European Commission

JRC CONFERENCE AND WORKSHOP REPORT

Establishing thresholds: workshop on the MSFD Newly Introduced NIS (D2C1)

Online 24th November 2022

9.30-16.30 (CET time)

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2023



Joint Research Centre

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JRC132962

PDF ISBN 978-92-68-01260-4 doi:10.2760/631257 KJ-03-23-086-EN-N

Luxembourg: Publications Office of the European Union, 2023

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How to cite this report: Magliozzi C., Bartilotti C., Botelho A., Bugeja M., Canning- Clode J., Carbonell A., Carvalho Magalhaes M., Carvalho N., Castriota L., Comas R., Desplatovic B., Dragičević B., Ferreira N., Fortič A., Galanidi M., Gervasini E., Gittenberger A., Gizzi F., Gruszka P., Guerin L., Jensen F., Kolind R., Krasniewski W., Lehtiniemi M., Livi S., Van Houten N. M., Masse C., Ojaveer H., Olenin S., Orlando-Bonaca M., Ouerghi A., Pantea E., Patania A., Patterson K., Png-Gonzalez L., Ramzi Sghaier Y., Ruiz M., Skorupski J., Smolders S., Srebaliene G., Staehr P., Strake S., Tuaty-Guerra M., Vasiliades L., Vidjak O., Yahyaoui A., Živana Ninčević G., Žuljević A., Cardoso A.C, Workshop report, *Establishing thresholds: workshop on the MSFD Newly Introduced NIS (D2C1),* Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/631257, JRC132962

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Abstract

The Workshop on '*Establishing thresholds: workshop on the Marine Strategy Framework Directive (MSFD) Newly Introduced Non-Indigenous Species (NIS) (D2C1)*' took place online on the 24th November 2022, aiming at discussing and making progress towards establishing threshold values for the criterion D2C1. The workshop was organised by the Joint Research Centre (JRC), in collaboration with representatives of the Regional Sea Conventions (RSCs), under the MSFD Descriptor 2 Core Group, in the context of the MSFD Common Implementation Strategy Good Environmental Status Working Group. The participants to the workshop included academic and public authorities' experts on MSFD NIS, RSCs representatives, the European Environment Agency (EEA), and Commission services. The workshop enabled sharing information on the state-of-the-art approaches on monitoring and assessment of D2C1 within Regional Seas and on the application of the time series analysis as a follow-up to Tsiamis et al. (2021) recommendations for setting threshold values. The discussion focused on ensuring comparability of approaches, how to account for uncertainties, and on areas for improvement. It was acknowledged that activities of RSCs are instrumental in coordinating the science and management of marine NIS. The various levels of monitoring across the North-East Atlantic Ocean, the Mediterranean Sea, the Baltic Sea and the EU Countries explain different methodological approaches for setting thresholds, while the limited monitoring restrict the application of these methodologies in the Black Sea. The workshop identified four main areas for improvements: i) establishment of acknowledged baselines for NIS introductions, ii) make further progress in monitoring and analysis methods, iii) agree on thresholds for new NIS introductions and, iv) ensure coherence and consistency between national and regional reports. The JRC will seek for opportunities to discuss and advance on identified areas for improvement with the MSFD national appointed NIS experts The MSFD Descriptor 2 (D2) Core Group will contribute to the discussions.

Acknowledgements

We would like to thank all the workshop experts (Annex 4) for their participation and insightful contributions to the topic.

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1 Introduction

During the workshop held on 6-7 October 2020, the JRC in cooperation with Member States (MS) nominated experts proposed an approach for setting threshold values for the MSFD (Directive 2008/56/EC) criterion Newly Introduced NIS (D2C1) (Tsiamis et al., 2021a). This is based on a percentage reduction of new NIS introductions compared to an average number of the new NIS introductions in previous 6-years periods (Tsiamis et al., 2021a). The approach, however, is not yet operational and requires sharing of information on its application and discussions among MS experts on the methodology to define reference conditions, and eventually apply the percentage of reduction.

To this end, this workshop worked towards the identification of best practices and methods for assessing D2C1, focusing on the application of the percentage-reduction approach. The main challenges were the use of common baseline datasets of NIS and updates, testing a selection of methods for NIS that account for the specificities of Marine Regions. While baseline datasets of NIS exist (Tsiamis et al., 2021a, JRC Data Catalogue[1]), the quality of available information varies spatially and temporally across the EU based on monitoring efforts.

The workshop aimed at considering, debating and exploring threshold values for the D2C1 assessment, by focusing on available threshold approaches, and encouraging collaboration across Marine Regions.

Ultimately, the workshop aimed to reach a common understanding of the extent to which the current methods can be used to establish a threshold value, overcoming the gaps in common baseline datasets and methods.

To this purpose, the workshop convened appointed academic and public authorities' experts on the MSFD NIS across Europe, representatives of RSCs, the Directorate-General for Maritime Affairs and Fisheries (DG MARE) and the European Environment Agency (EEA).

2 Methodology of the workshop

Before the workshop, the JRC carried out desk-based research to apply a time series approach and percentage-reduction (Tsiamis et al., 2021a), at regional level, and to the refined baseline data gathered through collaboration with the MSFD national appointed NIS experts for the JRC workshop on 6-7 October 2020. A summary of the applied methods and outcomes of this analysis was sent to the invited participants (Annex 2) before the workshop. Additionally, a short questionnaire was sent to the invited participants, to collect information on the applied threshold approaches for the implementation of the D2C1 across marine regions, and inform the discussions in the breakout rooms.

The workshop was moderated by Dr. Ana Cristina Cardoso (A.C. Cardoso) and Dr. Chiara Magliozzi (C. Magliozzi) from the JRC of the European Commission. The breakout sessions were moderated by Dr. Peter A.U. Staehr (P.A.U. Staehr; Department of Ecoscience, Aarhus University), Dr. Maiju Lehtiniemi (M. Lehtiniemi; Marine Research Centre, Finnish Environment Institute), Dr. Sergej Olenin (S. Olenin; Klaipeda University) and Dr. Laurent Guerin (L. Guerin; The Patrimoine naturel- PatriNat joint unit).

2.1 Workshop presentations

2.1.1 Welcome messages

A.C. Cardoso kicked off the workshop and welcomed the participants. She referred to the objectives and mentioned that the workshop had its origins in the MSFD Common Implementation Strategy activities on assessment and determination of Good Environmental Status (GES) overseen by the Ecological Status Working Group. In this context, the D2 Core Group aims to contribute to the harmonised application of the MSFD D2 requirements at regional, subregional and national level (roadmap[2]; see also Vasilakopoulos et al., 2022). JRC suggested that the outcomes of the workshop would be considered in future Core Group initiatives. She also recalled that the workshop built on previous works, including the JRC's led workshop and research (e.g. Tsiamis

[1]https://data.jrc.ec.europa.eu/collection/id-00358
[2]https://circabc.europa.eu/ui/group/326ae5ac-0419-4167-83ca-e3c210534a69/library/9bef5837-83a4-4e98-ba5e-760f2e45ebdb/details

et al., 2019; Tsiamis et al, 2021a), and the updates of the ongoing assessments at regional scale in the context of the RSCs.

2.1.2 Context

A.C. Cardoso gave a presentation on the "Policy aspects of setting threshold values for D2C1". In her presentation she pointed out the requirements for setting threshold values from Article 4 of the Commission Decision (EU) 2017/848 and the Assessment Guidance under Article 8 of the MSFD (European Commission, 2022). She also clarified the role of the Core Group in support of the MSFD assessment for D2 as contained in the roadmap.

2.1.3 Keynote presentations

M. Lehtiniemi, Marine Research Centre, Finnish Environment Institute, gave a presentation on the topic "Setting threshold for HELCOM NIS indicator". She provided details on the Helsinki Commission (HELCOM) indicator "Trends in arrival of new Non-Indigenous Species" which goal is to reduce anthropogenic introductions of NIS to zero. The threshold value between good and not-good status is 'no new introductions of NIS per assessment unit through human activities during a six-year assessment period'. In addition there is a mid-term goal to consider a decrease in the rate of new introductions. The indicator focuses on human-mediated introductions and not natural (most secondary introductions) spread and uses a baseline list of species to compare the new introductions over a six-year period. NIS records are reported to the AquaNIS database by country experts. Due to insufficient data availability, the indicator results are evaluated at the whole Baltic Sea scale. Finally, M. Lehtiniemi recalled about a joint group of experts between HELCOM and Oslo and Paris conventions (OSPAR) established in 2021: the Joint OSPAR/HELCOM Expert Group on NIS (JEG NIS).

A discussion on the need to align assessments across spatial scales followed the presentation, and on how MS could use the assessment results of the HELCOM indicator for the Art 8 assessment, since MS should assess and report NIS at the scale of national waters within a marine (sub)region (European Commission 2022).

Elena D. Pantea (E.D. Pantea), National Institute for Marine Research and Development "Grigore Antipa", Constanta, Romania, talked about "D2 Non-Indigenous Species: current state of descriptor assessment at regional level in the Black Sea (Romania and Bulgaria)". She pointed out that there is not a specific monitoring strategy for NIS in Romania and Bulgaria, and thus NIS are recorded from samples collected in the national monitoring programme with focus on zooplankton and zoobenthos. This programme consists of scientific cruises conducted 2 times/year. Due to the limited availability of data, no threshold values can be set for D2C1, while for D2C2 and D2C3 criteria, the values have been set with reference to a specific invasive NIS, i.e., *Mnemiopsis leidyi*.

Following the presentation, participants reflected on the need of data for the evaluations in the Black Sea.

P.A.U. Staehr, Aarhus University, Denmark, presented "QSR 2023: Trends in New Records of Non-Indigenous Species (NIS) Introduced by Human Activities". He provided an overview of the OSPAR indicator 'NIS Trend Indicator' for the quality status record (QSR) 2023, highlighting regional differences across the three OSPAR regions and the three periods of the assessment (2003-2020, 2009-2014, 2015-2020). The assessment indicates an overall reduction in the rate of introduction (trend) for the OSPAR regions, which suggests that the pressure from new NIS arrivals on the marine biodiversity state is decreasing. Despite the decreasing trends, several new NIS were introduced in each OSPAR Region during the latest assessment period. This shows that continued effort is required to reduce and prevent new NIS introductions. It should also be noted that there is substantial uncertainty around whether the observed decline is due to an actual reduction in introductions, a change in the monitoring effort, or to a time lag between new NIS records and their publication, which was not possible to account for. It was discussed whether the decline observed between 2015 and 2020 in the OSPAR analyses could be linked to the mentioned publication time lag. A protocol or guideline on how to deal with this delay, must be developed when setting D2 thresholds based on the number of new species recorded in the assessment periods.

Participants reflected on the inclusion of secondary pathways in the calculation of the indicator, and the need to focus on species whose pathways can be managed and controlled. Also, the differences across OSPAR subregions can be due to the adoption of different control measures but this has not been analysed yet and could be associated to monitoring issues.

Marika Galanidi (M. Galanidi) on behalf of the Specially Protected Areas Regional Activity Centre (SPA-RAC) presented "Current methodologies for setting threshold values for Ecological Objective 2 (EO2) under the

Barcelona Convention". She provided detailed information on progress achieved with the Common indicator CI6 'Trends in abundance, temporal occurrence, and spatial distribution of NIS, particularly invasive NIS, notably in risk areas and the results of a trend analysis across the Mediterranean subregions. The outcomes point out that: i) thresholds should be established separately for each of the Mediterranean subregions and should be sought by examining the data of the last two decades, ii) NIS introduction rates have been relatively stable in the Western Mediterranean and the Adriatic in the past 20 years, exhibiting a slight increase in the Eastern Mediterranean (but with a much higher absolute value) and have considerably increased in the Central Mediterranean, iii) a consensus needs to be reached about which species groups will be included in the calculations and how their environmental impact will be taken into account. These outcomes should provide guidance on pathways to be considered in the assessment, i.e., if to include only primary pathways, and if to and if to exclude unaided range-expanding species. Finally, she stated that current work is considering the contribution of regional experts for a validated list of NIS and their pathways of introduction in the Mediterranean countries (national and regional inventories). She also highlighted the current lack of a homogeneous monitoring strategy across the basin and that additional efforts are planned under the Integrated Monitoring and Assessment Programme (IMAP).

A discussion clarified the undergoing revision of the Mediterranean baseline. This data at subregional scale will be available through the Marine Mediterranean IAS (MAMIAS).

2.1.4 Previous work and results of the questionnaire

A.C. Cardoso summarized previous outcomes of JRC work on the MS' reports on D2 (Arts. 8, 9, 10, Tsiamis et al., 2021b) and on threshold values (Tsiamis et al 2021a). In her presentation, she highlighted that there were large gaps in using threshold values for the D2C1 criterion, particularly for the Mediterranean and North-East Atlantic MS. Baltic Sea MS reported the use of the HELCOM indicator although with inconsistencies in its use (e.g., reporting national threshold and regional threshold). Additionally, new NIS were under-reported (i.e. several new NIS published in literature and on online databases were not included in the MS reports, Tsiamis et al., 2021b) for 15 MS. A.C. Cardoso, also reminded about the recommendations on taxonomy, assessment areas and scales, and methods for adoption of a threshold value supported by the NIS experts gathered at the JRC threshold workshop held in 2020.

C. Magliozzi summarised the questionnaire (Annex 3) results. The questionnaire was addressed to workshop participants. 23 people across all marine regions answered. The majority uses or is planning to follow the approach proposed by Tsiamis et al. (2021a) for the next assessment of D2C1, while others indicated the OSPAR NIS3[3] and IMAP Common Indicator 6[4]. About the best scenario of reduction in the number of NIS, a pathway-based approach was indicated as the likeliest for threshold evaluation.

2.1.5 Examples of threshold approaches application

P.A.U. Staehr**,** presented a case study on "Testing the D2C1 GES indicator for non-indigenous marine species with long-term data from Danish Seas". He applied the approach suggested in Tsiamis et al. (2021a) to long term trends of NIS records in Denmark. Results show that trends in the accumulated number of NIS records appear to be exponential, but with marked differences before and after onset of regular monitoring. The rate in the reference period, defined for 1980-2002, is significantly higher compared to the annual mean rate prior to 1980. GES is not achieved when looking at the trends in the relative difference (% change) of NIS introduction rate, by comparing to the reference level, and applying a threshold of 50% reduction. This is so, despite a reduction of NIS introductions in the last three assessment periods (2003-2020).

A few open questions were addressed to the participants for discussion:

- How to account for differences in sampling effort and reporting time lags?
- Should separate baselines and GES threshold values be established for different taxonomic groups having into consideration the related importance of pathways?

[3] https://www.ospar.org/documents?v=38992
[4] https://www.medqsr.org/common-indicator-6-trends-abundance-temporal-occurrence-and-spatial-distribution-non-indigenous

- How to separate causes linked to increasing new NIS records? i.e. increased monitoring effort (spatial coverage and frequency of sampling), the tremendous increase in human activities (e.g., shipping), raising the likelihood of new NIS introduction, along with differences in environmental conditions.

Afterwards, Mr. Staehr clarified that for this preliminary analysis all introduction types (primary and secondary) and organism groups (e.g., phytoplankton, cryptogenic) were included.

C. Magliozzi presented a "Time series analysis as a follow-up step to Tsiamis et al. (2021a): data-driven". She presented an approach that aims at identifying changes in the NIS time series to determine reference periods and values for discussing GES scenarios as a follow-up step to Tsiamis et al. (2021a). The methodology makes use of the data reviewed by the experts in occasion of the JRC workshop 2020 and openly available as annexes to the Tsiamis et al. (2021a) publication, and updates thereafter available through the JRC Data Catalogue[1]. The approach builds upon the consensus found at the workshop on the main guidelines to define threshold values for D2C1. The time series analysis was summarized in four steps: data cleaning, analysis of rate of introduction, breakpoint analysis and GES scenarios.

A few open questions were addressed to the participants for discussion:

- Do you agree with the geographical unit of the analysis?
- Do you agree with time period of the analysis: aggregation or not of time periods?
- Could the reference value be the threshold value?
- Considering the pathways of introduction, how can they be used to adjust the threshold value?

A discussion followed on the pathways to be accounted for in the analysis. The fact that many pathways are assigned to a species indicates that confidence levels need to be considered for decision on species vs pathways to include in the analysis. Also, in the Mediterranean Sea the breakpoint analysis has shown significant differences at sub regional level to be considered, and, moreover, sensitivity of the method to the aggregation level of the data, i.e., different breakpoints may be calculated when using yearly averaged vs 3-year averaged data and when excluding some species groups from the analysis. A good way forward would be a comparison exercise for selecting the best aggregation of years and species. Finally, there was a comment about the comparability of a threshold of new NIS introductions per assessment period using the time series analysis with the zero new introductions in the Baltic Sea.

There was an additional presentation by P.A.U. Staehr on "Application of eDNA for NIS monitoring – preliminary results and recommendations". He summarized the pros and cons of new methodologies to detect NIS and case studies in Denmark.

2.2 Workshop breakout sessions

These breakout sessions aimed at discussing, exploring and listing ideas for setting the threshold value(s) for D2C1 based on methodologies presented. Towards this aim, the participants were asked to address i) advantages and disadvantages of each methodology, ii) approaches on geographic units, assessment period, how to use the reference period, if and how to use pathway information, and iii) how to ensure comparability of threshold values.

<u>Consider operational advantages and disadvantages of each methodology presented/ in development. What is the uncertainty associated with them?</u>

- Zero introductions (HELCOM approach):

The zero introductions threshold may be considered idealistic in terms of practical achievement and rather reflects a long-term objective. It may also act as a disadvantage by potentially discouraging short-term monitoring, particularly in areas of regular new NIS introductions (e.g., via Suez Canal). Additionally, the uncertainty on pathways makes it difficult to focus only on primary introductions.

The adoption of a zero introductions threshold could be considered in controlled areas such as Marine Protected Areas (MPAs), and regarding some types of pathways and relevant control measures. Also, the need of being ambitious and follow the precautionary principle was expressed.

- Time series analysis (OSPAR approach, MED, JRC):

Trend analysis may be a realistic approach but very sensitive to underpinning data. NIS data are biased in terms of monitoring efforts and therefore require to be related to the underpinning monitoring at local, national

and regional scale. Long time series are key for the analysis. Not only species records but also population status, distribution, and abundance dynamics (e.g., dispersal information) should be used to evaluate the number of new NIS introductions. This is necessary to account for the links to anthropogenic pressures (activities, vectors, pathways) and climate/environmental parameters changes.

GEOGRAPHICAL UNIT: Do you agree with the study area considered in the analysis? If no, why?

Application of nested scales (e.g., EU, regional sea, sub-unit of a given regional sea, country, sub-national level) to the analysis, to examine NIS and occurring vectors/pathways together is recommended. The regional scale is important, however, it is very difficult to decide for a single threshold value for all the region due to subregional differences. Therefore, the analysis at subregional scale should be preferred.

ASSESSMENT PERIOD: Do you agree with the time period of the analysis? Would you aggregate the data (multiple years) instead?

It is recommended to run the time series analysis at 1 year resolution to have statistical robustness to compute the breakpoint and assuming that the effort of data collection is constant across years. The number of new NIS introductions in the most recent year might be biased due to reporting delays and therefore should not be considered in a time series analysis or only be considered after an appropriate correction (Zenetos et al., 2019) has been applied.

THRESHOLD: Considering the outcomes of the break point analysis (Annex 2):

- In case of more than one reference value[5], which one would you consider for calculating the threshold value? (see Figures in Annex 2).
- Would you apply the percentage of reduction to the chosen reference value (as in the worked example in Tsiamis et al., 2021a) or would you use the reference value as the threshold?

Bilateral discussions will take place within the MSFD Expert Network to advance on these questions.

PATHWAYS: Considering the pathways of introductions, can we derive a threshold value based on the assessment data? Can it be adjusted with the reference value? Do you know any new techniques to refine detection of species considering different pathways? How to account for new methodologies that would increase the probability of species detection?

Introduction pathways should be linked with measures as this is the missing link to inform and evaluate NIS trends and thresholds. The assignment of pathways to species introduction often relies on expert judgement only, and for this reason, it is characterised by a certain degree of uncertainty. A way to move towards a data-driven assignment of pathways could be modelling the intensity of pathways at regional scale (e.g., intensity of shipping), and consider pathways jointly with monitoring effort, for example, by specifying the number of sampling sites, areas sampled, ports and marinas, methods, taxonomical expertise, etc. This would allow experts to set a percentage of reduction of new introductions by pathway. Finally, a selection of conventional methods and molecular techniques is required to increase the probability of species detection.

How could comparability of threshold values be ensured? What are the actions that need to be ensured to minimize the introductions? Could common targets be defined?

Comparability may be achieved by either setting thresholds excluding, e.g., unaided species and considering confidence levels for pathway assignment or by setting comparable reduction percentages for GES. It also requires harmonised monitoring efforts.

Minimizing introductions requires mitigation efforts to be adopted across Europe. Measures should consider the distinction between intentional and unintentional introductions and monitoring should include hot spots areas of introduction, to inform quick response measures.

[5] Reference value: a value obtained by the breakpoint analysis that define one or more reference period, i.e. a segment of time with coherent and stable statistical properties.

The work carried out under the Maritime Spatial Planning directive on "super-indicators or super-integration methods" (Directive 2014/89/EU) should be used to guide measures on activities/pressures on biodiversity and sources/impacts of NIS.

It was highlighted that it is important to have clear guidelines for the D2C1 assessment, taking into consideration specificities of each marine region (e.g., environmental, human pressures). These guidelines will be discussed for development in collaboration with the MSFD NIS Expert Network.

3 Remaining questions related to setting threshold values for D2C1

3.1 Baseline

- How to consider current monitoring issues in the baseline (e.g., sampling methods, monitoring frequency, geographic coverage, time lags)? At what scale (marine region, sub-region, MS, marine reporting unit) is it possible to retrieve information on the monitoring effort?
- Shall separate baselines be defined for different taxonomic groups?
- Shall the baseline include also non-EU countries?
- Given the overlap between the EU reporting in the period 2012-2017 (reported in 2018) and 2016-2021 (to be reported in 2024), what will be the data to be used in the next assessment (2024) by the MS?

3.2 Methods of analysis

- Shall only primary introductions be considered for the time series analysis?
- Shall only species with assigned pathways be considered for the time series analysis?
- Shall different timeframes be used in the time series analysis according to the marine region?
-

3.3 Threshold value

- Would you apply the percentage of reduction to the chosen reference value (as in the worked example in Tsiamis et al., 2021a) or would you use the reference value as the threshold?
- Could the zero new introductions be a common (across regions) threshold value?
- Could pathways be used to adjust the reference value to set the threshold values?
- How to adjust the reference value considering the monitoring efforts?
- Shall different threshold apply to different taxonomic groups?

3.4 Harmonisation of assessments

- How could MS use the RSCs indicators results for Art 8 assessment and reporting? It is expected that MSs assess NIS in the national part of the RSCs assessment.

4 Conclusions

The workshop identified four main areas for improvement: i) identifying baselines for NIS introductions, ii) making further progress in monitoring and analysis methods, iii) agreeing thresholds for new NIS introductions and, iv) ensuring coherence and consistency between national and regional reports.

To follow these issues up, the JRC will seek for opportunities to discuss and advance on identified areas for improvement with the MSFD national appointed NIS experts. The MSFD Descriptor 2 (D2) Core Group will contribute to the discussions.

The results of the workshop will be reported to the MSFD GES Working Group on 18-19 April 2023.

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List of abbreviations and definitions

DG MARE	Directorate-General for Maritime Affairs and Fisheries
EEA	European Environment Agency
HELCOM	Helsinki Commission (Baltic Marine Environment Protection Commission)
GES	Good Environmental Status
MS	Member States
MSFD	Marine Strategy Framework Directive
NIS	Non-Indigenous Species
OSPAR	Oslo and Paris conventions (for the Protection of the Marine Environment of the North- East
SPA-RAC	Specially Protected Areas Regional Activity Centre
JRC	Joint Research Centre

Annexes

Annex 1. Agenda

Establishing thresholds: workshop on the MSFD Newly Introduced NIS (D2C1)
Microsoft Teams, 24th November 2022
9.30-16.30 (CEST time)
09:15- 09:30 **Connecting to the meeting**
09:30- 09:35 **Welcome participants – housekeeping (JRC)**
09:35- 09:40 **WS Objective and Agenda (JRC)**

The workshop, organised in the context of the Marine Strategy Framework Directive (MSFD) Common Implementation Strategy (CIS) Good Environmental Status (GES) Working Group, aims at discussing threshold values for the criterion D2C1- Newly Introduced Non-Indigenous Species (NIS), constituting the specific output of the MSFD EU Core group in 2022 (GES_26-2022-09 D2 Core Group Roadmap[2]).
The workshop will gather the MSFD NIS (MSFD descriptor 2, D2) expert network, the Regional Sea Convention's representatives for D2, the EEA, and the JRC at an online venue for discussing the application of the approach for setting threshold values for the criterion D2C1 reported in Tsiamis et al. (2021a) on the baseline datasets of NIS, and other approaches.
Starting from the application of the percentage-reduction approach of Tsiamis et al. (2021a) at national and regional/subregional level, we will work towards the identification of best practices and methods for assessing D2C1.
The workshop will contribute to overcoming two key limitations in setting threshold values for the assessment of NIS (also discussed while drafting the Art. 8 guidance (European Commission, 2022): i) use of common baseline datasets of NIS and updates, and ii) testing a selection of methods for NIS that account for the specificities of Marine Regions.
Based on the workshop outcome the JRC will coordinate the drafting of a discussion paper to the MSFD GES Working Group with proposals for threshold values.

09:40- 09:50 Policy aspects of setting threshold values and overview for D2C1 (JRC).
- Legislation: what the Commission Decision 2017/848 requires to set threshold values, art8.
- Core group of NIS: working for harmonisation of approaches to assess D2C1.

09:50- 11:15 Current methodologies for setting threshold values.
- HELCOM/Black Sea EU Member States (MS)/ OSPAR/ SPA-RAC.
- Summary of IDA reports for used threshold.
- Summary of outcomes from Tsiamis et al 2021: taxonomy, assessment areas and scales, methods.
  Responses from MS to questionnaire.

11:15- 11:30 Break

11:30- 12:15 Testing the D2C1 GES indicator for marine NIS with long term data from Danish Seas (DK). Time series analysis as a follow-up step to Tsiamis et al. (2021): data-driven discussion (JRC).

12:15- 13:30 Lunch break

13:30- 15:00 Discussion in breakout groups

15:00- 16:00 Report back from groups and final discussion

16:00- 16:30 Conclusions and end of the meeting

Annex 2. Time series analysis

Time series analysis as a follow-up step to Tsiamis et al. (2021): supporting a data-driven discussion

Aim of the approach

The approach aims at identifying changes in the Non-Indigenous Species (NIS) time series to determine reference periods and values for discussing GES scenarios as a follow-up step to Tsiamis et al. (2021a). It makes use of the data collected and reviewed by the Marine Strategy Framework Directive (MSFD) Descriptor 2 (Commission Decision 2017/848/EU) expert network, coordinated by the Joint Research Centre (JRC). This data is openly, available as annexes to the publication of the 2020 JRC NIS thresholds workshop (Tsiamis et al., 2021a), and through the JRC Data Catalogue[1]. The approach builds upon the consensus found at the workshop on the main guidelines to define threshold values for D2C1.

> "The workshop's participants agreed that the most suitable approach for setting threshold values for D2C1 is to adopt the percentage reduction of new NIS, meaning that: a) the threshold is a quantitative measure, i.e. specific number of new NIS introductions during the assessment period for a specific MSFD region/subregion, and b) the number of new NIS introductions is defined based on a specific percentage reduction of new NIS occurred in this MSFD region/subregion compared to the average number of new NIS introductions that occurred in the previous 6-years cycle periods in the same area." (Tsiamis et al., 2021a).

Brief description of steps for timeseries analysis for establishing thresholds

Step 0- Clean the data. Keep only species with 'non-indigenous status', and exclude unicellular marine algae, parasite, extinct species. Filter records after 1970.

Step 1- Exploratory analysis of NIS data. Plot the accumulated records (aggregate number of records by year) and check for the rate of NIS introduction.

Step 2- Run breakpoint analysis. We look at the dynamic over time of NIS introductions. The analysis allows us to detect one or more breakpoint(s) that define one or more reference period, i.e. a segment of time with coherent and stable statistical properties. Details of the analysis in Ostman et al. (2020) and Zeileis et al. (2003), and application in Galanidi & Zenetos (2022).

Input:

- Define the baseline period: first and last year of baseline period, i.e. 1970-2017.

Output:

- Breakpoint(s), i.e. year(s) when there is a change in the NIS introduction dynamic. Select the reference period.

Step 3- GES scenarios

- Extract the mean of selected reference period.
- GES scenarios: consider different threshold scenarios according to reference value or other criteria.

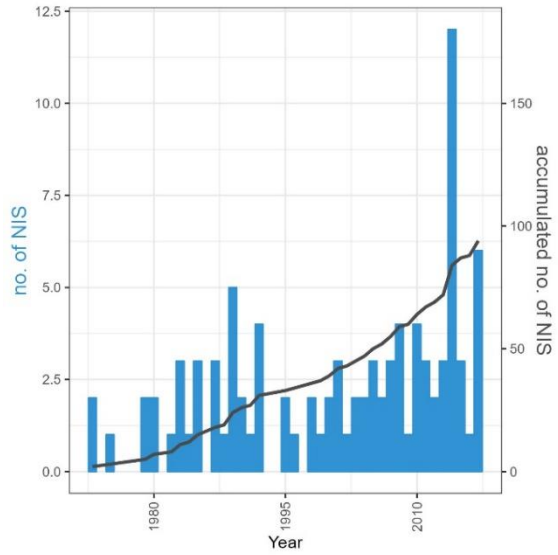
To consider

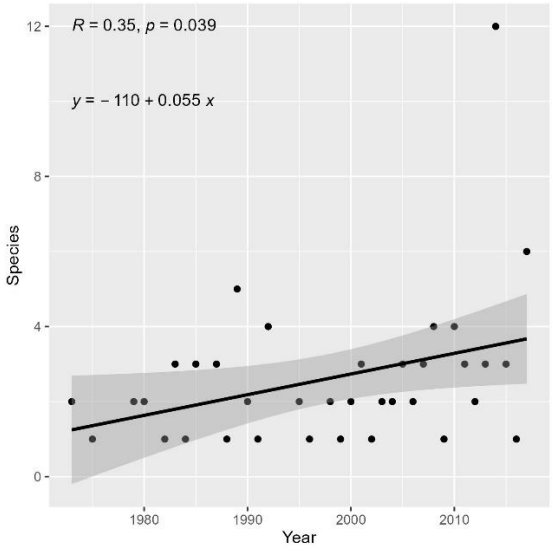
- time series analysis requires to have continuity of data.
- the length and period of the timeseries for defining the reference period are factors to consider for the reference value. The selection of the reference period is based on data quality. It is preferred this period to be the longest. Shorter period can be used if there is a better prior knowledge of environmental conditions or indicator status.

OUTCOMES BY MARINE REGION & SUB-REGION – yearly analysis

BALTIC SEA REGION

Step 1 Plot no. of NIS of time- look for increasing trends





Step 2

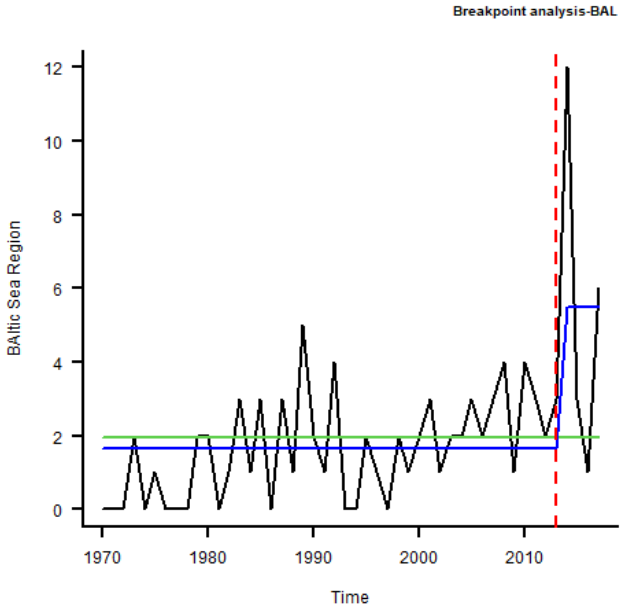
Inputs:

baseline 1970-2017

level of significance for breakpoint: 0.05

Outputs:

1 breakpoint 44 years from baseline->**2013**



Plot of the breakpoint analysis. Red line: break point, Blue line: fitted model, Green line: null model

Step 3

mean of reference period before break: 1.64 NIS/ Year

mean of reference period after break: 5.50 NIS/ Year

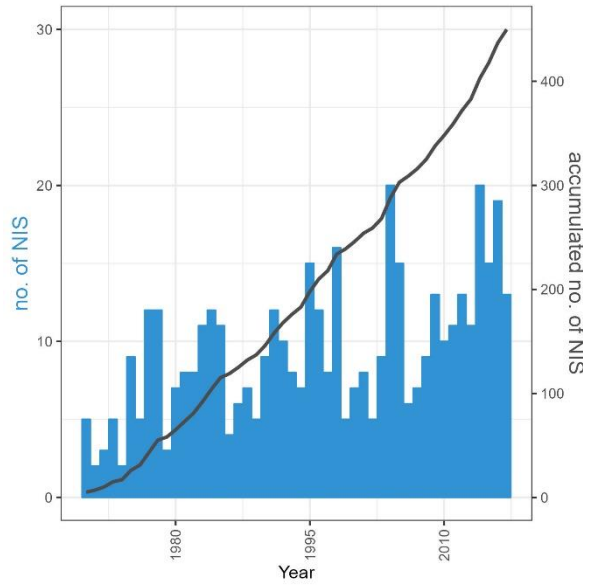
Points to discuss:

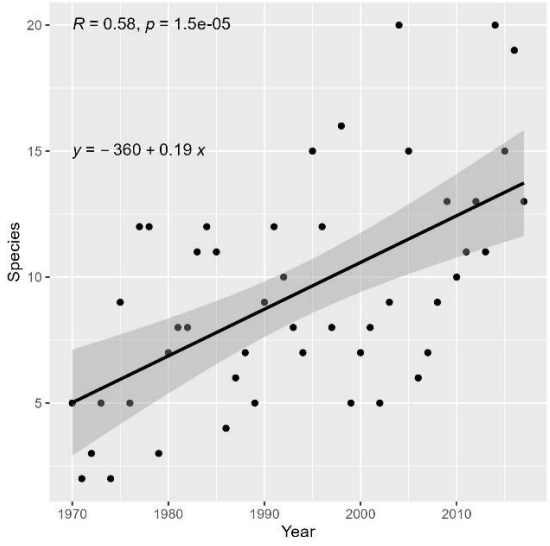
- Do you agree with the study area considered in the analysis? If no, why
- Do you agree with the time period of the analysis? Would you aggregate the data (multiple years) instead?
- How to use the reference value to set NIS threshold? Is it our threshold value?
- If so, what is the most reliable reference value? First or second period?

- Considering the pathways of introductions, can we derive a threshold value based on the assessment data? Can it be adjusted with the reference value?

MEDITERRANEAN SEA REGION

Step 1 Plot no. of NIS of time- look for increasing trends





Step 2

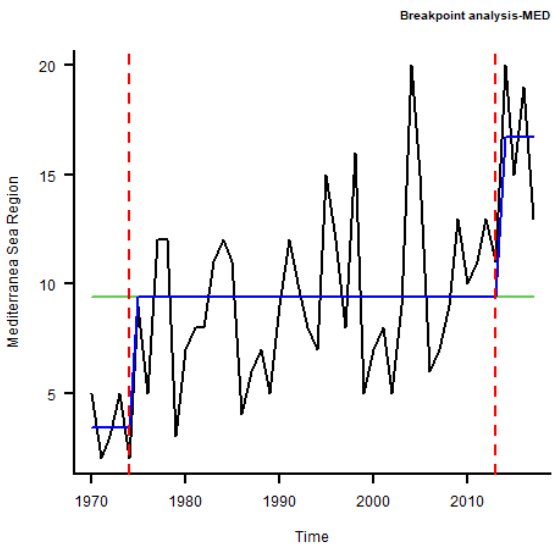
Inputs:

baseline 1970-2017

level of significance for breakpoint: 0.05

Outputs:

2 breakpoints: **1974, 2013**



Plot of the breakpoint analysis. Red line: break point, Blue line: fitted model, Green line: null model

Step 3

mean of reference period before break: 3.40 NIS/ Year

mean of reference period after first break: 9.38 NIS/ Year

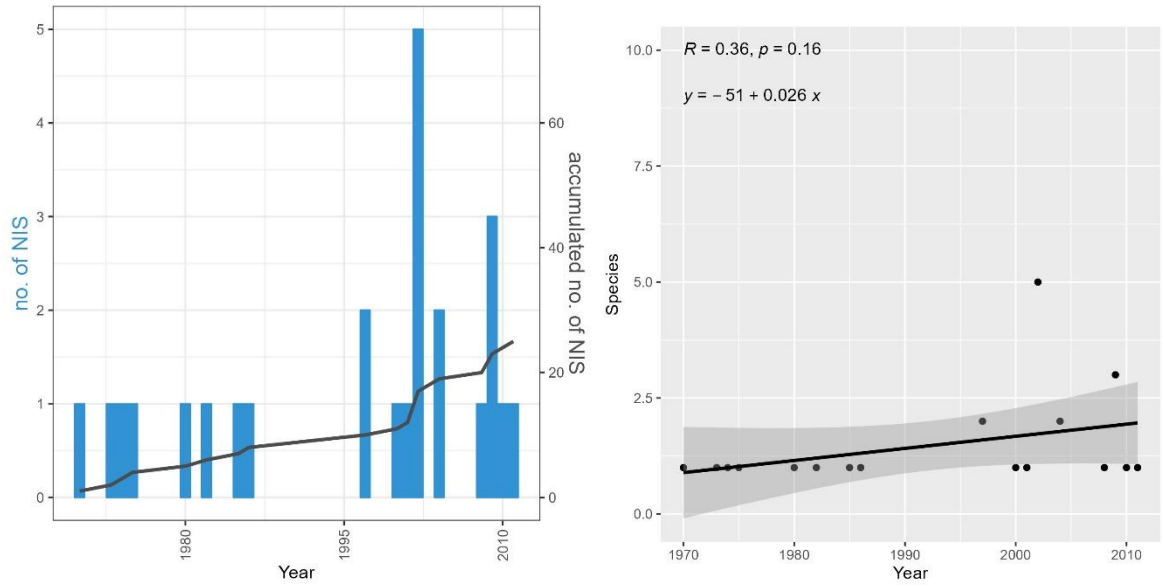
mean of reference period after second break: 16.75 NIS/ Year

Points to discuss:

- Do you agree with the study area considered in the analysis? If no, why
- Do you agree with the time period of the analysis? Would you aggregate the data (multiple years) instead?
- How to use the reference value to set NIS threshold? Is it our threshold value?
- If so, what is the most reliable reference value? First or second period?
- Considering the pathways of introductions, can we derive a threshold value based on the assessment data? Can it be adjusted with the reference value?

BLACK SEA REGION

Step 1 Plot no. of NIS of time- look for increasing trends



Step 2

Inputs:

baseline 1970-2017

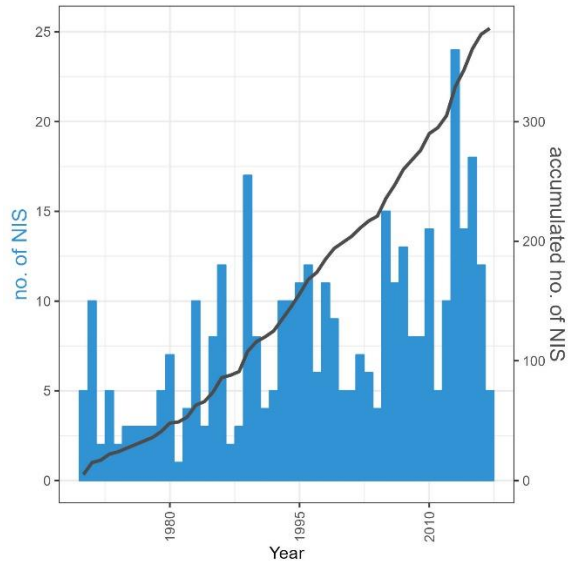
level of significance for breakpoint: 0.05

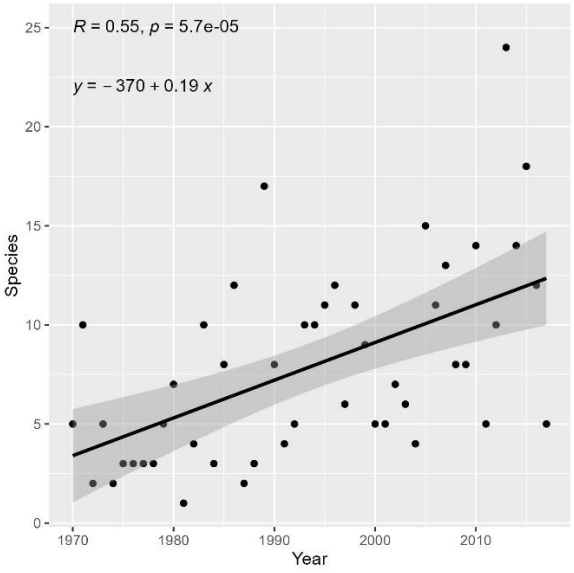
Outputs:

No breakpoint was detected! From 2012 to 2020 zero introductions detected

NORTH- EAST ATLANTIC REGION

Step 1 Plot no. of NIS of time- look for increasing trends





Step 2

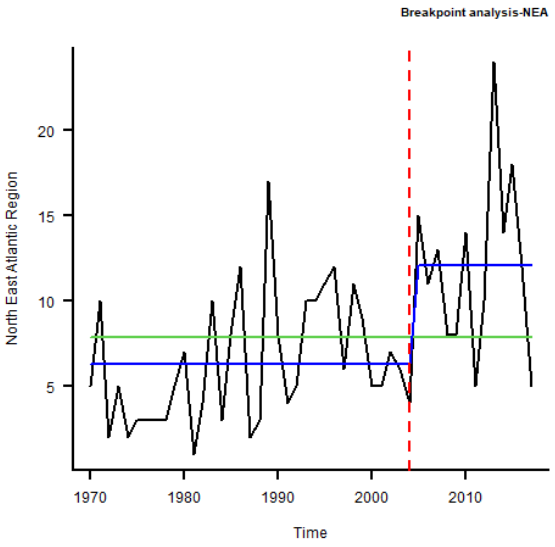
Inputs:

baseline 1970-2017

level of significance for breakpoint: 0.05

Outputs:

1 breakpoint 35 years from baseline->**2004**



Plot of the breakpoint analysis. Red line: break point, Blue line: fitted model, Green line: null model

Step 3

mean of reference period before break: 6.31 NIS/ Year

mean of reference period after break: 12.08 NIS/ Year

Points to discuss:

- Do you agree with the study area considered in the analysis? If no, why
- Do you agree with the time period of the analysis? Would you aggregate the data (multiple years) instead?
- How to use the reference value to set NIS threshold? Is it our threshold value?
- If so, what is the most reliable reference value? First or second period?
- Considering the pathways of introductions, can we derive a threshold value based on the assessment data? Can it be adjusted with the reference value?

SUMMARY OUTCOMES BY MARINE REGION

Aggregated data	**Marine region**	**YEAR BREAKPOINT**	**FIRST SEGMENT**	**SECOND SEGMENT**	**Third segment**
1 year	BALTIC SEA	2013	1.64	5.50	/
6 years[6]	BALTIC SEA	1976, 2000	3.50	10.75	22.00
1 year	MEDITERRANEAN SEA	1974, 2013	3.40	9.38	16.75
6 years[2]	MEDITERRANEAN SEA	1988	44.00	24.50	/
1 year	BLACK SEA	No breakpoint	/	/	/
6 years[2]	BLACK SEA	No breakpoint	/	/	/
1 year	NORTHEAST ATLANTIC OCEAN	2004	6.31	12.08	/
6 years[2]	NORTHEAST ATLANTIC OCEAN	1976, 2000	24.50	46.75	71.00

[6] trimming parameter to test the maximum number of breaks set to 0.25 due to the small number of datapoints.

Annex 3. Questionnaire

These questions aim at collecting information from workshop participants about the approaches used to assess D2C1 in the context of the MSFD. Your answers will be used to inform workshop discussions.

Please select your MSFD working area:

1) Mediterranean Sea:

- West Mediterranean
- Adriatic Sea
- Aegean- Levantine Sea
- Ionian Sea and the Central Mediterranean Sea

2) Baltic Sea

3) Black Sea

4) North-East Atlantic Ocean:

- Bay of Biscay and the Iberian Coast
- Celtic Seas
- Macaronesia
- Greater North Sea

1. Which approach do you use to assess D2C1? (e.g., threshold values)

- We follow recommendations in Tsiamis et al 2021? Yes/no
- We have our own methodology. Please summarize the approach you are using:

2. Which scenario of reduction in the number of NIS, is the best to consider in your working areas for D2C1 GES?

- Precautionary approach (NIS=0)
- Pathways-based (manageability)
- Measure-driven (efficiency)

Please justify your answer:

Annex 4. Participants list

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Information about the European Union in all the official languages of the EU is available on the Europa website (european-union.europa.eu).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (eur-lex.europa.eu).

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

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