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SCICOM STEERING GROUP ON SUSTAINABLE USE OF ECOSYSTEMS

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Report of the Working Group on the value of Coastal Habitats for Exploited Species (WGVHES)

17–21 June 2013

ICES Headquarters, Copenhagen

ICES International Council for the Exploration of the Sea
CIEM Conseil International pour l'Exploration de la Mer

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Contents

Participants in year 1 of the ICES Working Group on the value of Coastal Habitats for Exploited Species.

From left: Dave Eggleston, Karen van de Wolfshaar, Håkan Wennhage, Rochelle Seitz, Rom Lipcius, Rita Vasconcelos, Jaap van der Meer, Josianne Støttrup. (Photo edited in Photoshop).

Executive summary

This report summarizes the work of the 2013 ICES Working Group on the Value of Coastal Habitats for Exploited Species (WGVHES) held 17–21 June 2013 at ICES headquarters in Copenhagen, Denmark. There were 8 participants from five countries (Denmark, The Netherlands, Portugal, Sweden, USA); participants included scientific and technical experts with extensive experience dealing with fishery management and conservation issues.

The primary goal of this working group is to provide the foundation for integrating habitat value quantitatively in models of the population dynamics of exploited species, for which ICES gives management advice, as well as those species that are important in the foodweb of ICES species. The group is attempting to determine the relative value of coastal nursery habitats (e.g. seagrass beds, salt marshes, kelp beds, rocky bottom), feeding grounds, and spawning areas for the suite of species of interest to ICES by (i) documenting and evaluating case studies where the quantity and quality of coastal habitats can be linked directly to the population dynamics of exploited species; (ii) producing reviews that synthesize and critically evaluate the evidence of the importance of coastal habitats to exploited species; and (iii) establishing quantitative methods for determining how coastal habitats influence population abundance and fishery yield. We expect the findings will improve predictions of fishery yield, age class strength and long-term population status for species of commercial value, and to define key habitats for restoration efforts.

This first working group meeting consisted of a series of introductory talks by various participants, followed by working sessions of subgroups addressing specific ToRs. A suggested revision of the original ToRs and Work Plan, listed in Sections 2 and 3, was prepared and is described in Section 6. At the end of the meeting, a draft interim report was generated to be submitted to ICES.

The accomplishments of the workgroup and subgroups included:

i) For revised ToR a (*Produce a review paper that synthesizes and critically reviews the evidence for the importance of coastal habitats to exploited species and general patterns that may be applicable over a broad range of situations*) a subgroup revised a review, initiated in the 2012 Workshop, on the state of knowledge of quantitative assessments of habitat-specific demographic rates, and submitted it for publication in ICES Journal of Marine Science (JMS).

ii) For revised ToR b (*Produce a review paper on the characteristics and function of natural and anthropogenic hard bottom habitats for fish and invertebrates in coastal waters*) a subgroup initiated a comprehensive review of hard-bottom habitats and their effects on exploited species, to be completed in (2014).

iii) For revised ToR c (*Assess availability of coastal habitat maps and distribution for integration into demographic models*) initial contacts were made with the ICES Working Group for Marine Habitat Mapping (WGMHM) to assess the availability of quantitative maps of different habitat types, in preparation for integrating habitat quantitatively into the population models.

iv) For revised ToR d (*Quantify the importance of habitats for exploited species*) four subgroup activities were conducted including (1) initiation of a population model for plaice; (2) initiation of a Dynamic Energy Budget (DEB) model for prey of flatfish such as plaice; (3) initiation of a DEB

model and population model for oyster species including *Ostrea* and *Crassostrea* spp.; and (4) completion of a review of quantitative modelling approaches for integrating habitat quality into population models, which will be submitted for publication in ICES JMS.

1 Administrative details

WGVHES – Working Group on the Value of Coastal Habitats for Exploited Species

Year of Appointment – 2012

Reporting year within current cycle (1, 2 or 3) – 1

Chair(s)

Romuald N. Lipcius, USA

Håkan Wennhage, Sweden

Meeting venue

ICES Headquarters, Copenhagen, Denmark

Meeting dates

17–21 June 2013

2 Terms of Reference a) – z)

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Produce a review paper that synthesizes and critically reviews the evidence for the importance of coastal habitats to exploited species and general patterns that may be applicable over a broad range of situations	In the 2012 workshop three subgroups made a start with three reviews to be published late 2012. The general feeling was that these were not comprehensive enough due to the lack of time	131,132,134	1 year	Review paper in primary literature
b	Literature studies on quantitative data on fish and invertebrate demographic rates in habitats difficult to census	Focus literature studies on hard bottom habitat types (kelp forests, rocky shores and macroalgae) where many census techniques are inadequate to attain quantitative data on fish and invertebrates (both population and individual level data) demographic rates	131,132,134	2 years	Review paper in primary literature
c	Quantify coastal habitat availability	Quantify the availability of different habitat types (habitat quantity), specifically comprehensive habitat maps in cooperation with WGMHM	131,132,134	3 years	Coastal habitat maps for all important habitats
d	Quantify the importance of habitats for exploited species	Attaining quantitative esti-mates of the importance of habitats for species that are important for the ICES community by means of	131,132,134	3 years	Paper

	modelling

3 Summary of Work plan

Year 1	Review papers falling under a and b will be prepared and result in a draft version. In the meeting of 2013 ToR c and d will be started investigating what models will be used and species will be studied
Year 2	Focus on modelling work
Year 3	Finalize modelling work and identify future research priorities

4 List of Outcomes and Achievements of the WG in this delivery period

Papers

- Vasconcelos, R.P., Eggleston, D.B., Le Pape, O., Tulp, I. Patterns and processes of habitat-specific demographic variability in exploited marine species. Submitted to ICES Journal of Marine Science.
- Seitz, R., Wennhage, H., Berstrom, U., Lipcius, R., Ysebaert, T. Value of coastal habitats for exploited species: Coastal habitat use by commercially and ecologically important species. Submitted to ICES Journal of Marine Science.
- Lipcius, R., Eggleston, D.B., Fodrie, J., Moore, J., Schreiber, S.J., Van der Meer, J., Van de Wolfshaar, K.E., Vasconcelos, R. Populations models quantifying the value of coastal habitats for exploited species. In preparation for submission to ICES Journal of Marine Science.

Presentations at ICES ASC 2013

THEME SESSION: Quantitative value of coastal habitats for exploited species.

Organizers: Romuald Lipcius (USA), Ingrid Tulp (The Netherlands), Håkan Wennhage (Sweden)

- Rita P. Vasconcelos, Olivier Le Pape, Dave B. Eggleston, Håkan Wennhage, Ingrid Tulp. Quantitative assessment of the value of coastal habitats for exploited marine fish and invertebrates: a review
- Rochelle D. Seitz, Håkan Wennhage, Ulf Bergström, Romuald N. Lipcius, Tom Ysebaert. Coastal habitat use by commercially and ecologically important species
- Romuald N. Lipcius, David B. Eggleston, Joel Fodrie, Julia Moore, Sebastian J. Schreiber, Jaap van der Meer, Karen van de Wolfshaar, Rita Vasconcelos. Population models quantifying the value of coastal habitats for exploited species
- Nicholas Ducharme-Barth, Romuald N. Lipcius, Leah B. Shaw, Junping Shi. Habitat effects on population dynamics and fishery production of the eastern oyster

5 Progress report on ToRs and workplan

ToR a. Produce a review paper that synthesizes and critically reviews the evidence for the importance of coastal habitats to exploited species and general patterns that may be applicable over a broad range of situations

Participants: Rita Vasconcelos, David Eggleston, Olivier Le Pape, Ingrid Tulp

In the 2012 Workshop the participants initiated a critical review on the current state of knowledge of quantitative assessments of habitat-specific demographic rates. In the 2013 Working Group further work was done to improve the review and this was incorporated in the final version of the manuscript, which was submitted for publication to ICES Journal of Marine Science.

The current understanding of patterns of habitat-specific demographic variability of exploited species, as well as processes underlying these patterns, was reviewed. We described patterns of habitat-specific density and demographic rates (i.e. immigration, emigration, growth, reproduction, survival), such as ontogenetic changes in habitat use, which involves immigration to nursery habitats and emigration from settlement habitats, and growth and mortality in all habitats. We also described attempts to integrate habitat-specific demographic rates with population dynamics.

We found that, despite the stated importance of coastal habitats for fish and invertebrate species and the vulnerability of these habitats to human impacts, there was ambiguous evidence on their role in driving population dynamics (Figure 1). Roughly 65% of the studies were descriptive, 21% experimental, 11% used a combination of descriptive and experimental approaches, and only 5% used meta-analyses. Habitat-specific density was the most common pattern quantified, followed by growth and mortality, with relatively few examples of studies of habitat-specific larval settlement. There were numerous examples of the influence of coastal habitats on survival, growth and movement, especially at young stages, and there was an emerging focus on the effects of habitat degradation on demographic rates.

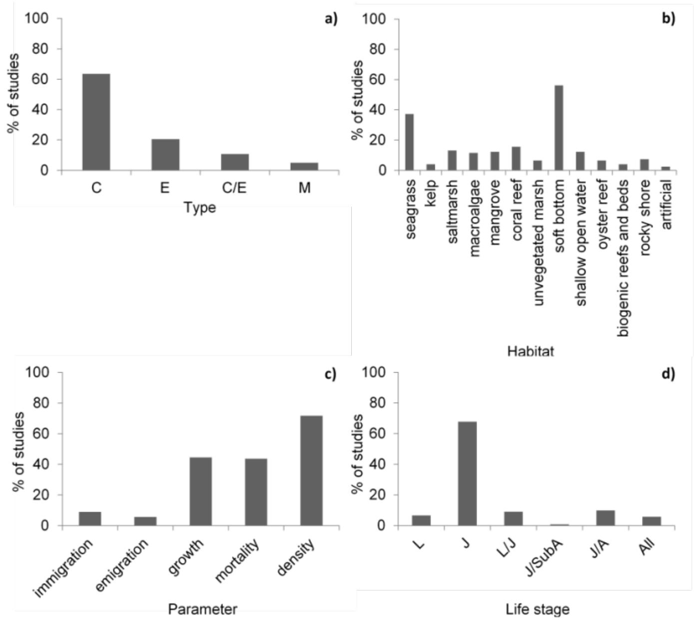

Figure 1. Proportion of selected publications (%) quantitatively estimating the value of coastal habitats for fish and invertebrate species according to: a) the type of approach (C – correlative, E – experimental, C/E – correlative and experimental, and M – meta-analysis or reviews), b) the habitats (seagrass, kelp, salt marsh, macroalgae, mangrove, coral reef, unvegetated marsh, soft bottom, shallow open water, oyster reef, other biogenic reefs and beds, rocky shore, and artificial), c) the parameters (immigration, emigration, growth, mortality, and density), and d) the life stages studied (L - larvae, J - juvenile, L/J - larvae and juvenile, J/SubA – juvenile and subadult, and A – adult) (n = 120).

There is a paucity of studies relating demographic effects to habitat condition experienced by fish, especially during the first post-settlement life stage, in coastal areas for marine species. Moreover, although studies determining habitat-specific vital rates were numerous for some species, they preferentially targeted some habitats (e.g. soft bottom, seagrass) and some parameters (e.g. density, growth) over others. As a result, only for some species do several vital rates seem to be available across several habitats, which greatly restricts our ability to predict the effects of varying habitat characteristics on population dynamics. Thus, obtaining data on habitat-specific demographic rates for various life-history stages should be a priority for fisheries ecologists, so that such data can be integrated in population dynamics models which, in turn, should facilitate disentangling the role of habitat use vs. other factors in driving population dynamics as well as predicting sustainable exploitation rates.

ToR b. Produce a review paper on the characteristics and function of natural and anthropogenic hard bottom habitats for fish and invertebrates in coastal waters

Participants: Josianne Støttrup, Rochelle Seitz

Rationale: Hard-bottom habitats are vital to the health and function of coastal ecosystems. These habitats provide nursery areas for juveniles and feeding grounds for adult fish of commercially important fish species. Recent reviews on the importance of coastal habitats for exploited species recognized that there is a lack of information on how fish utilize some habitat types in the North Atlantic, particularly complex hard-bottom habitats such as kelp forests, rocky shores, and macroalgae, where many census techniques are inadequate for quantitative studies (Vasconcelos *et al.*, in review; Seitz *et al.*, in review). Thus, additional information on fish and invertebrate use of these habitats can help promote awareness of the importance of these habitats, and a determination of gaps in knowledge can help direct future research. In Europe, reef habitats are biologically important habitats and are one of the few marine habitat types included in the EU Habitats Directive (1170 Reef Habitat; Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora). For this reason, reef areas are included in national Nature-2000 networks such as the Danish Nature2000 network. In the United States, the Environmental Protection Agency (US EPA) has the Environmental Monitoring and Assessment Program's National Coastal Assessment, which collects estuarine and coastal data from hundreds of stations along the coasts of the continental United States to evaluate the estuarine condition of US estuaries. Types of data include assessment of water quality, benthic communities, demersal fish, and tissue contaminants (http://www.epa.gov/emap/nca/html/data/index.html). In addition, each state has different management efforts for protection of hard-bottom habitats (e.g. North Carolina has the Coastal Habitat Protection Plan).

<u>Focus:</u> Given the lack of information on the characteristics and functions of hard-bottom habitats for fish and invertebrates in coastal waters, we will address our review on these habitats. We will concentrate on the North Atlantic, which is of particular interest to ICES countries and management. We will focus on natural habitats, and fill in information on anthropogenic reefs where information for natural reefs is lacking. There is an extensive literature on "artificial reefs" and we do not specifically include those reefs in our review, except where relevant. We will characterize the use of hard-bottom habitats by fish and invertebrates. Our objectives are to discern the importance of these habitats for exploited species and to direct future research.

<u>Definitions of hard-bottom habitats:</u> To define hard-bottom habitats, we will use several sources including the Habitats Directive (92/43/EEC), Marine Strategy Framework Directive (2008/56/EC), Water Framework Directive (2000/60/EC), a report of the ICES Working Group on Marine Habitat Mapping (ICES, 2010), a report from the ICES Workshop on the Value of Coastal Habitats for Exploited Species (ICES, 2012), and a recent scientific review (Airoldi and Beck, 2007). In the EUNIS Habitat Types, hard-bottom habitat is described under several subsections of Marine Habitats, including A1: Littoral rock and other hard bottom substrata and A3: Infralittoral rock and other hard bottom substrata. As such, these habitats include hard structures such as rocky shores (intertidal and subtidal rock, boulders, and cobble), some man-made structures constructed of hard substrata (e.g. subtidal structures associated with wind farms and wind turbines, riprap revetments), as well as hard habitats with macroalgae and kelp. We include macroalgae because they colonize coastal habitats, particularly shallow hard substrata such as rock, cobbles and artificial structures, from intertidal to subtidal habitats as deep as 30 m (Airoldi and Beck, 2007).

<u>Approach:</u> Our approach will be to use a comprehensive literature search.

<u>Organization:</u> We will use separate sections for each habitat, and the results for each section will include the species supported, structure, and function. The habitat sections will be as follows:

1) Rocky shores (including man made jetties) - intertidal
2) Subtidal – shallow stone reefs, high exposure and high light, with macroalgae
    a. Gravel bottom –
    b. Small stone reefs (flat or slope) without relief (including wind farms)
    c. Large stone reefs – cavernous reefs with high relief
    d. Other reefs – including bubble reefs

For each of these we will investigate the role of water depth (shallow vs. deep), light, temperature, and salinity.

Monitoring methods: We will include a critical review of monitoring methods used for sampling on hard-bottom habitats. These methods include trawls, baited fishing gear, video monitoring, and quadrat sampling, among others.

Focus: We will highlight the importance of habitats for the following functions:

1) biodiversity
2) fish production
3) invertebrate production
4) anthropogenic use (e.g. fishery, recreational)
5) secondary functions (e.g. coastal protection, water quality, services)

We will conclude with an assessment of the needs and knowledge gaps, including those for appropriate and effective monitoring methods. Other authors may be brought on board if they can add value to sections on various hard-bottom habitats.

ToR c. Assess availability of coastal habitat maps and distribution for integration into demographic models.

Current participant: Håkan Wennhage

Initial contacts have been made with the ICES Working Group on Marine Habitat Mapping (WGMHM), to assess the availability of maps of different habitat types (habitat quantity). The next step will be to compare and harmonize the habitat classifications used for habitat mapping with the habitat types needed for predictions from models relating commercial species to habitats. An inventory can then be made to assess the relevant habitat data available and its geographical coverage.

ToR d. Quantify the importance of habitats for exploited species

1. Demographic model for plaice

Current participants: Håkan Wennhage, Josianne Støttrup, Karen van de Wolfshaar

Participation of others will be sought, including members of WGBEAM and WGIPEM as well as other researchers responsible for survey data.

Both along the Dutch coast and in the Kattegat, trawl surveys aimed at monitoring juvenile flatfish abundance show a steep decrease of larger juveniles during the early 1990s, whereas the age 0 group do not show a corresponding change in density (Table 1). IMARES researchers have hypothesized that the larger juveniles leave the shallows for deeper areas due to warming temperatures (Teal *et al.*, 2012). In both areas, stocks assessments suggest that the plaice populations have increased over the last few years (ICES, 2013)

Table 1. Overview of changes of plaice occurrence in the North Sea (NS) and Kattegat (Ka).

		before	after	Survey	Contact
Ka	shallow	0, 1	0	Juvenile Survey Denmark	Josianne Stuttrup
	deep	2+	1+	IBTS	
NS	shallow	0,1,2	0	DFS	Loes Bolle
	deep	2+	1+	IBTS/DTS	

Given that the same phenomenon is occurring for the two plaice populations a case study is initiated by WGVHES. To this extent a) comparison will be done to investigate in more detail if the observations are indeed comparable and if a mechanism driving the changes can be identified, and b) a model exercise will be done to study the effects of large juveniles shifting from shallow to deeper habitat on population dynamics.

Data approach: Both the Dutch and the Danish have a juvenile flatfish survey and the IBTS covers plaice habitat in the Southern North Sea and in the Kattegat. Contact has been made with WGBEAM and in particular with the British participants as the UK also has time-series from a juvenile and a beam trawl survey. Inclusion of other geographical areas with plaice nurseries would be of great interest and will be pursued during the coming year of WGVHES.

Model approach: Observations in different regions show that plaice age 1 have become rare in shallow coastal areas, and recent publications show that more juveniles are present in deeper waters (Poos *et al.*, 2012; van Keeken *et al.*, 2007; Teal *et al.*, 2012) supporting the suggestion that age 1 plaice shifted to deeper waters. The movement from coastal habitat to deeper habitat by age 1 plaice implies that they shifted feeding areas. The consequence is that age 1 plaice no longer share resources with age 0 plaice that still inhabit the coastal zone, but now potentially compete with older plaice.

To study this effect of larger juveniles shifting habitat and thus shifting competition within the population, a biomass-based stage-structured model (De Roos *et al.*, 2008) was developed. Three stages are recognized and two resources (Figure 2). The small juveniles (S) only forage on the resource in the shallow area (Rs), whereas adults (A) only forage on the resource in the deeper area (Rd). Large juveniles (L) forage on both resources. Thus, the fraction (α) of large juveniles in shallow or deeper areas is varied.

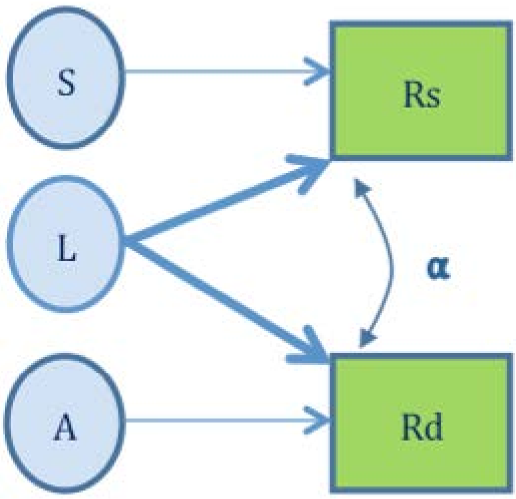

Figure 2. Model schematic. Small juveniles (S) have their resource in the shallow area (Rs), while adults (A) have their resource in the deep area (Rd). Large juveniles (L) change from feeding solely on the resource in the shallows (Rs) to feeding solely on the resource in the deep areas (Rd) by changing α.

In addition, carrying capacity of the two resources may differ (here illustrated by the fraction of a population's habitat consisting of nursery grounds). In the North Sea approximately 4% of the area is ≤ 10 m deep (ICES areas 4b and 4c), whereas in the Kattegat, 19% of the area is ≤ 10 m deep.

Parameter values for plaice were taken from Van de Wolfshaar *et al.* (2012). We assumed that the resource recovery rate is equal for shallow and deep areas for simplicity. Harvesting is not included in the results presented here, but may be included in future, as bycatch of large juveniles will increase when they are increasingly present in the deeper areas (Van Keeken *et al.*, 2007), which in turn affects resource competition and population dynamics.

Preliminary results: When large juveniles forage only on the resource in the shallow habitat, competing with small juveniles, most biomass is in the large juvenile stage and least biomass is in the adult stage (Figure 3). This is due to the fact that smaller individuals can sustain lower resource levels, making large juveniles weaker competitors in the shallow habitat. As they are resource limited, growth and maturation to the adult stage is hampered. When increasing the fraction of resource taken from the deeper habitat, thus increasing α, most biomass is in the adult stage. This is due to large juveniles competing less with small juveniles and more with adults, over which they have a competitive advantage. Large juveniles then grow faster and mature quicker to the adult stage. In terms of adult biomass, the disadvantage from increased resource competition is compensated by the increased maturation rate of large juveniles.

Increasing the ratio of shallow habitat productivity over deeper habitat productivity (Figure 3, top to bottom) increases the total population biomass. When the shallow habitat productivity is 40% of the total, an increase in adult biomass occurs when large juveniles forage equally in both habitats (α=0.5; Figure 3, bottom graph). At the same time, the biomass of small juveniles decreases because the increased resource competition in the deeper habitat has become so severe that adult's net energy intake is reduced, thereby limiting reproduction.

Implications: Note that differences in resource productivity of the shallow and the deeper habitats is not taken into account, but only the proportion of nursery habitat. If productivity estimates for shallow and deeper habitats are available this could improve the model. An attempt will be made to obtain values for benthic biomass from ERSEM. This would allow comparing the North Sea and Kattegat areas based on total productivity as well as on relative productivity of shallow and deeper habitats. To this extent contact with WG IPEM will be made to assess the availability of ERSEM results. $\gamma(\upsilon_i(R_i)) = (v_i(R_i) - \mu_i) / (1 - z^{(1-\mu_i/\upsilon_i(R_i))})$

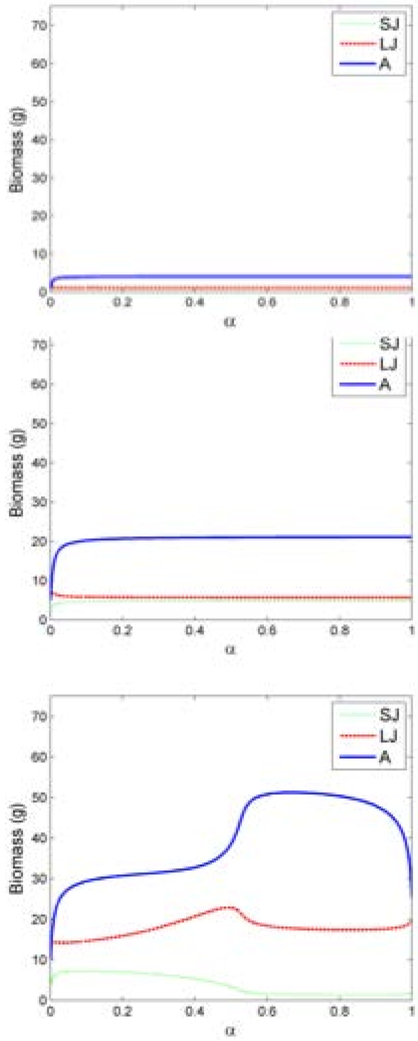

Figure 3. Bifurcation analysis of α. If α equals zero large juveniles forage only in the shallow habitat, whereas if α equals 1 they forage solely in the deeper habitat. Solid lines represent stable equilibria; hatched lines represent unstable equilibria. Maximum carrying capacity is set to 10. Top graph: shallow habitat productivity is 4% of the total; Middle graph: shallow habitat productivity is 20% of the total; Bottom graph: shallow habitat productivity is 40% of the total.

2. Dynamic Energy Budget model for prey of flatfish such as plaice

Current participants: Rochelle Seitz, Jaap van der Meer

The importance of coastal populations of the non-commercially fished Baltic tellin *Macoma balthica*, a small bivalve species as a major food source for the first age-classes of several commercially fished flatfish species especially plaice *Pleuronectes platessa*, and also dab *Limanda limanda* and flounder *Platichthys flesus* will be explored. The Wadden Sea has been identified as the most important juvenile habitat for plaice in the North Sea (Rijnsdorp *et al.*, 1984).

We aim to quantitatively assess the importance of this non-commercial prey species for commercial plaice by modelling the energy transferred between the two trophic levels. First, published estimates of overall consumption rates of these flatfish within coastal areas will be compared with published secondary production data of the bivalve species for the relevant size classes. Such a comparison has been made between

Baltic tellin and cockle *Cerastoderma edule* production and consumption by birds (Van der Meer *et al.*, 2001), and a modification of this model will be used here.

The modelling will require information on stomach content analyses that indicate what fraction of flatfish consumption consists of the Baltic tellin. Specifically, we will require data on: (i) Diet composition of plaice for various cohorts (0-group, I-group, II-group; De Vlas, 1979, 1985; Rijnsdorp and Vingerhoed, 2001); (ii) Intake rates of clams and siphons (Lockwood, 1984; Thijssen, 1974); and (iii) Secondary production (or mortality) of *Macom*a for Wadden Sea or north coast (Van der Meer *et al.*, 2001).

De Vlas (1979, 1985) studied in detail the consumption of 0, I and II year age-classes of plaice on the Balgzand, a tidal flat area in the western Wadden Sea. He noticed that a major part of the consumption consisted of body parts of the invertebrate fauna, such as bivalve siphons and polychaete tails. *Macoma* siphons were taken April through the beginning of July. The southern portion of the Wadden Sea is where most siphons were taken, as this is where *Macoma* densities are highest (200/m^2). Diet of I-group plaice consisted of 20% *Macoma* siphons in April (after which plaice shifted to other prey). De Vlas (1979) noted that "The stomachs of young plaice may contain tens to hundreds of siphon tips." Such body parts can be regenerated and this re-growth may contribute a considerable part of the secondary production of the benthos. Similar findings are reported for the North Sea, where for example arms of the brittle star *Amphiura filiformis* are an important food source for fish (Duineveld and Van Noort, 1986). In addition, diet composition of plaice has been similarly identified to include ~20% bivalves (Rijnsdorp and Vingerhoed, 2001) after about 13 cm fish size.

A Dynamic Energy Budget (DEB) model will be developed, which will incorporate regrowth of body parts. Such a model is an extension of the standard DEB model, which has already been applied to *Macoma balthica* (Van der Veer *et al.*, 2006). In the DEB model used for *Macoma* effects on birds (Van der Meer *et al.*, 2001), for each summer and winter between 1973 and 1998 estimates of the secondary production of *Macoma balthica* and *Cerastoderma edule* were obtained by the removal summation method. The production for those age-classes that were profitable as a food source for two shellfish eating birds, the oystercatcher *Haematopus ostralegus* and the knot *Calidris canutus*, were compared with the consumption by the bird populations. This consumption was estimated by multiplying the counted numbers of birds present with a literature based energy demand per individual bird. Results showed a weak relationship between annual production and consumption, pointing to unknown sources of mortality in high-production years (Figure 4).

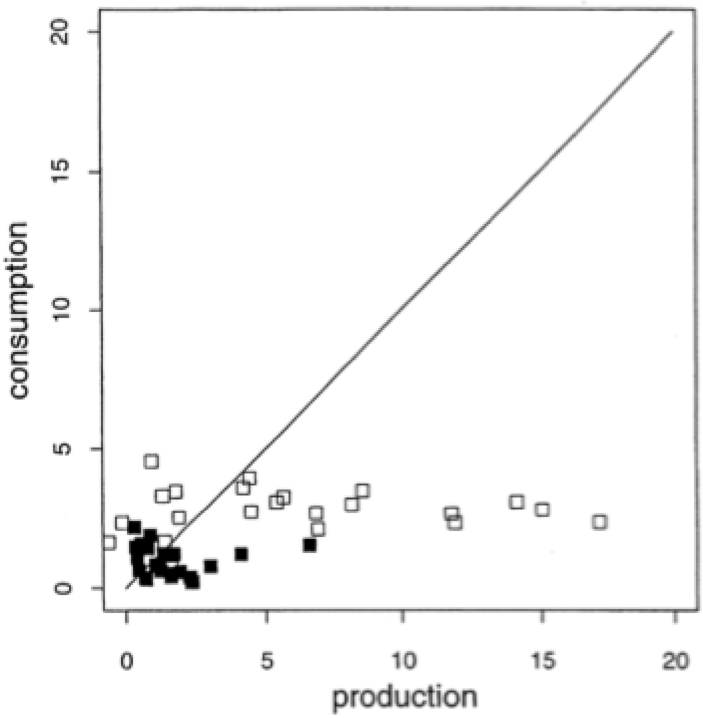

Figure 4. Winter consumption (g AFDM m^{-2}) as a function of winter consumption (g AFDM m^{-2}) of prey of suitable size for knots (filled squares) and oystercatchers (open squares). Each point refers to a winter from the period 1975/1976 to 1997/1998.

Before the next meeting of the ICES Working Group on the Value of Coastal Habitats for Exploited Species, work will be done to extend the standard DEB model. In addition, we will compile further data on the diet of plaice, and will explore the availability of data on diets of other commercially important flatfish that consume *Macoma*.

3. Dynamic Energy Budget (DEB) model and population model for oyster species including Ostrea and Crassostrea spp.

Current participants: Jaap van der Meer, Romuald Lipcius, David Eggleston, Rochelle Seitz

Three of the main biotic and environmental drivers expected to affect habitat suitability of fish and invertebrates in coastal habitats are water temperature, food availability, and dissolved oxygen levels. Water temperature has been increasing, dissolved oxygen levels have been depleted, and food availability has varied significantly, and these are expected to influence metabolic demands, growth and reproduction of fish and invertebrates. As examples of these effects we will model the influence of temperature, food availability and dissolved oxygen on two species of oysters, the European flat oyster *Ostrea edulis* and the eastern oyster *Crassostrea virginica*, using DEB models as described above. In addition, we will use an existing DEB model of the Pacific oyster *Crassostrea gigas*, an exotic species introduced to Europe, to assess the likelihood that these two species will co-occur in Europe's coastal habitats in future. We will also adapt an existing demographic model for the eastern oyster to assess the role of harvest-induced degradation on oyster reef habitats and populations.

4. Review of quantitative modelling approaches for integrating habitat quality into population models

Current participants: Romuald Lipcius, Jaap van der Meer, Karen van de Wolfshaar, Joel Fodrie, David Eggleston, Rita Vasconcelos, Julia Moore, Sebastian Schreiber

Many exploited marine and estuarine populations have experienced significant reductions in spawning-stock biomass and recruitment. For instance, in an assessment of global FAO marine fisheries data for 210 stocks, 27% were fully exploited, 25% were overexploited, and 16% had collapsed. Concurrently, essential habitats such as nursery and foraging grounds have been degraded in many areas such that these critical habitats are no longer adequate to fulfil nursery, feeding or reproductive functions (Airoldi and Beck, 2007). Although the influence of coastal habitats on specific rates of survival, growth, and reproduction of exploited marine species has been demonstrated widely (Beck *et al.*, 2001; Heck *et al.*, 2003; Minello *et al.*, 2003), the absolute value of these habitats to their population dynamics has rarely been quantified. Consequently, it has been difficult to estimate the optimal extent of habitat required for the persistence and sustainable use of exploited species, and therefore, to effectively manage habitat with respect to abundance of exploited species. In addition, recent research indicates that many species inhabit linked sets of primary (e.g. seagrass beds) and secondary (e.g. salt marsh fringed coves and shorelines) nurseries (e.g. Lipcius *et al.*, 2007). Yet there is little to no information on the relative value of these different nurseries to the population dynamics of exploited species, leading to the recognition that effective fishery management will require modelling the effects of habitat upon population dynamics. Thus, we sought to lay the foundation for determining the quantitative value of coastal nursery habitats, feeding grounds, and spawning areas for exploited species by defining suitable population modelling approaches that assess variation in population abundance and fishery yield as a function of habitat. In the 2012 Workshop on the Value of Coastal Habitats for Exploited Species (WKVHES), we began a comprehensive review of the different modelling approaches (statistical and mathematical) that would be useful for modelling the quantitative effects of habitat upon fisheries production and population dynamics. During the 2013 Working Group meeting of WGVHES, we continued the review and added habitat suitability modelling as a complementary tool for integrating habitat into population models. In the review we also describe the methods involved in each of the modelling approaches and provide examples of their implementation and utility to facilitate their use in ecosystem-based fishery management. We expect that such population models will improve predictions of fishery yield and long-term population status for species of commercial and recreational value, and reveal key habitats for restoration efforts. The review is being prepared as a manuscript for submission to the ICES JMS.

6 Revisions to the work plan and justification

Suggested ToRs for 2014–2015

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Produce a review paper that synthesizes and critically reviews the evidence for the importance of coastal habitats to exploited species and general patterns that may be applicable over a broad range of situations	In the 2012 workshop three subgroups made a start with three reviews to be submitted in 2013. This ToR reflects expansion and revision of the work begun by one subgroup at the 2012 workshop	131,132,134	1 year	Review paper in primary literature
b	Produce a review paper on the characteristics and function of natural and anthropogenic hard bottom habitats for fish and invertebrates in coastal waters	Focus literature studies on hard-bottom habitat types where many census techniques are inadequate to attain quantitative data on fish and invertebrates	131,132,134	2 years	Review paper in primary literature
c	Assess availability of coastal habitat maps and distribution for integration into demographic models	Communicate with WGMHM to assess the availability of maps for different habitat types (habitat quantity)	131,132,134	3 years	Recommended use of coastal habitat maps in population models
d	Quantify the importance of habitats for exploited species	Attaining quantitative estimates of the importance of habitats for representative species that are important for the ICES community by means of modelling	131,132,134	3 years	Paper(s)

Summary of the Work Plan

Year 1	Two review papers falling under ToR a will be revised and prepared for publication in ICES Journal of Marine Science (JMS). The remaining review under ToR d will be completed and prepared for submission to ICES JMS. In the meeting of 2013 ToR c and d will be started investigating what models will be used and species will be studied
Year 2	Focus on modelling work
Year 3	Finalize modelling work and identify future research priorities

7 Next meeting (Interim reports only)

Date and Venue for meeting in year 2 – Tentatively 23-27 June 2014 in Lisbon, Portugal

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