Assessment of cephalopods in European waters: state of the art and ways forward

ICES CM 2019/H:134

Graham J. Pierce[1,2], Jean-Paul Robin[3], Carlos Montero-Castaño[4], Christopher Barrett[5], Vladimir Laptikhovsky[5], Ángel F. González[1], Ana Moreno[6], Alberto Rocha[6], M. Begoña Santos[7], Julio Valeiras[7], Esther Abad[7], Catalina Perales-Raya[7], Ignacio Sobrino[7], Luis Silva[7], Marina Santurtun[8], Ane Iriondo[8], Fedor Lischenko[9], Jessica Jones[10], Daniel Oesterwind[11], Sebastian Villasante[12], Cristina Pita[2], Anne Marie Power[13], Louise Allcock[13], Lisa Hendrickson[14]

(1) IIM CSIC, Vigo, Spain, (2) Universidade de Aveiro, Portugal, (3) Université de Caen Caen, France, (4) Marine Stewardship Council, (5) Cefas, Lowestoft, UK, (6) IPMA, Lisbon, Portugal, (7) Instituto Español de Oceanografía, Spain, (8) AZTI, Sukarieta, Spain, (9) A.N. Severtsov Institute of Ecology and Evolution, Russia, (10) FIFD, Stanley, Falkland Islands, (11) Thuenen Institute, Rostock, Germany, (12) Universidad de Santiago de Compostela (Spain), (13) National University of Ireland, Galway, Ireland, (14) NMFS, Woods Hole, USA.

INTRODUCTION: Cephalopods in EU waters are caught in both large-scale (LSF) and small-scale (SSF) fisheries but this fishing is not covered by the Common Fisheries Policy. Cephalopods are attracting increasing interest from the fishing industry, markets and consumers, e.g. during periods of high abundance of cuttlefish ("black gold") in the English Channel. Integrated Ecosystem Assessment (IEA, Fig. 1) and Ecosystem-Based Management (EBM) consider stock assessment and fishery management in the context of the status of marine ecosystems and the services provided to society (e.g. an abundant supply of healthy food). Here we consider requirements, state of the art and future prospects for achieving sustainable cephalopod fishing under an IEA / EBM framework.

Scoping (goals, obstacles to achieving them)

GOALS: To ensure healthy cephalopod stocks in healthy ecosystems, providing services to society at optimum levels. Decisions about what this means (e.g. can we return to pristine oceans) require consensus between scientists, stakeholders, governments and the public.

THREATS: In EU waters, cephalopods stocks are data-poor. Cephalopod biology makes them unsuited to traditional stock assessment. Stocks are poorly defined and fishery monitoring is inadequate. Few catches are identified to species. There is no stock assessment and little management except in some SSF. At least in LSF, cephalopod fisheries have no effort or catch controls.

Monitoring the system and its management

GOALS: To collect sufficient information to annually assess stock status, the ecosystem and ecosystem services (ES), and to evaluate the effectiveness of management and the governance framework.

ISSUES: Monitoring EU cephalopod stocks requires **stock definition**, (at least) **monthly data collection** for annual assessments, **reliable species ID**, and reliable catch, effort and biological data by species and fishing area. SSF are difficult to monitor. IEA implies a substantial increase in data requirements (e.g. to assess ecosystems and ES).

SOLUTIONS: DNA barcoding offers a means to **identify cephalopods and assess species composition** and to determine error rates for results based on morphological ID. The Folmer COI gene fragment can reliably differentiate squid species (Fig. 2).

INTEGRATION OF MULTIPLE DATA SOURCES: Fishery and environmental monitoring will be supplemented by monitoring for economic and social metrics, also citizen science data, fisher knowledge, expert opinion and ecosystem model output.

MSE, management measures and governance

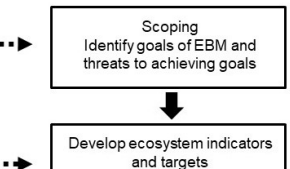
GOALS: To deliver (a) formal Management Strategy Evaluation which predicts impact of management on fisheries, marine ecosystems and society, (b) appropriate management measures and (c) appropriate governance arrangements (e.g. co-management, enforcement, regulatory framework), thus ensuring sustainable fisheries, healthy marine ecosystems and coastal communities, an adequate supply of healthy food, etc.

ISSUES: In the EU, MSE is still in its infancy; linking MSE to IEA is challenging, e.g. in terms of data needs and procedures to manage trade-offs between multiple objectives.

SOLUTIONS: **Management measures in cephalopod SSF and LSF** could include catch quotas, closed areas and seasons, deployed flexibly to account for variable abundance and to protect both spawners and new recruits. Market-based solutions (e.g. fishery certification or catch shares) can also promote sustainability.

In SSF for EU cephalopods, existing management is **regional and stakeholder-focused** and eschews formal stock assessment. While the system lacks the scientific rigour of assessment and management under the CFP, stakeholder buy-in allows it to achieve better compliance with management measures. Arguably, such a system is also well-placed to adopt **indicators, fisher knowledge and expert judgement** alongside analytical assessments and hence to embrace feasible implementation of IEA and EBM.

Acknowledgements: This poster is based on work undertaken under the auspices of ICES WGCEPH and the Cephs & Chefs project (EAPA_282/2016, Atlantic INTERREG) and has benefitted from discussions with members of both groups. Figure 1 is adapted from Levin et al. (2009), doi:10.1371/journal.pbio.1000014



Integrated Ecosystem Assessment

Figure 1

Defining indicators and targets

GOALS: To identify indicators of system status (for stocks, fisheries, ecosystems, social and economic benefits, etc.) and for performance of management and governance (e.g. compliance), which are specific, responsive, measurable, easily communicated, etc.; define targets and references points (at which management measures are triggered).

CURRENT SITUATION: Reference points for spawning stock biomass and fishing mortality are not defined for EU cephalopods. The **Marine Strategy Framework Directive** offers environmental and fishery indicators while the **Marine Stewardship Council's Fisheries Standard** uses indicators of fishery performance, environmental impacts and effectiveness of management. Once issues of scale (stock *v* fishery *v* ecosystem) are addressed, such approaches could be adapted to cephalopods (MSC certified an EU octopus fishery).

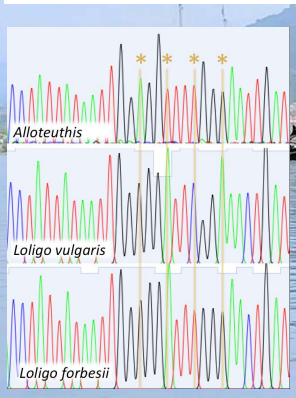


Figure 2. Electro-pherogram of a region of the COI gene, illustrating base-pair substitutions that differentiate loliginid species. Base pairs G, T, C, A are indicated in black, red, blue and green respectively.

Assessment/risk analysis for system components

GOALS: To assess status and risk of non-sustainable status for stocks, fisheries and the socio-ecological system.

ISSUES: Short and plastic life cycle, migrations and environmental sensitivity preclude using many assessment methods (e.g. cephalopods require a shorter time-scale than many finfish). Variable growth rates and extended spawning periods make length-based methods unsuitable. Wide inter-annual fluctuations in abundance are strongly influenced by environmental conditions; fixed reference points may be inappropriate. IEA requires assessment of multiple system components at different scales.

SOLUTIONS: Progress in **cephalopod age estimation** using daily growth increments in statoliths, beaks, etc., could permit identification of seasonal cohorts and age-based assessment.

Real time assessment using depletion methods (while expensive) is feasible if there is a well-defined recruitment period. **Production models with variable carrying capacity** environmentally driven) can provide retrospective assessment. Statistical **models with environmental predictors and recruitment survey indices** can provide useful forecasts.

For most IEA components, it is necessary to accept that analytical assessments are not always possible: assessments based on **indicators** and incorporating **stakeholder knowledge and expert opinion** must be used. Stakeholder-focused approaches can also improve credibility and compliance.

Integrated Assessment

GOALS: To integrate assessments of all system components (including cephalopod fisheries), undertaken at different spatial and temporal scales and responding to different EU Directives, into a coherent whole, supported by an understanding of the drivers of sustainability for each component.

ISSUES: There is currently no Integrated Assessment in European seas.

SOLUTIONS: The **Cephs & Chefs Project** is currently looking at ways to join stock, fishery, environmental, social and economic assessments to provide an overall assessment of sustainability for EU Atlantic cephalopod fisheries.