider et al., 2007). There are three types of data: data that is publicly available is provided on the accompanying CD-ROM, instructions are provided on how to access other data, and contact details are provided where data needs to be requested from the data originator. We briefly review relevant publications for the different areas. There is only a small amount of data for the Mediterranean Sea and none that we are aware of for the Aegean Sea; there is rather little specific data for the Benguela region; there is a relatively large amount of data for the North Atlantic and for adjacent NW European Shelf Seas. More data is however becoming available over time, in part because of new time-series starting up due to the concern over ocean acidification. It takes time for this data to become available. In order not to provide modelers with incorrect data, we only include data that has undergone proper quality control, including checking by Bob Key and his group at Princeton. Once data has undergone such checks and been incorporated into the CDIAC database then it can be safely used by modelers.

**Accompanying CD-ROM:** Where data has been made publicly available, we provide it on the CD that accompanies this document. It also contains PDFs of relevant articles and reports; where a citation is marked with an asterisk then it is included in the reference materials folder of this disk. The data can also be accessed through the link: [http://www.noc.soton.ac.uk/soes/staff/tt/MEECE\\_OA\\_datasets.zip](http://www.noc.soton.ac.uk/soes/staff/tt/MEECE_OA_datasets.zip)

**Longer Version of This Report:** An extended version of this document is available in the supplementary information section.  
[http://www.meece.eu/documents/deliverables/WP1/D1.3\\_supplement.pdf](http://www.meece.eu/documents/deliverables/WP1/D1.3_supplement.pdf)

### 1.1 Global Datasets

*GLODAP* ([http://cdiac.ornl.gov/oceans/glodap/Glodap\\_home.htm](http://cdiac.ornl.gov/oceans/glodap/Glodap_home.htm))

The Global Data Analysis Project (GLODAP) has brought together inorganic carbon data collected on cruises of the World Ocean Circulation Experiment, the Joint Global Ocean Flux Study, and the Ocean Atmosphere Carbon Exchange Study. Shelf seas and marginal seas are not included. The data is available as either bottle data or gridded data. The gridded dataset consists of global grids with  $1^\circ$  horizontal resolution, interpolated onto 33 depth intervals from the surface to 5500m. Gridded data fields are of annual average values, or in other words seasonality is not considered. This may lead to biases, e.g. towards summer data at high latitudes. GLODAP has also attempted to separate anthropogenic from natural DIC in order to create gridded fields of pre-industrial DIC and “present day” anthropogenic  $\text{CO}_2$ . For detailed information on the production of the GLODAP dataset see Sabine et al. (2005)\* and for analysis of the data see Key et al. (2004)\*. The gridded data for alkalinity, total  $\text{CO}_2$ , anthropogenic  $\text{CO}_2$  and potential alkalinity are included on the CD-ROM as netCDF files. The bottle data is provided in unzipped .txt files which are comma delimited. The data is divided into the Indian, Atlantic and Pacific Oceans and a pdf is included for each ocean which gives details of the cruises from which the data came and the correction factors that were used.

*Lamont-Doherty Earth Observatory (LDEO)  $p\text{CO}_2$  dataset (Version 2007)*  
<http://cdiac.ornl.gov/oceans/doc.html>)

The LDEO dataset contains 3 million measurements of surface water  $p\text{CO}_2$  obtained from 1968 to 2007. Data coverage includes open ocean as well as some shallow seas, although unfortunately not the Mediterranean. The dataset (LDEO database NDP-088) is included on this disk and was taken from the Carbon Dioxide Information Analysis Centre (CDIAC). For detailed information on the production of the LDEO dataset see Takahashi and Sutherland (2008)\*. For an in depth analysis of  $\text{CO}_2$  fluxes across the sea-surface, calculated using this dataset, see Takahashi et al. (2009)\*. An even larger global dataset of surface ocean  $\text{CO}_2$  measurements called SOCAT and expected to contain order 7.6 million measurements, is in course of preparation and due to be released mid-2010 (<http://ioc3.unesco.org/ioccp/SOCAT.html>).

## 1.2 Mediterranean Sea and Black Sea Datasets

Carbonate chemistry data for the Mediterranean Sea and Black Sea are scarce, especially for the Eastern Mediterranean basin and the Black Sea (CIESM, 2008; Tyrrell et al., 2008). Some carbonate chemistry measurements have been made in the Black Sea such as those on cruise 134 of R.V. Knorr in 1988 (Goyet et al., 1991); a few surface measurements were also made in 2001 in the southwestern Black Sea (Hiscock and Millero, 2006). Carbonate chemistry measurements were also made in the Mediterranean (predominantly the eastern half) in 2001 during the Meteor 51/2 cruise (Schneider et al., 2007). The DYFAMED time series station is located in the Western Mediterranean basin and data collected between 1991 and 2007 (including alkalinity and pCO<sub>2</sub>) can be accessed at (<http://www.obs-vlfr.fr/dyfBase/>). A coastal time series has also recently been established in the Western Mediterranean off Villefranche-sur-mer, in the south of France, where DIC and total alkalinity (TA) are measured at the surface and at 50m on a weekly basis. For more information contact Jean-Pierre Gattuso ([gattuso@obs-vlfr.fr](mailto:gattuso@obs-vlfr.fr)). A recent dataset for the Adriatic, by an Italian researcher, Anna Luchetta, at CNR ISMAR (Trieste) in Italy: "We are running the only monthly time series of physical and chemical + carbon parameters (including pH, CO<sub>2</sub>, carbonate system parameters and atmospheric CO<sub>2</sub>) in the Adriatic Sea since January 2008. The Adriatic Sea time series is not yet published, we are working on it." New data is also likely to be produced eventually through the recently-funded EU F7 project MERSEA, although most likely not within the timescale of MEECE. Apparently a manuscript by Rivaro et al. is presently in press in *Marine Chemistry*.

## 1.3 Benguela Datasets

There is relatively little carbonate chemistry data for the Benguela Upwelling System. Although the GLODAP dataset consists primarily of measurements made in open-ocean deep waters, two cruises (A10 and A11) sampled the Benguela. Alkalinity, DIC, pH and CO<sub>3</sub><sup>2-</sup> values from four stations along the SW African continental margin are presented in table 3 of Wilke et al. (2006)\*.

## 1.4 North Atlantic and Neighbouring Marginal Seas Datasets

The CARINA project (carbon dioxide in the North Atlantic) has created an inventory of carbonate chemistry data from the North Atlantic as a whole. The cruise tracks and data can be accessed easily and conveniently from: [http://cdiac.ornl.gov/oceans/CARINA/Carina\\_table.html](http://cdiac.ornl.gov/oceans/CARINA/Carina_table.html). Maps of data distribution in the Arctic and Southern Oceans can also be found at [http://cdiac.ornl.gov/oceans/CARINA/Carina\\_inv.html](http://cdiac.ornl.gov/oceans/CARINA/Carina_inv.html). The CARINA Atlantic dataset is included on this disk. There is overlap between CARINA and GLODAP as several cruises are used in both.

### *Northwest North Atlantic:*

Corbiere et al. (2007)\* analysed the variations of sea surface dissolved inorganic carbon (DIC) and total alkalinity (TA) in the North Atlantic over the period 1993–2003 (SURATLANT Program). The contact scientist for this dataset is Nicolas Metzl ([nicolas.metzl@upmc.fr](mailto:nicolas.metzl@upmc.fr)).

### *Northeast Atlantic Sub-Tropical Gyre:*

Long-term trends, seasonal and interannual variability of upper ocean carbonate chemistry have been studied over >10 years at the ESTOC (European Time Series in the Canary Islands) Station (e.g. Santana-Casiano et al., 2007). Alkalinity, pH and pCO<sub>2</sub> have been measured. Melchor González-Dávila ([mgonzalez@dqui.ulpgc.es](mailto:mgonzalez@dqui.ulpgc.es)) can be contacted about the data.

### *Nordic Seas:*

For a review of the contemporary inorganic carbon cycle of the Nordic Seas and Barents Sea see Skjelvan et al. (2005)\* and for a discussion on the possible evolution of the carbonate system in the Nordic Seas over this century see Bellerby et al., (2005). Weather Station Mike (OWSM) is located at 66°N, 02°E on the eastern margin of the Norwegian Sea deep basin. Measurements of dissolved inorganic carbon have been made at OWSM from the early 1990s (Gislefoss, 1998) for four years and the measurement record was rekindled by the University of Bergen who have collected carbonate chemistry data (including pCO<sub>2</sub>, DIC and alkalinity) at this site since 2002 (Skjelvan et al., 2008). Contact Richard Bellerby for access to the data. The seasonal cycles of pCO<sub>2</sub> and DIC at this site have been ascertained (Gislefoss, 1998; Skjelvan et al., 2008). Using the this information the seasonal cycles of other carbonate system parameters (including pH and carbonate ion) at OWSM have been

derived (Findlay et al., 2008)\*. A recent paper used time series measurements collected in the Iceland Sea over many years to investigate its ongoing acidification (Olafsson et al., 2009)\*.

#### *Bay of Biscay and western English Channel:*

The Ferrybox project collects data from the P&O ferry Pride of Bilbao which runs between Portsmouth (UK) and Bilbao (Spain). The project has measured the carbonate chemistry along this route for several years. Contact David Hydes at the National Oceanography Centre, Southampton for more information ([djh@noc.soton.ac.uk](mailto:djh@noc.soton.ac.uk)).

#### *North Sea:*

Thomas et al. (2005)\* investigated the controls on surface water CO<sub>2</sub> partial pressure in the North Sea. They used DIC and pCO<sub>2</sub> data collected on four comprehensive surveys during four consecutive seasons, and from this were able to calculate maps of surface carbonate chemistry properties at different times of year (e.g. Figure 16b). A later study used the same dataset to provide evidence that anaerobic degradation of organic matter generates total alkalinity and increases the CO<sub>2</sub> buffer capacity of seawater (Thomas et al., 2009)\*. The corresponding author for these papers (a contact for the data) is H. Thomas ([helmuth.thomas@dal.ca](mailto:helmuth.thomas@dal.ca)).

#### *Baltic Sea:*

Most data collected until recently in the Baltic consisted of total alkalinity and electrode pH measurements. Most of this older data is either not available or not suitable. pH measurements using spectrophotometric techniques are generally preferred, and electrode-based measurements thought to be of lower accuracy (Dickson, 2007). New, high-quality data is being collected within the project BALTIC-C (part of BALTEX-II). Descriptions and metadata are available at: <http://www.baltex-research.eu/baltic-c/metadata/metadata.html>. We have enquired to see if any of this data is now lodged with CDIAC.

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## 2. Validation of spatially resolved Pollution Impact Models

A key driver of ecosystem change in the marine environment is pollution. Man has introduced a large number of manmade compounds to the marine environment since the advent of synthetic chemistry, in the impacts of which are largely un-quantified.

In MEECE we are developing parameterisations (T2.2.6) of pollution impacts which will represent pollution related stress on organisms as a penalty function on growth. MEECE considers 2 classes of compounds Copper (Cu) and herbicides. The development of parameterisations will draw on the experimental and meta analysis work in WP1. The experiments in MEECE have looked at the response of phytoplankton, zooplankton, fish larvae and mussels to Cu and phytoplankton to herbicides. While we have data to develop the parameterisations, there is a major challenge in devising methodologies for the validation of such models. Environmental toxicology uses a wide range of biomarkers to assess the response of organisms to toxic stress. Much of the information in the environmental toxicology literature shows the response of a range of biomarkers to a single pollutant. However many biomarkers only exhibit a response in a part of the health status space (Figure 1. from Dagnino et al 2007 *Biomarkers*; 12(2): 155\_172)

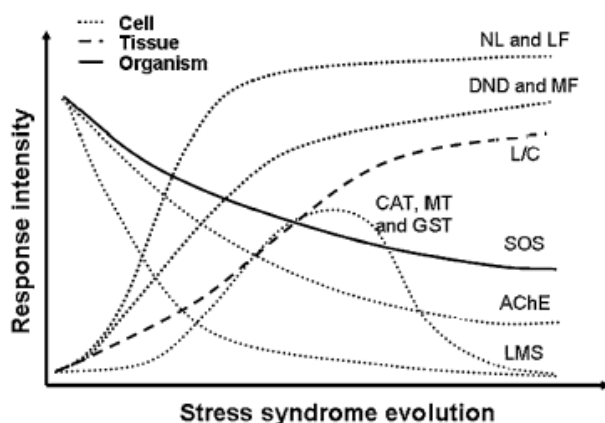


Figure 1. Different response profiles of biomarkers in a pollution gradient, related to the development of the stress syndrome. Decreasing: i.e. lysosomal membrane stability (LMS), acetylcholinesterase activity (AChE), stress on stress response (SOS). Increasing: i.e. neutral lipid lysosomal content (NL), lipofuscin lysosomal content (LF), DNA damage (DND), micronuclei frequency (MF), lysosome/cytoplasm volume ratio (L/C). Bell-shaped: i.e. catalase activity (CAT); metallothionein content (MT); GSH transferase activity (GST).

In order to use this data we need to identify biomarkers which can clearly be related to model outputs. The challenge is to link sub-lethal biomarker data to physiological, high level, impairments relevant in terms of modelling.

One such candidate is **Scope for Growth (SfG)** which is defined as the difference between the energy input to an organism from its food and the output from respiratory metabolism. SfG gives a good physiological measure of stress that, at least in principle, is straightforwardly related to population and community processes.

$$\text{SfG} = \text{C} - \text{F} - \text{R}$$

Where C is the energy consumed as food, F the energy released as faeces and R the energy released through respiration. Clearly SfG is also readily calculated from the same energy balance equations that underpin any functional group in an ecosystem model; taking into account the conversion from experimental units (generally joules/g tissue/ per day) to model units of gC / area / day. The penalty functions to be employed by MEECE will act to either reduce the energy consumed C or enhance the loss terms F, R, thereby lowering the SfG when to functional type is stressed.

SfG data is most commonly available for mussels (*Mytilus spp*) and has been used as a proxy for estuarine contamination (e.g. Widdows et al 1995 MEPS 127 131-128). For phytoplankton the closest approximation of SfG is  $C^{14}$  primary production estimates which are a proxy for C uptake, respiration and other loss terms.

The main disadvantage of SfG is that it is time consuming to measure. However there are some generic biomarker which can act as a proxy for scope for growth. One such is Lysosomal stability, which reflects toxicant induced cell pathologies and integrates various classes of pollutants. It is a good indicator of the degree of stress or disease and health status of the animal (see Moore, 2002 Aquatic Toxicology, 59, 1–15 and references within). Taking the example of the bivalve mollusc *Mytilus spp* (blue mussel), the energy balance of the organism (scope for growth) is a robust indicator of the health status of the animal. Scope for growth is linearly correlated with the lysosomal stability of molluscan digestive gland epithelial cells (Figure. 2) indicating that lysosomal stability is also a good indicator of the overall health of the organism. Moore et al 2006 (MER 61, 284-301) conclude that measures of lysosomal stability appear to provide potentially powerful prognostic biomarkers for whole animal health and may also have predictive use for larval health status. Furthermore, the evidence is steadily accumulating that lysosomal membrane stability is a generic indicator of cellular health in eukaryotic cells, as is indicated by studies with protozoans, coelenterates, annelids, crustaceans, molluscs, fish and mammals.

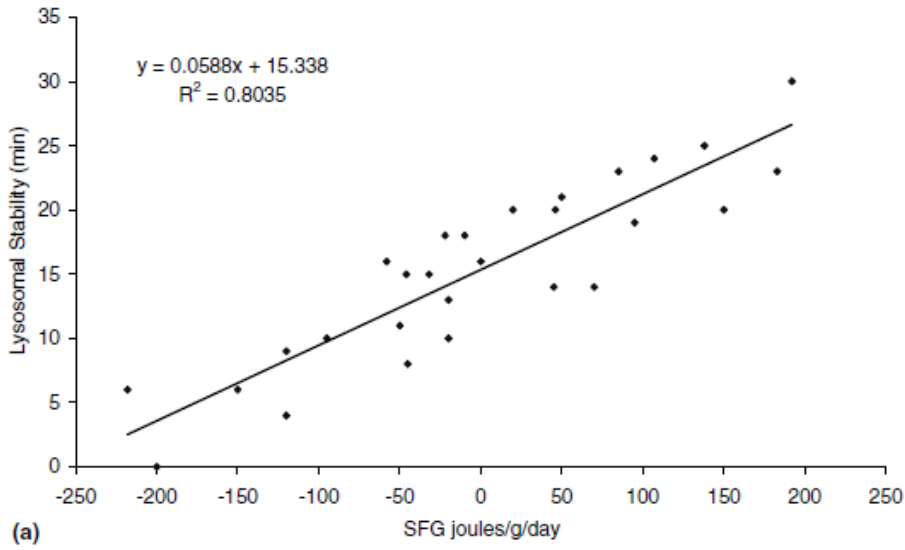


Figure 2. Relationship between Lysosomal stability and Scope for Growth (from Allen and Moore 2004 MER 58 227-232).

Clearly if we have lysosomal stability data for an organism then we also have a proxy for SFG which can be easily related to model outputs. Fortunately lysosomal stability is easily measured. The neutral red assay is an indicator of stress response in mussels. It measures retention time of neutral red dye in the lysosome, which gives a measure of lysosomal stability (Figure 3). The neutral red assay is widely applicable in eukaryotic cells and potentially, could provide validation data across the whole foodweb. For example the combination of the neutral red assay, with  $C^{14}$  and contaminant chemistry could potentially provide the required information to validate such models.

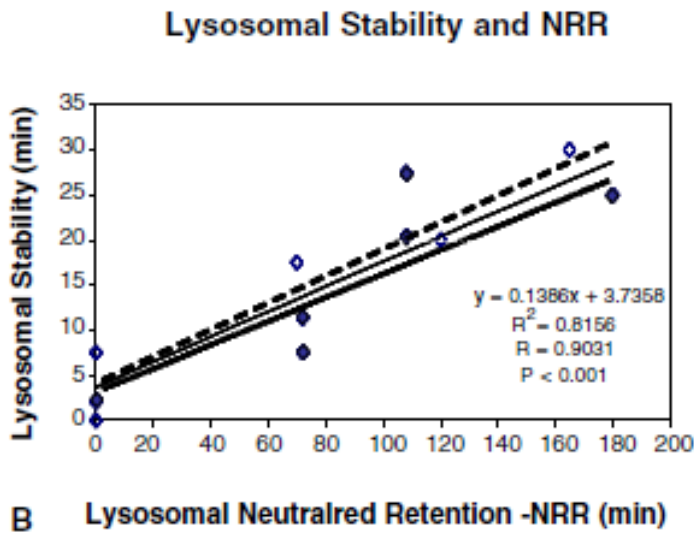


Figure 3. Relationship between neutral red retention and lysosomal stability (from Moore et al 2006).

## 2.1 Available *In-situ* Data Sets

In assembling and interpreting in-situ data for model validation we have to remember that the observed pollution stress responses are a consequence of a mixture of contaminant including metals, PAH;s, PCBs, nanoparticles, herbicides etc. There will in practice rarely be a clear cut response to a particular pollutant. Consequently we have to focus more on the generic responses of the model. Does it realistically represent observed responses to contaminate gradients rather than focusing on detailed validation of the system in space and time.

### 2.1.1 Molluscs

Mesocosm experiments (Widdows and Johnson 1998) indicate a general trend of decreasing SFG with increasing copper concentration (Figure 4). While this is not a statistically robust relationship it provides rough qualitative guide by which to judge model performance. This can be used a qualitative guide to assess the impacts of Cu on suspension feeders in ERSEM/BFM type models.

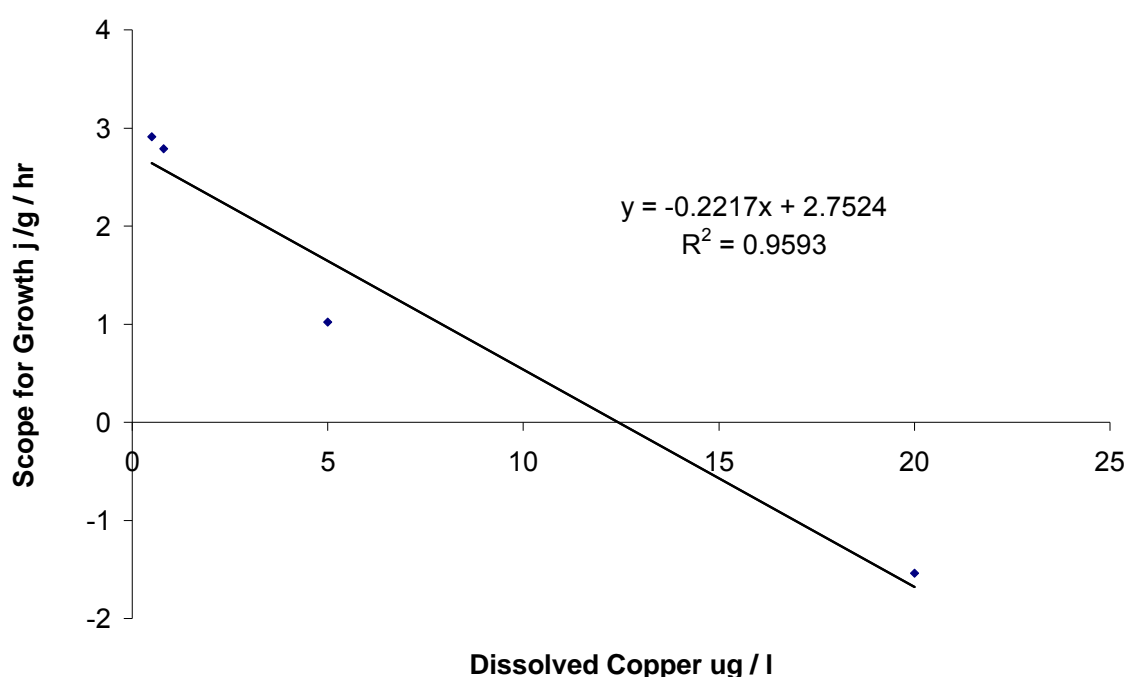


Figure 4. Relationship between dissolved copper concentration and scope for growth in mussels. Data taken from Widdows and Johnson 1988 MEPS, 46, 113-125.

We have identified the pressing need for more experimental information comprising the following in-situ data; contaminant concentration (e.g. Cu), with either SfG or Lysosomal Stability or NRA.

### 2.1.2 Fish / fish larvae

The in-situ data required is contaminant concentration (e.g. Cu), with either SfG and or Lysosomal Stability or NRA.

**Data Set:** Selected liver biomarker data (including neutral red) from the flatfish Dab (*Limanda limanda*) collected by the ICES/UNESCO-IOC Bremerhaven Workshop (Stebbing et al., 1992). Collected along a concentration of contaminants (including Cu) in the German Bight. Station locations are given in the dataset. (Bremerhaven data for DAB; <http://www.meece.eu/secure/datasets/WP1.html>)

### 2.1.3 Plankton

To the best of our knowledge there is little in-situ data in the literature to validate the impacts of contaminants on phytoplankton and zooplankton. There are experimental studies which contain information on the impacts of herbicides commonly used as antifoulants on phytoplankton (Table 2. Devilla et al MEPS 286, 1-12) and community structure (Fig 5. Devilla et al 2005. *Aquatic Toxicology*, 71, 25-38) which provide some information to qualitatively assess model behaviour. There is a clear need to undertake further research to quantify the impacts of pollutant on plankton on the natural environment.

Species	Biocide type	Biocide ( $\mu\text{g l}^{-1}$ )	$\mu^a$ ( $\text{div d}^{-1}$ )	Cell $\text{ml}^{-1}$ ( $\times 10^4$ )	Chl a: cell	Chl $c_1$ :Chl a	Chl $c_2$ :Chl a	Fuc:Chl a	19'-Hex:Chl a	Diad:Chl a	$\beta$ -Car:Chl a	Zea:Chl a
<i>Emiliania huxleyi</i> (Prymnesiophyceae)	Diuron	0	1.12	7.23	0.40	0.28	0.20	0.60	0.19	0.17	0.032	
		MEOH	1.11	7.48	0.40	0.27	0.20	0.57	0.18	0.17	0.032	
		0.2	1.05	6.38	0.37	0.26	0.22	0.50	0.25	0.16	0.030	
		0.5	1.02	6.54	0.26	0.25	0.22	0.48	0.27	0.17	0.031	
		5	0.51	2.23	0.25	0.24	0.21	0.48	0.27	0.17	0.029	
		12	0.42	1.74	0.23	0.23	0.21	0.50	0.24	0.18	0.031	
		50	0.38	1.70	0.16	0.16	0.19	0.45	0.23	0.19	0.025	
			*	*	*	*	*	*	*	*	*	*
	Zinc pyriithione	0	1.15	5.86	0.46	0.24	0.11	0.42	0.19	0.19	0.022	
		0.2	1.13	5.63	0.52	0.23	0.11	0.39	0.20	0.18	0.024	
		0.4	1.06	4.55	0.23	0.24	0.12	0.37	0.31	0.34	0.022	
		0.6	0.84	2.54	0.16	0.19	0.17	0.23	0.35	0.38	0.026	
		0.8	0.18	6.88	0.11	1.37	0.61	1.98	3.27	0.94	0.004	
		1	-0.62	1.23	0.12	4.70	1.25	7.05	10.37	2.09	0.000	
			*	*	*	*	*	*	*	*	*	*
	SeaNine 211 <sup>®</sup>	0	1.17	3.02	0.81	0.25	0.17	0.51	0.15	0.11	0.024	
		MEOH	1.13	2.91	0.80	0.23	0.12	0.58	0.19	0.14	0.019	
		0.4	0.74	1.24	0.69	0.26	0.14	0.45	0.22	0.12	0.023	
		0.8	-1.33	0.02	0.76	0.19	0.07	0.43	0.35	0.16	0.011	
			*	*	*	*	*	*	*	*	*	*
	Irgarol 1051 <sup>®</sup>	0	1.17	3.02	0.81	0.25	0.17	0.50	0.15	0.11	0.024	
		MEOH	1.13	2.91	0.80	0.23	0.12	0.58	0.19	0.14	0.019	
		0.1	1.02	2.33	0.37	0.82	0.29	2.15	0.83	0.28	0.009	
		0.2	0.86	1.61	0.46	0.21	0.17	0.39	0.23	0.13	0.022	
0.5		0.52	0.80	0.40	0.31	0.16	0.72	0.35	0.24	0.015		
		*	*	*	*	*	*	*	*	*	*	
<i>Synechococcus</i> sp. (Nostocophyceae)	Diuron	0	1.23	12.85	0.0033						0.12	0.61
		MEOH	1.26	11.89	0.0034						0.12	0.64
		0.2	1.03	8.76	0.0037						0.14	0.64
		0.4	1.07	7.82	0.0043						0.12	0.56
		2.2	0.53	2.96	0.0025						0.18	0.64
		3.3	0.29	1.80	0.0035						0.13	0.65
			*	*	*	*	*	*	*	*	*	*
	Zinc pyriithione	0	1.18	5.37	0.0049						0.11	0.71
		0.4	1.18	5.15	0.0042						0.13	0.64
		0.6	1.15	7.10	0.0046						0.11	0.66
		1	1.02	4.76	0.0054						0.11	0.64
	SeaNine 211 <sup>®</sup>	0	1.18	5.37	0.0049						0.11	0.71
		MEOH	1.19	5.15	0.0045						0.11	0.68
		0.2	1.23	5.60	0.0042						0.12	0.69
		0.4	1.18	6.70	0.0040						0.12	0.67
			*	*	*	*	*	*	*	*	*	*
	Irgarol 1051 <sup>®</sup>	0	1.13	8.39	0.0036						0.14	0.74
		MEOH	0.97	6.11	0.0050						0.13	0.83
		0.2	0.58	3.07	0.0022						0.21	0.65
		0.5	0.08	1.08	0.0037						0.12	0.71
1		-0.10	0.77	0.0031						0.14	0.81	
		*	*	*	*	*	*	*	*	*	*	

<sup>a</sup>  $\mu$  was estimated by taking into account the 3 days of the experiment

Table 2. Growth rate ( $\mu$ , divisions  $\text{d}^{-1}$ ), cell numbers (cell  $\text{ml}^{-1}$ ), chlorophyll a to cell ( $\text{pg cell}^{-1}$ ) and marker pigment to chlorophyll a ratios for the prymnesiophyte *Emiliania huxleyi* and the cyanophyte *Synechococcus* sp. exposed to different type and concentrations of antifouling biocides. Data represent means of 3 replicated cultures. \*Significant differences in pigment ratios and growth rates due to different concentrations of biocides for each marked column ( $p < 0.05$ )

Source: Devilla et al. (2005). Impact of antifouling booster biocides on single microalgal species and on a natural marine phytoplankton community. *Marine Ecology Progress Series*. Vol. 286: 1-12.

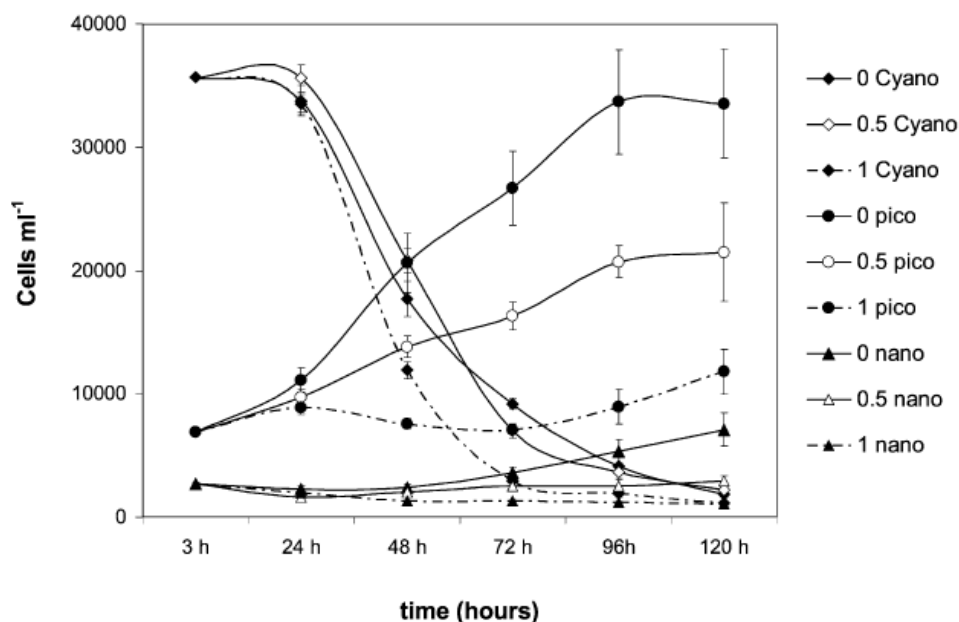


Figure 5. Growth responses of picoeukaryotes (pico), nanoeukaryotes (nano), and cyanophytes (Cyano) under exposures to 0.5 and 1.0  $\mu\text{g l}^{-1}$  Irgarol 1051® and the controls (no Irgarol 1051® added) over a 120 h period of incubation. Data are expressed as mean cell abundances (measured by AFC). Bars indicate standard deviations ( $n = 5$ ).

Source: Devilla RA, Brown MT, Donkin M, Readman JW (2005). The effects of a PSII inhibitor on phytoplankton community structure as assessed by HPLC pigment analyses, microscopy and flow cytometry *Aquatic Toxicology* 71, 25-38. Page 30

### 3. Fish Communities

#### 3.1 Validation for the Different Regional Sea Areas:

Validation data concerning fisheries are available for all the MEECE greater model areas through the database of "The Sea Around Us Project" ([www.seaaroundus.org](http://www.seaaroundus.org)). All the areas modelled in MEECE are covered within 8 designated Large Marine Ecosystems (Baltic Sea, Barents Sea, Black Sea, Benguela Current, Celtic Sea/Bay of Biscay, Mediterranean, North Sea, Norwegian Sea – see Figure 6). To a large extent this data is based on FAO fish production data reporting, with corrections and manipulation. The database allows the use of common data categories across all the geographic areas.

For the project, data sets have been extracted for the eight areas concerning four different but useful categories. The categories are:

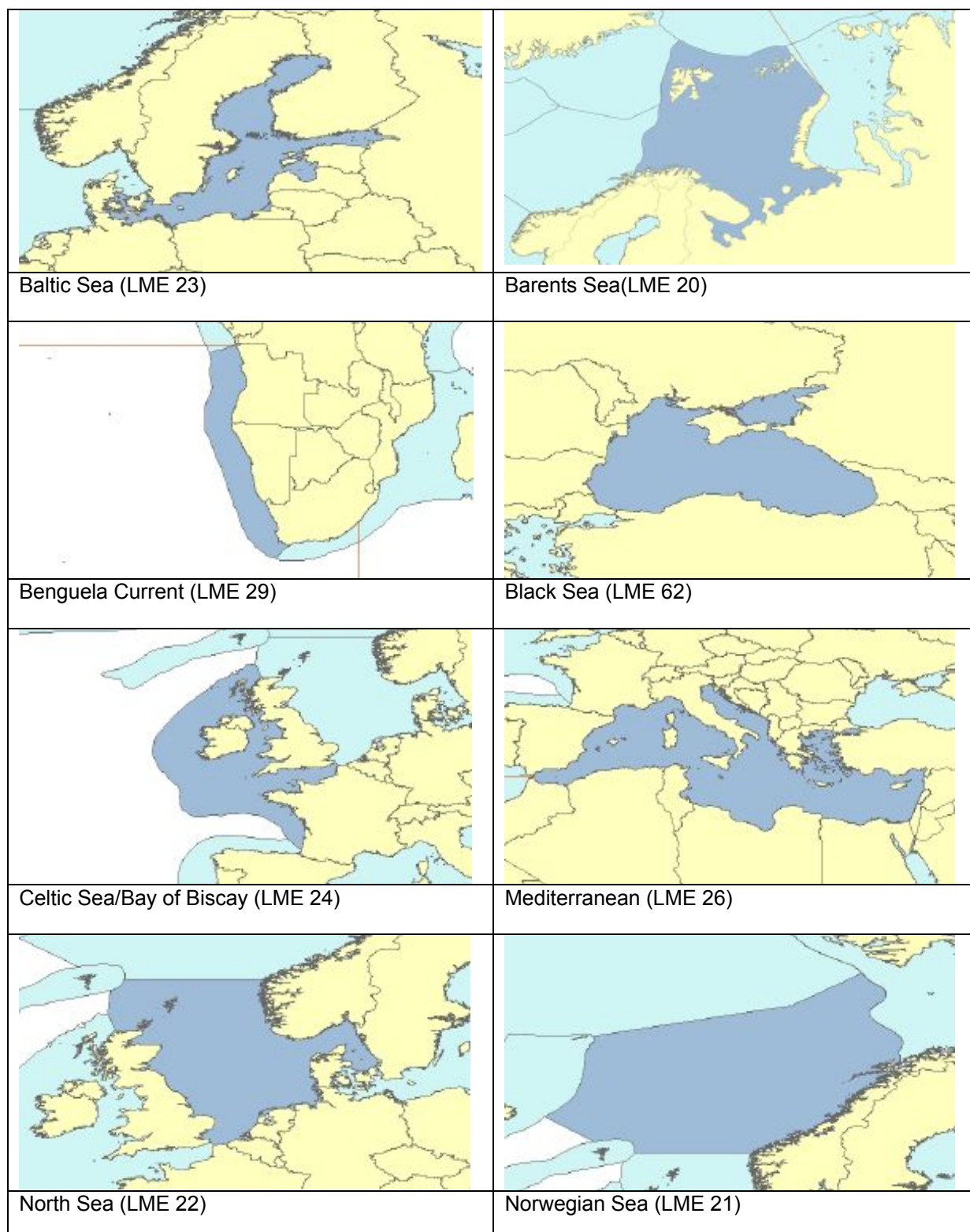
- total production
- production by commercial group, including 5 most common catching methods (purse seine, pelagic trawl, bottom trawl, nets, long line hooks)
- production by major functional group, including 4 most common groups (small pelagic, medium pelagic, large pelagic and demersal fish)
- production by species, including the 11 top dominant species and rest of the mixed species (12<sup>th</sup> group) over the time period investigated

The complete data set contains data from 1950 to the latest date reported (in 2010 the latest common date was 2006). For the MEECE project, data have been collated at the differing levels of: total,

functional group and dominant species to have firstly a common availability, and secondly the different models being used within the project may have differing levels of differentiation, with only some models able to use the highest resolution at species level. Various examples of the data are given in the following section and figures.

Figure 7 shows the total production of all the different geographical areas over the last reported decade. The different regional areas exhibit differing levels of production and trends. Highest production is seen in the North Sea and Norwegian Sea. Production in the last reported decade exhibited a decrease in the Baltic, Barents, Celtic, North Seas and in the last few years in the Benguela Current. Production in the Black Sea and Norwegian Sea has remained reasonably constant, whilst an increase in the last years has been seen in the Mediterranean. Some further production examples are given here for reasons of brevity for 3 of the areas for the previous 5 recorded years; the Baltic Sea, Benguela Current and Mediterranean Sea. Figure 8 shows production by different catching method. The mid-water trawl production dominates in the Baltic Sea, mid-water trawl and bottom trawl in the Benguela whilst in the Mediterranean there is a much more even distribution of production between the two types of trawl, purse seine and bottom nets. In terms of functional group (Figure 9), the production in the Baltic Sea is dominated by the small pelagic fishery, the Benguela by medium pelagics and the Mediterranean equally by demersal and small pelagics. Figure 10 shows production of the top 3 dominant species per area. In all three areas the dominant species are primarily pelagic, although the demersal hake is of equivalent importance in the Benguela Current.

Figure 6: Greater areas from the Sea Around Us Project modelled within the MEECE project (with their Large Marine Ecosystem code).



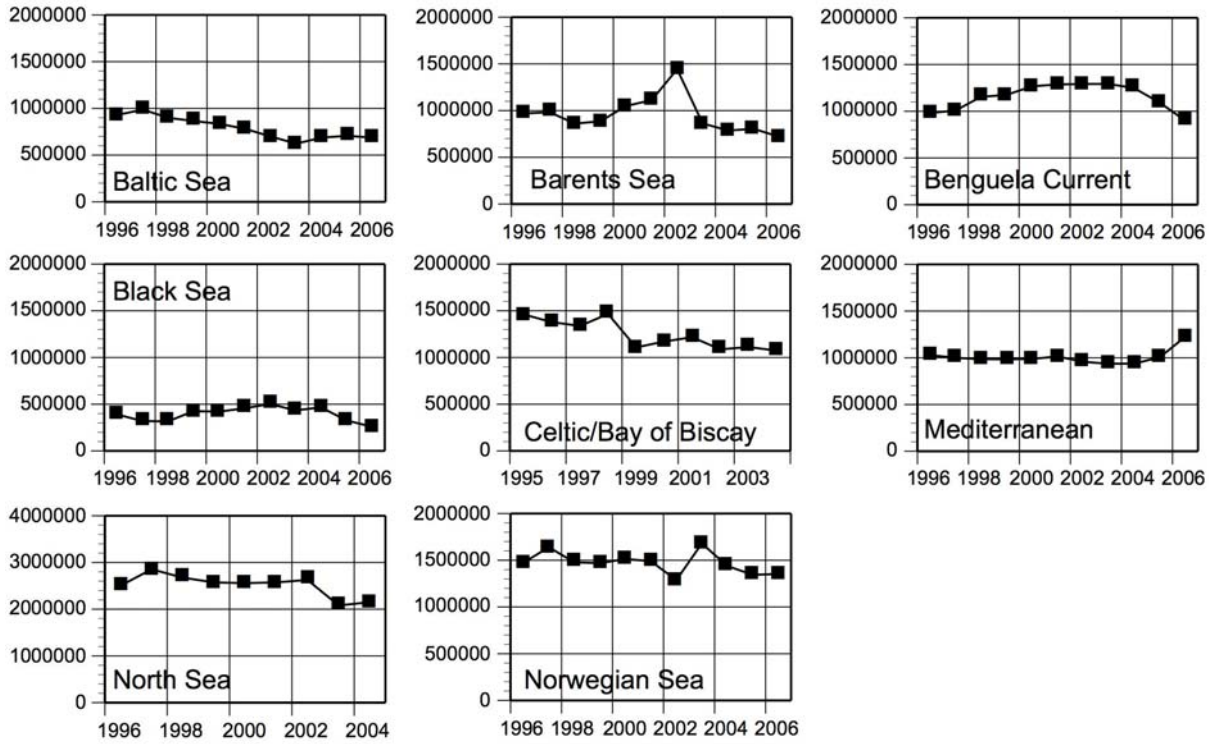


Figure 7: Production figures (tons) from the different MEECE geographical areas in the last published decade (1996-2006).

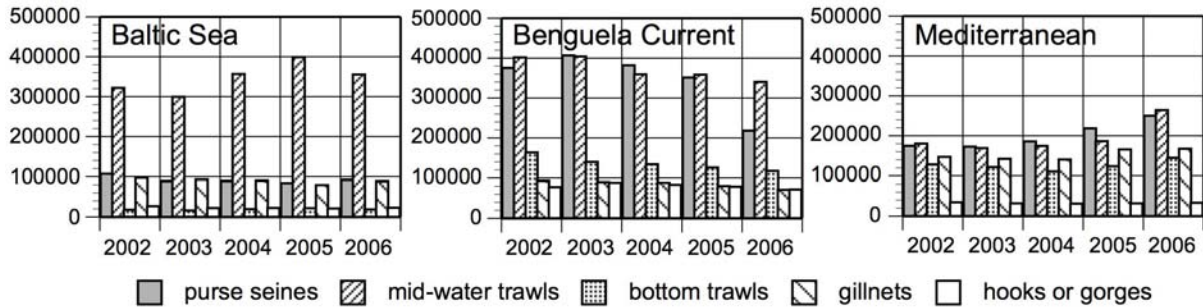


Figure 8: Production (tons) by different catching method for the 3 example areas 2002-2006.

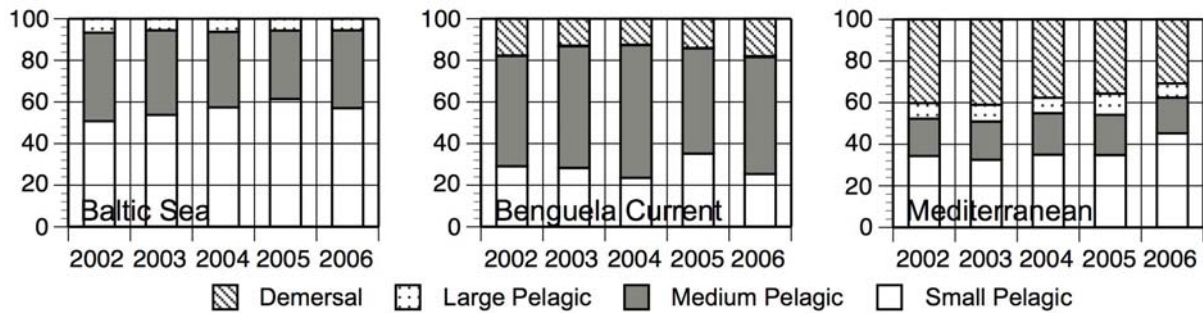


Figure 9: Percentage composition of production by major functional group for the 3 example areas 2002-2006.

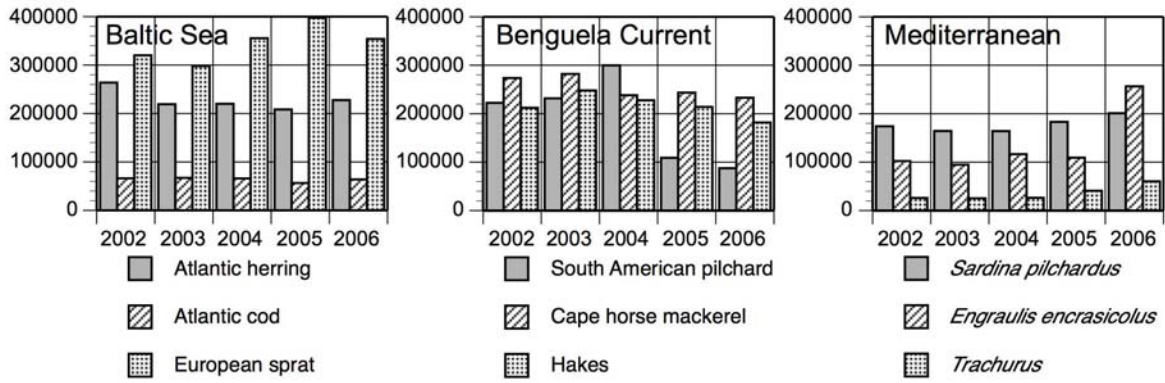


Figure 10: Production (tons) of the top 3 dominant species from the 3 example areas 2002-2006.

#### Validation Data for the Northern Aegean

Within the EU Mediterranean countries, each country is responsible for monitoring defined data and indicators through individual national data collection/monitoring efforts, reporting annually to the EU. Validation data concerning fishing in the Northern Aegean (WP3 and WP4 modelling) are available through the HCMR Greek National Fisheries database. The database includes; survey data, catch data, discards, etc, but as with the majority of Mediterranean countries it is very limited in formal stock assessment. It can be queried through many routes (species, gear, vessel size, sub-area, time-step, etc.) and is accessible through HCMR data centre.

The northern Aegean presents some of the most productive fishing grounds in Greece. During the period 2004-2008 there has been an overall decrease in the total number of vessels fishing (see Figure 11-15). This has been a result of the policy to reduce effort through reductions in licenses primarily through voluntary withdrawals using various incentive measures. Although effort, in terms of days fished, peaked in the middle of the last decade, it had shown an overall decrease by 2008, indicating that the management measures were succeeding. Effort as expressed as days at sea and Kw/GT has also followed this decrease.

When looking at the composition of the fleet, in terms of numbers it is dominated by coastal and artisanal vessels (approximately 95%) with the same pattern for the total number of days fished. When vessel power and tonnage are taken into account, otter trawlers and purse seiners make up a large proportion of the effort particularly when taking into account tonnage (GT) where effort is then almost equally shared (35-45%) between the coastal/artisanal and trawling fleet with the purse seiners having about 15%. In this category, artisanal effort has decreased over the decade with increasing seine and trawl share.

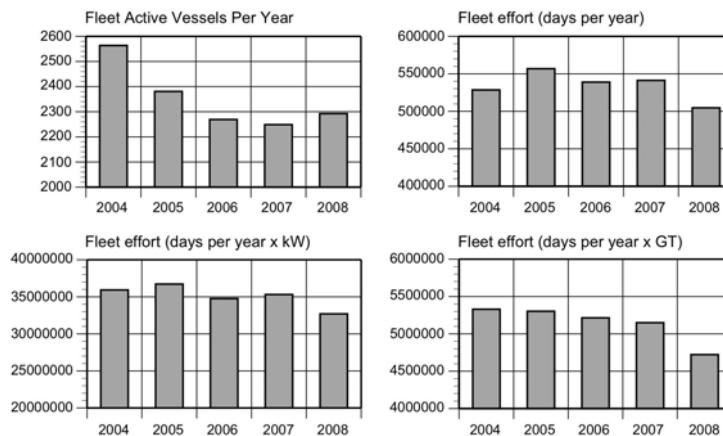


Figure 11. Total number of vessels and effort measures.

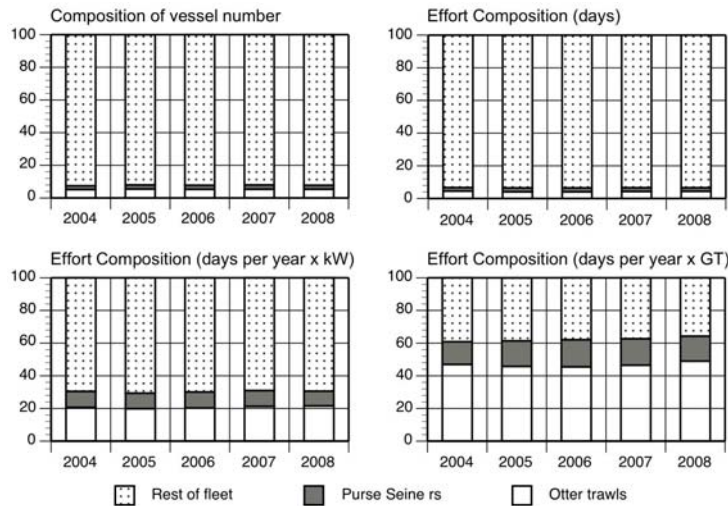


Figure 12. Composition of fleet vessels and effort.

Despite reductions in effort, total production in the northern Aegean has risen by approximately 20% in the past decade and is in the region of 50,000 tons. Although the catch composition from the artisanal and coastal sector has somewhat decreased this has been made up by an increase in the purse seine fleet targeting small pelagic fish and to a lesser extent trawling. Whilst a large number of species are landed in the northern Aegean it is notable that catches are dominated by a few species. Landings are dominated by the small pelagic species anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) which together make up approximately 40% of the total landings in the area and comprise 60-70% of the total purse seine landings. Most of the increase in northern Aegean production has been from a 50% increase in catch of the dominant species anchovy. This species has increased in terms of total catch composition from 20% in 2004 to 30% in 2008. Other dominant species including sardine, hake (*Merluccius merluccius*) and octopus (*Octopus vulgaris*) have shown various forms of decrease in production (with the largest decrease in hake, of approximately 50%), whilst the rose prawn (*Parapenaeus longirostris*) has indicated a small increase in the same period. Large pelagic fisheries are limited in the northern Aegean low catches of swordfish and tunas in comparison to the southern Aegean.

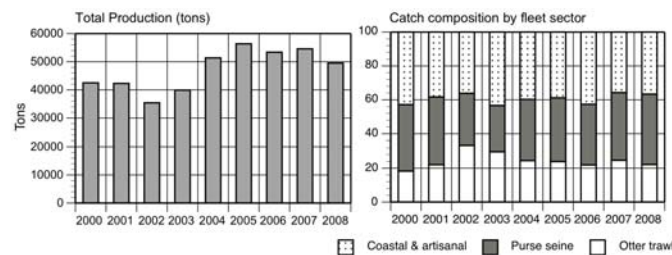


Figure 13. Total production and composition of production by fleet sector.

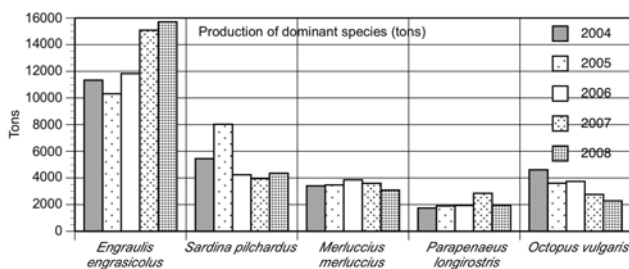


Figure 14. Production of dominant species.

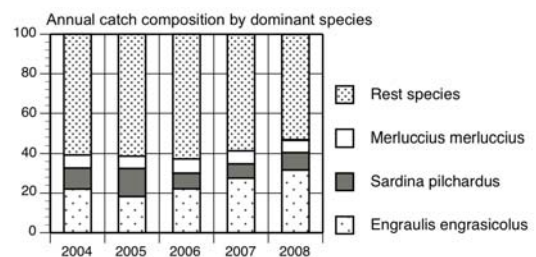


Figure 15. Composition of catch of dominant species.

#### 4. Plankton Data set for model validation

Plankton data have been regularly collected since 1958 from the Continuous Plankton Recorder (CPR) in different ecosystems investigated by MEECE (Fig. 16).

Monthly records of the following plankton variables are available between 1960 and 2007 for model validation:

1. Phytoplankton Colour Index (PCI), i.e. a proxy for phytoplankton standing stock;
2. Total phytoplankton abundance calculated as the total number of diatoms and dinoflagellates, two main phytoplankton functional groups that have been consistently counted throughout the years;
3. Biomass of zooplankton trophic functional groups (i.e. herbivorous, omnivorous and carnivorous) and
4. Abundance of the non-indigenous phytoplankton species *Odontella sinensis* and *Coscinodiscus wailesii*.

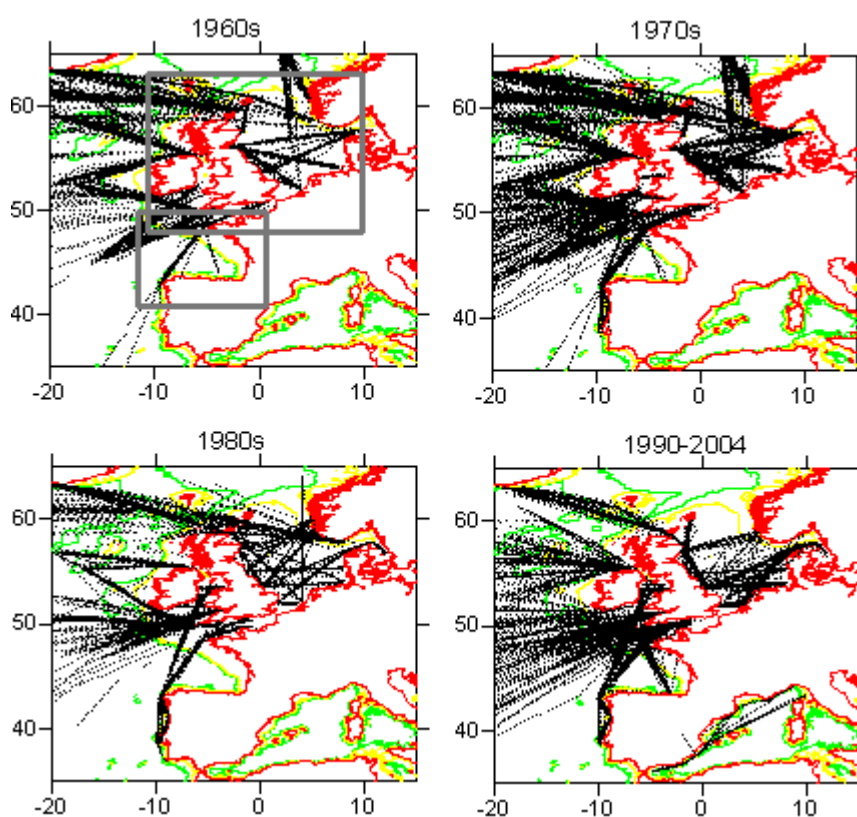


Figure 16. CPR routes along which plankton was monthly sampled since 1958. MEECE regions are indicated by the gray squares superimposed on the upper left panel.

Zooplankton biomass (dry weight,  $\text{mg m}^{-3}$ ) was derived for all the zooplankton taxa counted in CPR samples (Table 3). Dry weights were obtained for the total 173 zooplankton categories (108 species, 42 genera and 23 groups) multiplying the abundance of each taxon by the average dry weight per individual, which was obtained by direct measurements or calculated using dry weight taxa-specific weight-length regression equations. Zooplankton dry weight was then converted in Carbon using the conversion proposed by Mauchline, 1998.

Table 3. CPR major taxa used to calculate the biomass of different zooplankton functional groups. Dietary preferences (C= Carnivorous, H= Herbivorous, O= omnivorous) characterizing the different taxa counted within each group are also indicated.

	Diet
Siphonophora	C
Polychaeta larvae	H,C
Cirripidae larvae	H
Mollusca Pteropoda	H
Bivalvia	H
Bryozoa	H
Ostracoda	C
Cladocera	H
Copepoda	H,C,O
Mysidacea	O
Cumacea	O
Isopoda	O
Amphipoda	C
Euphausiacea larvae, post-larvae	H, C
Sergestidae larvae	C
Decapoda larvae	C
Echinodermata	H
Chaetognata	C
Larvacea	O
Thaliacea	H

The CPR data for model validation are available under request to MEECE participants according to the SAHFOS data policy requirements for the use of CPR data.

The data will be provided in the format and at the spatial resolution requested.

Please contact Priscilla Licandro (prli@sahfos.ac.uk) or David Johns (djoh@sahfos.ac.uk)

## 5. Invasive species

MEECE will apply the biopollution assessment method of Olenin et al, (2007) with invasive model validation performed for a single area in MEECE; namely the Baltic Sea. The method was used to assess the magnitude of impacts of the 33 alien species established in the Baltic Sea. According to the Baltic Sea Alien Species Database (<http://www.corpi.ku.lt/nemo>) there are 121 alien species registered in the Baltic Sea. 79 of them are established (sustain self-reproducing population), and 33 – are those with ecological impacts documented in the Baltic Sea (multicellular species only). The former were considered in the analysis. The information sources used for the analysis were 162 peer-reviewed papers (1992-2009) and ICES WGITMO Reports.

For the bioinvasion impact assessment procedure 9 assessment units were defined:

1. Baltic Proper
2. Kattegat and Belt Sea
3. Gulf of Bothnia
4. Gulf of Finland
5. Gulf of Riga

6. Curonian Lagoon
7. Vistula Lagoon
8. Odra Lagoon
9. Gulf of Gdansk and Puck Bay

Then the abundance and distribution range (ADR), impact on communities, habitats, ecosystem and overall biopollution level (BPL) of the each registered alien species was assessed.

For the BPL analysis only data with Medium or High confidence level (data from the corresponding assessment unit) were applied. If information on the species impact was not available, it was assumed that this impact level=0 (with medium confidence level).

The original dataset for the assessment is presented in CORPI\_alien\_sp\_T1\_4\_database.xls file (<http://www.meece.eu/secure/datasets/WP1.html>).

Analogically, the BPL for phytoplankton species *Prorocentrum minimum* was assessed for different Baltic subsystems, and different time periods. Dataset Prorocentrum\_BPL.xls (All datasets can be found at <http://www.meece.eu/secure/datasets/WP1.html>)

## References

Olenin S., Minchin D., Daunys D. (2007). Assessment of biopollution in aquatic ecosystems. Marine pollution bulletin, 55 (7-9), 2007, 379-394.

## 6. Satellite Plankton functional types

PHYSAT is a method that makes it possible to use ocean color signals (OCTS, SeaWiFS, MODIS sensors) to determine the dominant phytoplankton functional Types (PFTs) in the surface waters. Using PHYSAT 6 PFTs (i.e., Prochlorococcus, Synechococcus, nanoeucaryotes, phaeocystis, coccolithophorids, and diatoms) can be identified from SeaWiFS measurements (Alvain et al., 2005; 2008). Currently, this method is used to study global dominant phytoplankton distribution at seasonal (Alvain et al., 2008) and interannual scales (Masotti et al., 2009). However, several efforts have begun to use PHYSAT at the regional scale, by example during PFT-MED, and now in the MEECE project. A more detailed description of applications and a list of references can be obtained from the PHYSAT website (<http://log.univ-littoral.fr/Physat>).

### 6.1 PHYSAT datasets for MEECE regions

The standard PHYSAT datasets that are available for MEECE are organized into two time-series (1997-2007): one is covering all regional waters around Europe, and the other the Benguela upwelling region. Using standard SeaWiFS products we also produce time-series of Chlorophyll a (Chla) for the same regions (see examples in Figure 17).

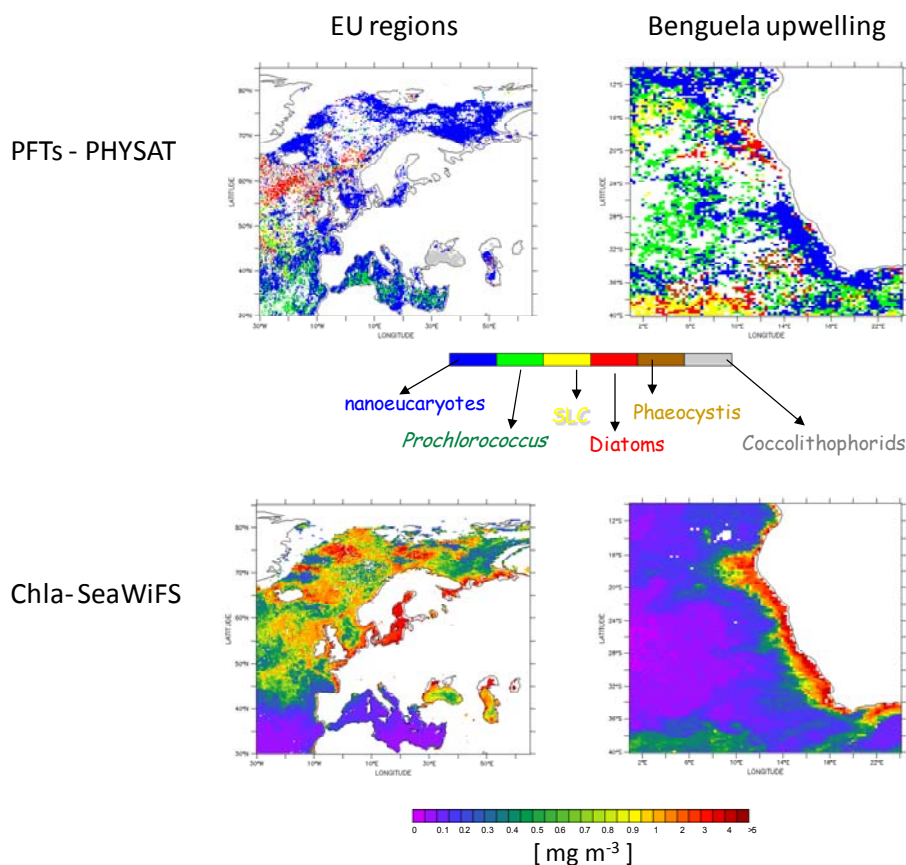


Figure 17. Examples of monthly PHYSAT (upper panel) and chlorophyll a (lower panel) datasets for the MEECE regions.

## 6.2 Datasets description

The standard PHYSAT database contains two time-series from SeaWiFS (from September 1997 to December 2007) of monthly composites distribution of the main PFTs (0.25 degree resolution). The first time series corresponds to all regional waters around Europe (30°W-65°E, 30°N-85°N, 381x221 pixels ) and the second the Benguela upwelling region (1°E-24°E, 40°S-10°S, 93x121 pixels). They are in NetCDF files. The values in the files corresponds to each PFT groups: Nanoeucaryotes = 1 , Prochlorococcus = 2, Synetochococcus = 3, Diatoms = 4, Phaeocystis = 5, and Coccolithophorids = 6. When no data is available or the PFT has not been detected the value is 0. Land areas have the value of -2. We also provide the corresponding Chla time-series; here when no data is available or in areas covered by land the value is 0.

Additional information and support can be provided by the originator of this document [Italo Masotti, [Italo.masotti@lscce.ipsl.fr](mailto:Italo.masotti@lscce.ipsl.fr)]. PFT-PHYSAT datasets are available at 0.25 ° and 9km resolution and could be downloaded from <http://dods.extra.cea.fr/data/p48maso/meece/>

## References

- Alvain, S., C. Moulin, Y. Dandonneau, and F. M. Bréon (2005). Remote sensing of phytoplankton groups in case 1 waters from global SeaWiFS imagery, *Deep Sea Res., Part I*, 52, 1989-2004.
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- Mauchline, J. (1998). The biology of Calanoids copepods. *Advances in Marine Biology*, 33, 1-710.
- Masotti et al., (2010). Large-scale shifts in phytoplankton groups in the Equatorial Pacific during ENSO cycles. *Biogeosciences Discuss.*, 7, 2523-2548, 2010.