HELCOM

Trends in arrival of new non-indigenous species

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1 Key message

Thirteen new non-indigenous species (NIS) or cryptogenic species (CS) have appeared for the first time in the Baltic Sea during the assessment period 2016-2021. Since the threshold value between good environmental status (GES) and not good environmental status is no new introductions of NIS per assessment unit through human activities during a six year assessment period, the indicator trends in arrival of new non-indigenous species does not reach GES, as can be seen in Figure 1.

The Baltic Sea assessment units in which these new NIS/CS have been recorded are the Kattegat, Great Belt, Kiel Bay, Bay of Mecklenburg, Bornholm Basin, Gulf of Gdansk, Archipelago Sea and Gulf of Finland. The new species have been detected both during regular environmental monitoring activities, as well as research surveys and citizens science observations. The data have been verified by national experts. The indicator is only considering new human-mediated introductions and thus the secondary spread by natural means (migration, water currents etc.) within the Baltic Sea is not specifically part of this indicator.

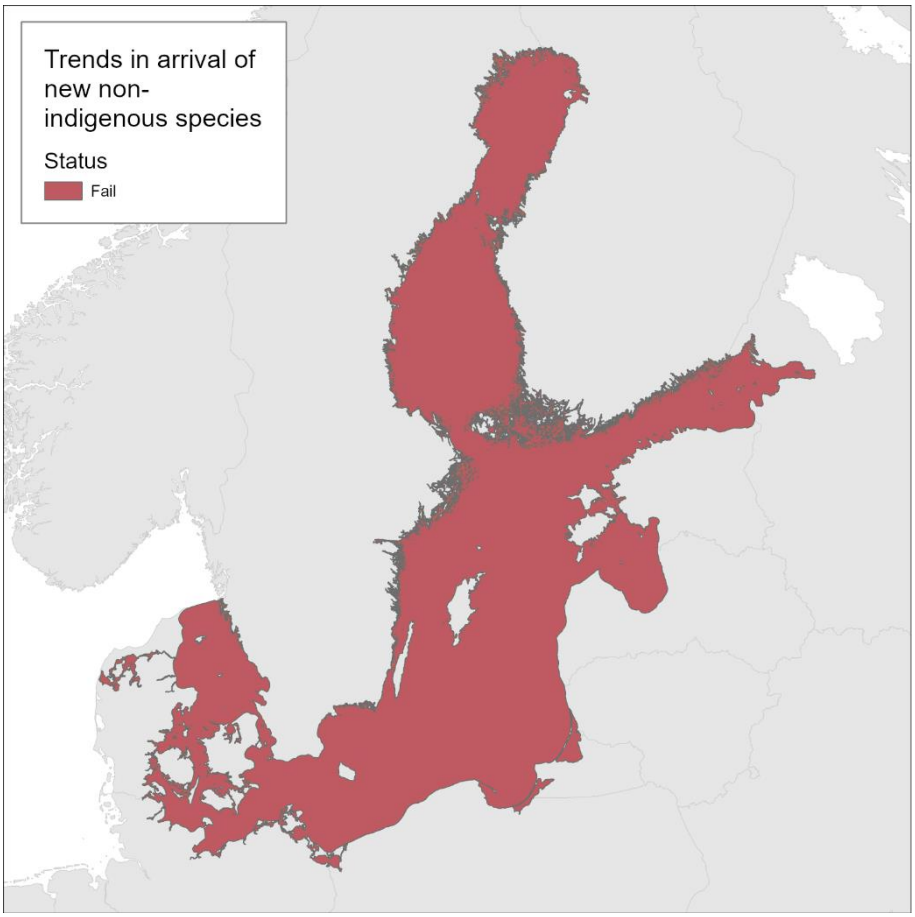

Figure 1. Status evaluation results based evaluation of the indicator 'Trends in arrival of new non-indigenous species'. The evaluation is carried out using Scale 1 HELCOM assessment units (defined in the HELCOM Monitoring and Assessment Strategy Attachment 4). **See 'data chapter' for interactive maps and data at the HELCOM Map and Data Service.**

The trend in arrival of new NIS/CS has been increasing since the beginning of the 1900s, generally indicating a clear anthropogenic impact on the Baltic Sea environment. It may also be due to more intense monitoring activities. However, there has been an increase in the number of new NIS/CS detected during the current assessment period (thirteen) as compared to the previous one (2011-2016, twelve). This pattern is complicated by reporting of records from the previous period that took place subsequent to the completion of the previous indicator evaluation. The main human induced pathway, in addition to introduction by natural means, associated NIS/CS is maritime transport.

Routine monitoring does not cover all invasion hotspots, habitats and taxonomic groups in many of the countries surrounding the Baltic Sea. The confidence in the evaluation for areas where detections of new NIS/CS have been made is high. In assessment units where no observations were recorded, the confidence may be low if no regular monitoring is conducted. This however varies between assessment units. However, the overall confidence is considered moderate for the evaluation made since the available records clearly show that the threshold value has not been achieved.

The indicator is applicable in the waters of all countries bordering the Baltic Sea but can be considered as fully operational only in the assessed areas and habitats supported by proper monitoring data.

1.1 Citation

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited. The indicator should be cited as follows:

HELCOM (2023). Trends in arrival of new non-indigenous species. HELCOM core indicator report. Online. [Date Viewed], [Web link].

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2 Relevance of the indicator

In total of 220 NIS/CS have been observed in the Baltic Sea (AquaNIS 2022, as of 7 October 2022). The pathways responsible for the currently established species (~60% of all introduced species) are shipping and natural spread from neighbouring areas. Substantial uncertainty in the information on introduction pathways (except for deliberate releases) hampers detailed analyses and makes it very difficult to assess new human-mediated introductions both into and within the Baltic Sea. Thus, the indicator assesses only the new introductions for the whole Baltic Sea (i.e. HELCOM Scale 1, Whole Baltic Sea) but also reports these new sightings at an assessment-unit level (i.e. HELCOM Scale 2, 17 sub-basins) to provide more detail information on occurrence.

NIS/CS in the report comprise not only the established taxa but all new species independent of the establishment success as both categories (i.e. established and not established) signal a breakdown or deficiency in introduction pathway management. Thus, the number of NIS/CS evaluates the successfulness of preventive management as well as the status of the ecosystem by indicating the areas where the level of unpredictable risk is high.

2.1 Ecological relevance

The introduction of NIS is a severe threat to marine environments. NIS have caused ecological, economic and public health impacts globally (Ruiz *et al.*, 1997; Mack *et al.*, 2000; Lockwood *et al.*, 2007; Ojaveer & Kotta, 2014). NIS can induce considerable changes in the structure and dynamics of marine ecosystems and may also hamper the economic use of the sea or even represent a risk for human health. Ecological impacts include changes in habitats and communities and alterations in food web functioning, in extreme cases even loss of native species can occur (Galil, 2007). Economic impacts range from financial losses in fisheries to expenses for industries for cleaning intake or outflow pipes and structures from fouling (Black, 2001; Williams *et al.*, 2010). Public health impacts may arise from the introduction of pathogens or toxic algae. The impacts, especially when taken cumulatively with other pressures, on marine ecosystems can be unpredictable and may be large.

NIS may also have positive effects e.g., increase fisheries, make water clearer by effective filtering or improve oxygen conditions on the seabed (Reise *et al.*, 2021).

The indicator only focusses on new human-mediated introductions and the secondary spread by natural means (migration, water currents etc.) within the Baltic Sea, although highly relevant from an ecological perspective, is not part of this indicator. Only a small number of all NIS become invasive i.e. have a potential to spread and cause negative impacts. Those NIS which cause the most harm on the environment and/or humans are the most important to monitor, not only in terms of evaluating the current and changing status of the ecosystems (requirement from the MSFD), but also in terms of the marine management perspective in order to incorporate the evidence in appropriate ecosystem-based management.

Our knowledge is very limited for the majority (60%) of wide-spread NIS of the Baltic Sea (Ojaveer *et al.* 2021). According to the biopollution index (Zaiko *et al.* 2011), the highest biopollution (BPL = 3, strong impact) occurs in coastal lagoons, inlets and gulfs, and the moderate biopollution (BPL = 2) in the open sea areas. None of the Baltic sub-regions is classified as 'low impact' (BPL = 0 or 1) indicating that invasive species with recognized impacts are established in all areas.

2.2 Policy relevance

Since the early 1990s when the Marine Environmental Protection Committee (MEPC) of the International Maritime Organisation (IMO) put the NIS issue on the agenda, the issue has gathered an ever- increasing weight in marine environmental protection. In 2004, the International Convention for the Control and Management of Ship's Ballast Water and Sediments (BWM Convention) was adopted by the IMO. The Convention requires ships in international traffic to manage their ballast water and sediments (Regulation B-3) to certain standards specified in the Convention (Regulation D-2), as well as keeping a ballast water record books and an international ballast water management certificate. There is a phase-in period for ships to implement their ballast water and sediment management plan, during which they are allowed to exchange ballast water (Regulation B-1) in the open sea under certain premises of depth and distance from the shore (Regulation D-1). The Convention entered into force 8 September 2017.

In the Baltic Sea Action Plan (BSAP 2007) Contracting Parties agreed to adjust/extend by 2010 the HELCOM monitoring programmes to obtain reliable data on non-indigenous species in the Baltic Sea, including port areas, in order to gather the necessary data to conduct and/or evaluate and consult risk assessments according to the relevant IMO guidelines. As a first step, species that pose major ecological harm and those that can be easily identified and monitored should be covered. The evaluation of any adverse ecological impacts caused by NIS should form an inherent and mandatory part of the HELCOM monitoring system.

Good Environmental Status (GES) according to the EU MSFD is to be determined on the basis of eleven qualitative descriptors. One of the descriptors concerns NIS and describes the Good Environmental Status (GES) for this descriptor as 'Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem' and sets the ambition level as achieved where the number of non-indigenous species introduced is minimised and where possible reduced to zero (Commission Decision (EU) 2017/848).

In order to minimize adverse effects of introductions and transfers of marine organisms for aquaculture ICES published the 'ICES Code of Practice on the Introductions and Transfers of Marine Organisms' (ICES, 2005). The Code of Practice summarizes measures and procedures to be taken into account when planning the introduction of NIS for aquaculture purposes. On the European level, the EC Council Regulation No 708/2007 concerning the use of NIS and locally absent species in aquaculture (EC, 2007) is based on the ICES Code of Practice. With a wider scope the recently adopted EU Regulation on the prevention and management of the introduction and spread of invasive alien species,

entering into force on 1 January 2015, aims to protect native biodiversity and ecosystem services, as well as to minimize and mitigate the human health or economic impacts that these species can have (EU, 2014). The new BSAP (BSAP 2021) and its relevant attributes are shown in Table 1.

Table 1. Key policy relevance attributes

	Baltic Sea Action Plan (BSAP)	**Marine Strategy Framework Directive (MSFD)**
Fundamental link	Segment: Sea-based activities Goal: "Environmentally sustainable sea-based activities" • Ecological objective: "No or minimal disturbance to biodiversity and the ecosystem". • Management objective: "No introductions of non-indigenous species".	Descriptor 2 Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems. • Criteria 1 The number of non-indigenous species which are newly introduced via human activity into the wild, per assessment period (6 years), measured from the reference year as reported for the initial assessment under Article 8(1) of Directive 2008/56/EC, is minimised and where possible reduced to zero. • Feature – Newly-introduced non-indigenous species. • Element of the feature assessed – Number of Newly-introduced non-indigenous species.
Complementary link	Segment: Biodiversity Goal: "Baltic Sea ecosystem is healthy and resilient" • Ecological objective: "Viable populations of all native species", "Natural distribution, occurrence and quality of habitats and associated communities" and "Functional, healthy and resilient food webs". • Management objective: "Minimize disturbance of species, their habitats and migration routes from human activities"; "Effective and coordinated conservation plans and measures for threatened species, habitats, biotopes, and biotope complexes", and "Reduce or prevent human pressures that lead to imbalance in the foodweb".	
Other relevant legislation:	IMO Ballast Water Management Convention, 2004	

2.3 Relevance for other assessments

The NIS indicator is not currently included in integrated assessments within HELCOM work (e.g. the State of the Baltic Sea reports, HOLAS) but is included as part of the overall thematic assessment of pollution. When future indicator and assessment work to address key issues such as spread, establishment, or potential impacts has been developed there may be scope for a more detailed and integrated assessment related to NIS.

3 Threshold values

3.1 Setting the threshold value(s)

The ultimate goal is to minimize human-mediated introductions of NIS/CS to zero. The threshold value between good status and not good status is 'no new introductions of NIS per assessment unit (HELCOM Scale 1, Whole Baltic) through human activities during a six-year assessment period' (Figure 2). As a mid-term goal a decrease in the rate of new introductions should be considered. The evaluation against the baseline species list is carried out and all new species introduced to the Baltic Sea over a six-year period are listed and counted.

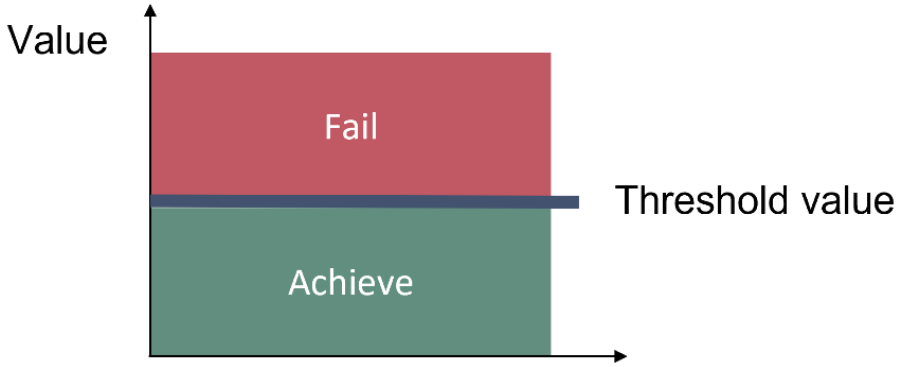

Figure 2. Schematic representation of the threshold value, where the threshold is achieved if no new species appear in the Baltic Sea due to human activities during the six-year assessment period.

The indicator is only considering new human-mediated introductions and thus the secondary spread of already documented introduced species within the Baltic Sea is not specifically part of this indicator. There are large regional inconsistencies in the evaluation of introductions due to vectors/pathways because of different knowledge levels and information availability in different sub-basins. This is an area where future work and development is vital to better understand the ecosystems impacts and dynamics related to NIS. Therefore, the indicator considers only new introductions into the Baltic Sea as a whole (where we have a better level of confidence for the vector/pathway) and not the spread inside the Baltic, even though part of this within-Baltic Sea spread is likely due to human actions (certainly for some bivalve species e.g. *Mytilopsis leucophaeata* and *Rangia cuneata*).

The confidence in the applicability of the threshold value is moderate as the concept is broadly considered to be valid. As monitoring data is not readily available across the entire region and the indicator has not been evaluated with national monitoring data alone, the success and suitability of monitoring data remains to been sufficiently tested. It is however a critical tool in improving the understanding of NIS in the Baltic Sea. The six-year evaluation period has been selected based on management cycles (e.g. BSAP and MSFD) and may not be the most ecologically relevant assessment period. However, a study conducted by ICES on the temporal adequacy of a three year period assessment states

that this is likely to be a too short a period and considers a six-year assessment period to be more appropriate (ICES, 2013).

Eradication of already established NIS has proven not to be feasible in aquatic environments (Sambrook *et al.* 2014). No knowledge of eradication of already established NIS has been recorded in Europe. Thus, reaching a pristine status cannot be used as a relevant threshold value.

To enable an evaluation of status, the indicator requires a baseline in the form of a list that specifies which NIS/CS were already present in each assessment unit, and ultimately the entire Baltic Sea, at a certain point in time. The baseline list for this evaluation has been made for the year 2015, i.e. the year prior to the current assessment period, showing altogether 205 NIS and cryptogenic species in the Baltic Sea (based AquaNIS 2015) (see Metadata for details). The number of species present in 2015 varies between assessment units but for the evaluation for the whole Baltic Sea level at which this indicator is evaluated this overall value a as baseline is relevant. It should also be noted that some flexibility in the indicator evaluation against the baseline should be allowed if a NIS/CS is later found to have invaded an area during a previous assessment period.

4 Results and discussion

The results of the indicator evaluation that underlie the key message map and information are provided below.

4.1 Status evaluation

Thirteen new human-mediated introductions to the Baltic Sea were observed from 2016 to 2021, thus, since evaluated at the whole Baltic Sea level the indicator fails its threshold value. These species are: *Haminoea solitaria, Laonome xeprovala sp. nov., Caprella mutica, Fenestrulina malusii, Hemigrapsus sanguineus, Polydora aggregata, Chelicorophium robustum, Moerisia inkermanica, Mytilicola orientalis, Nippoleucon hinumensis, Echinogammarus ischnus, Proterorhinus nasalis* and *Babka gymnotrachelus. Laonome xeprovala sp. nov.* was observed during the same year (2016) the first time in German and Finnish waters.

To provide additional context to the evaluation the spatial distribution of new records across the whole Baltic Sea area are also provided based on records from each of the 17 sub-basins of the Baltic Sea. In four sub-basins two new NIS were observed (Kattegat, Great Belt, Kiel Bay and Bay of Mecklenburg), in one area three new NIS were observed (Bornholm Basin) and in three areas (Gulf of Gdansk, Archipelago Sea, Gulf of Finland) only one new NIS was observed for the first time in the Baltic Sea (14 sub-basins are listed here as one of the species, *Laonome xeprovala sp. nov.,* was recorded in two sub-basins in the same year as a first introduction). These sub-basins are considered to fail the established threshold value, thus the overall evaluation at the whole Baltic Sea level (HELCOM Scale 1 assessment units) also fails to achieve GES. As the uncertainty related to vectors and pathways concerning many new introductions inside the Baltic Sea is high we cannot conclude that the other sub-basins are in good status although there are no known new Baltic Sea-first observations recorded in them. There are however several human-mediated introductions or spread from one Baltic country or sub-basin to another during the assessment period, indicating failed threshold value conditions elsewhere (even where a species has previously been recorded at the whole Baltic Sea scale). Therefore we are not able to assess the sub-basins independently as their own assessment units based on the current level of knowledge and the indicator status is therefore evaluated based on the Baltic Sea-first observations and at the whole Baltic Sea scale 1 (i.e. as a single assessment unit for the whole Baltic Sea).

The current results are based on AquaNIS with all the information in the database being verified by national or international experts. The indicator results could be significantly improved if dedicated monitoring program for NIS are launched in all countries. Current evaluations are biased towards better investigated groups (molluscs, crustaceans, fish), whereas almost no information on micro- and meio organisms and pathogens is available.

4.2 Trends

The number of new NIS/CS introductions has been fairly low until the mid-20th century but generally much higher afterwards (Figure 3). The lack of knowledge about the intensity in monitoring activities as well as on species identification make it difficult to estimate the accuracy of the values registered at the early years in figure 3.

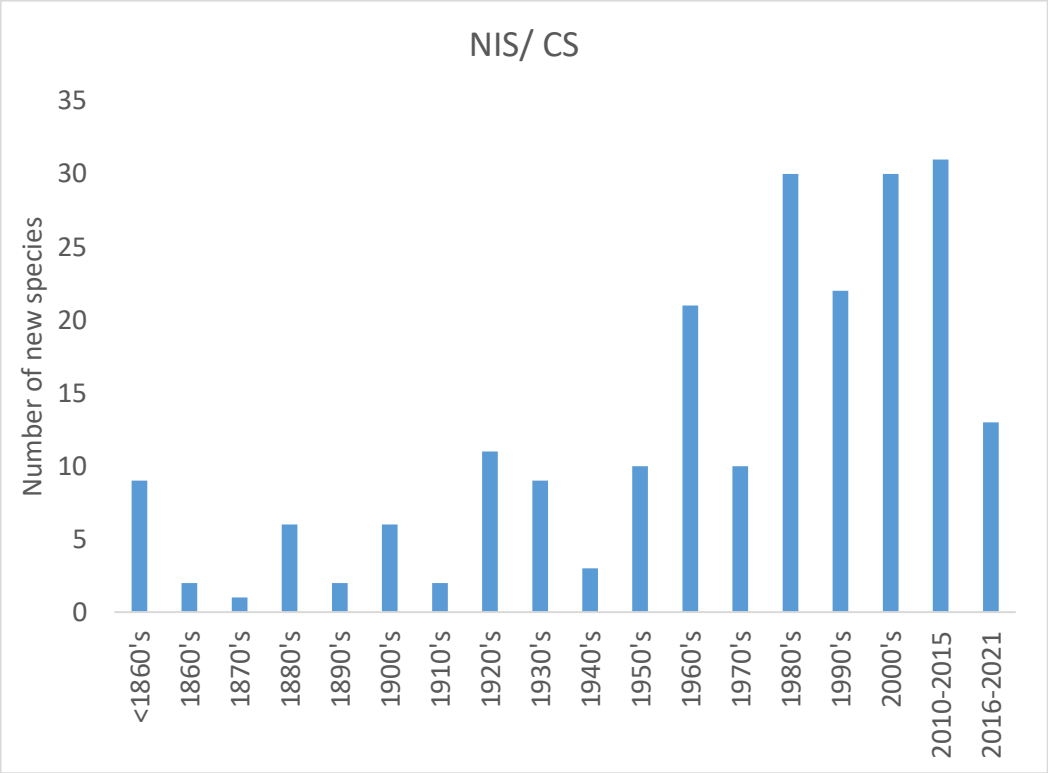

Figure 3. Number of new NIS in Baltic Sea until 2021. The bars indicate the number of new introduced species per time-period. Note that the latter period on the figure is not representative of equal time periods.

The trends in arrival of new NIS to the Baltic Sea increased sharply in the second half of the 20th Century and has not shown signs of decline in 2000s. However, the number of new NIS records in the present assessment period (Table 2) was similar to that reported in the previous 6-y period (Table 3). The discrepancy in the new NIS introductions in figure 3 and Table 3 for the HOLAS 2 period (2011-2016) is due to retrospective reporting of many new NIS after publishing the HOLAS 2 report. Thus, there is an apparent large decrease in reported NIS for this current assessment period (HOLAS 3, 2016-2021) as compared to the latest available information related to the preceding 5-year period (see Figure 3).

Table 2: New NIS/CS records in the present assessment period, by country, sub-basin and year of first introduction.

New NIS/CS	Country	Sub-basin	Year of first introduction
Haminoea solitaria	Germany	Bay of Mecklenburg	2016
Laonome xeprovala sp. nov.	Germany Finland	Kiel Bight Archipelago Sea	2016 2016
Caprella mutica	Denmark	Belt sea	2017
Fenestrulina malusii	Denmark	Kattegat	2017
Hemigrapsus sanguineus	Denmark	Kattegat	2017
Polydora aggregata	Denmark	Belt sea	2017
Chelicorophium robustum	Poland	Bornholm Basin	2018
Moerisia inkermanica	Germany	Bornholm Basin	2018
Mytilicola orientalis	Germany	Kiel Bight	2018
Nippoleucon hinumensis	Germany	Bay of Mecklenburg	2019
Echinogammarus ischnus	Germany	Bornholm Basin	2020
Proterorhinus nasalis	Estonia	Gulf of Finland	2020
Babka gymnotrachelus	Poland	Gulf of Gdansk	2021

Table 3: Status summary and comparison to prior evaluation. *Note that 2016 is included in both periods.

HELCOM Assessment unit name	Threshold value achieved/failed – HOLAS II	Threshold value achieved/failed – HOLAS 3	Distinct trend between current and previous evaluation.	Description of outcomes, if pertinent.
Baltic Sea	12 new NIS/CS - failed	13 new NIS/CS - failed	Stable - no trend or obvious change between the two assessment periods* is observed.	13 new NIS/CS were observed in the Baltic Sea. As the threshold for GES is 0 new introductions, the indicator results show that the assessment has failed the established threshold value.

5 Confidence

The confidence for areas where detections of new NIS have been made is high. The detections have been verified by experts, and the observations are considered to be correct.

In sub-basins where no detections have been made, the confidence may be low if no regular monitoring is conducted. This however varies between sub-basins.

Regular monitoring dedicated to NIS is not available in most countries and areas and thus data is not considered to sufficiently cover all areas of the Baltic Sea in a manner that would ensure that all new introductions are detected, thus a zero result for an assessment unit may be a false negative.

The overall indicator evaluation confidence is considered to be moderate as at the scale of assessment (HELCOM Scale 1, whole Baltic Sea) and the confidence in the recorded new NIS within this assessment scale are considered accurate.

6 Drivers, Activities, and Pressures

The indicator evaluates the status of the marine environment affected by anthropogenic pressures. It is important to distinguish between naturally spreading and anthropogenically introduced species. If it is not possible to distinguish between a human mediated introduction and natural spread the species is called cryptogenic. For the indicator all new observed species are therefore first to be treated as NIS or cryptogenic and only species which can be shown to have spread naturally will be removed from the indicator.

According to Minchin *et al.* (2008), nine main categories of pathways through which species may spread for all aquatic environments can be defined. These are: shipping, canals, wild fisheries, culture activities, ornamental and live food trade, leisure activities, research and education, biological control and alteration to natural waterflow. In the Baltic Sea, the increasing shipping activities and development of new navigable waterways during the last 60 years has dominantly resulted in the increasing number of unintentional introduction of NIS/CS, transported in ballast tanks or on ship hulls (Olenin *et al.*, 2009). Besides shipping, especially aquaculture has been identified as a very important vector in some parts of the Baltic Sea (Wolff and Reise 2002). Finally, the introduction of infrastructure associated with renewable and non-renewable energy to the marine environment (e.g., offshore wind turbines, oil and gas platforms) provides hard substrate which may be colonised by marine organisms, and subsequently serve to spread NIS.

Table 4. Brief summary of relevant pressures and activities with relevance to the indicator.

	General	**MSFD Annex III, Table 2a**
Strong link	Maritime traffic, especially ballast water management and biofouling, aquaculture.	Biological - Input or spread of non-indigenous species
Weak link	Offshore wind turbines, oil and gas platforms; leisure activities	Biological - Input or spread of non-indigenous species

7 Climate change and other factors

Changes in abiotic conditions and increased stress of native species (Stachowicz at al. 2002, Occhipinti-Ambrogi, 2007; Hellmann *et al.* 2008) can be favourable for some invasive species and their ecological impacts can be expanded by climate change (low confidence: Pyke *et al.* 2008; Rahel *et al.* 2008). Such issues may support new NIS/CS to establish or spread in and to the Baltic Sea in the future, though significant further research is required on this topic for the region.

Climate change has generally shifted species boundaries towards the poles so immigration of new species can be expected. If the salinity of the Baltic Sea is reduced at the same time this can prevent successful invasions of marine species, but facilitate invasion of freshwater species (Holopainen *et al.* 2016).

Several parameters are highly inter-correlated, and also high impact of other direct and indirect anthropogenic disturbances like eutrophication and habitat degradation may interact with biological invasions.

Within the 2021 Climate Change in the Baltic Sea Fact Sheet a number of parameters were linked to NIS, indicating that changes in these could support the occurrence or establishment of NIS. These include direct parameters: water temperature, salinity, carbonate chemistry, and via indirect parameters (i.e. subsequent changes as a consequence of direct parameters): oxygen, benthic habitats, marine protected areas, and ecosystem function (HELCOM and Baltic Earth 2021)

8 Conclusions

Thirteen new NIS/ CS were reported for the Baltic Sea for the reporting period 2016-2021. These observations covered several sub-basins of the Baltic Sea (i.e. were spatially spread across a large area) and thus the evaluation of status against a threshold value of zero new introductions at the level of the whole Baltic Sea (HELCOM scale 1 assessment unit) fails to achieve GES. These findings indicate a failure in management of the main introduction vectors and pathways. The BWMC is in force but due to time lags in obligatory installations of ballast water treatment systems in old vessels it is not yet possible to confirm whether the Convention has had effects in the indicator results.

8.1 Future work or improvements needed

Improvement of NIS monitoring should be the priority of the Baltic Sea countries if the objective is to improve the confidence of the indicator and perform an evaluation that has higher confidence and can be carried out at a more appropriate assessment unit scale (e.g. HELCOM Scale 2 assessment units, 17 sub-basins). New and emerging technologies and methods (incl. molecular and semi-automated tools) should be implemented in monitoring programs. Such issues require concerted effort and resourcing. Beyond HOLAS 3, and interlinked to other issues addressed under future work here, it may also be relevant to explore harmonisation of threshold value approaches with other regions (e.g., threshold values that incorporate a reduction of new introductions or may differ sub-regionally where suitable monitoring and data collection is available). In addition, further work on the topic of NIS though not directly related to this specific indicator is also needed, for example to better understand and evaluate issues, where relevant, such as spread, establishment and impact. A trend analysis of not only the new NIS introductions but also the total number of NIS present may be of interest, in particular, from the managerial perspective.

9 Methodology

9.1 Scale of assessment

The indicator status (i.e. achievement of the threshold value) is currently evaluated at HELCOM Assessment Scale 1 – the whole Baltic Sea as a single assessment unit. The indicator results are also provided at HELCOM Scale 2 assessment units, these being the 17 sub-basins in the HELCOM area, to provide a spatial component to the evaluation. The assessment units are defined in the HELCOM Monitoring and Assessment Strategy Attachment 4. The indicator covers the entire Baltic Sea: national coastal and offshore waters divided to sub-basins. There are however wide gaps in the spatial coverage of the current biodiversity monitoring especially in the coastal areas. Currently, the monitoring of coastal and estuarine biodiversity is not conducted to reliably show the distribution and abundance of several NIS.

The time series data may overemphasize the recent decades and show too steep increase in the rate of introductions due to improved monitoring of NIS.

The large uncertainty related to new introductions, especially concerning their vectors/pathways, as well as unequal monitoring effort, prevents the use any more detailed scale in the assessment with this current indicator. At present the indicator only considers new introduction to the Baltic Sea as a whole but the indicator results show these introductions per sub-basin in addition. This approach however underestimates the NIS introductions in many areas as we cannot obtain reliable data for intra-Baltic spread (for vectors/pathways) and thus we cannot assess the status of new arrivals per sub-basin, which would give a better view of the status.

9.2 Methodology applied

The majority of the relevant data is in point format. The processing required for making an evaluation against the baseline species list for an assessment unit only requires summing the number of new species introduced to the Baltic Sea per assessment unit. The 17 sub-basin assessment units (HELCOM Scale 2) are used for the evaluation but due to differing monitoring efforts the indicator evaluation (against the threshold) is done on the whole Baltic scale (scale 1).

The borders of the sub-basins reflect the large scale environmental gradients typical of the Baltic Sea, with salinity often being the most relevant gradient in relation to the introduction and potential large-scale spreading of NIS. The relevance of evaluating the number of new introductions on the scale of sub-basins is also due to the relatively low current detection rate of new arrivals. Monitoring programmes do not currently cover coastal areas adequately, however some monitoring activities are carried out in the coastal areas. Also, future wider implementation of port surveys and other monitoring programmes may warrant evaluations based on the coastal assessment units. Thus, existing programmes should be used for the indicator and be adapted, if possible. A further opportunity is the implementation of a cost-efficient rapid-assessment program on NIS, which already exists in some countries.

The main parameters used to evaluate whether the threshold value is achieved in this core indicator are the new species introduced by human actions to the Baltic Sea per assessment unit after the year used to determine the baseline. However, in order to increase regional coherence and comparability between the HELCOM and OSPAR environmental evaluations, the same indicator parameter processing is proposed. Therefore, the parameters 'inventory' and 'dispersal' are also considered in this core indicator. These two parameters are to be considered as supporting parameters that provide important information and their use in providing information of the spread of NIS might become more strongly incorporated in the indicator concept at a later stage of development.

Indicators evaluating the negative effects of NIS are not currently being developed in HELCOM. Advantages with the approach of the current indicator is considered to be that the indicator:

- is based on quantitative and qualitative data, not on expert judgement,
- works on a short time scale (in contrast to assessing environmental impact),
- can reflect the effectiveness of measures,
- evaluation is not dependent on earlier evaluations
- can be applied to a range of monitoring types and efforts,
- pragmatic, simple and considered to be effective,
- takes into account the current levels of uncertainty in relation to requirements for monitoring for NIS in the marine environment, and
- incorporates the same parameters as the comparable OSPAR indicator promoting regional coherence.

1. Species-Parameter

This main parameter describes how many new NIS/CS have been recorded in the Baltic Sea per assessment unit due to human actions during the assessment period. Only this parameter is used in the trend evaluation at this point in time.

SP (assessment period) = number of new introduced non-indigenous and cryptogenic species in the Baltic Sea per assessment unit

Regular monitoring of species has to be conducted to identify new human-mediated arrivals. The parameter depends on the 2010 baseline list of NIS, and only documents new species detected after 2010 per assessment unit. This parameter can be used to measure the effectiveness of measures aimed at stopping or reducing the human-mediated introductions of NIS.

The parameter can also be used to evaluate the provisional threshold value, i.e. the rate of introduction. This could provide the most accurate indication of the effectiveness of implemented management measures. For example the species parameter could be used to show the trend in the annual numbers of introductions after the implementation of ballast water management measures to enable conclusions on the ballast water management effectiveness as a management option.

2. Inventory-Parameter

The calculation of the Inventory-Parameter is not applied to the trend evaluation, but contains additional information for the state of the NIS community:

IP (assessment period) = number of NIS and CS in the assessment unit - number of NIS in the same assessment unit from the previous assessment period.

The parameter focuses on changes in the number of NIS detected in a specific assessment unit irrespective of regional species-baseline lists. The 'inventory' parameter quantifies whether the NIS species composition changes over time and focuses on changes in the total number of NIS individuals independent of the species list.

This supporting parameter enables an evaluation of whether recently introduced species persist over a longer period of time or vanishes after, for example, the following winter. The inventory parameter concentrates on the community of NIS and changes therein.

The inventory is negative if the number of disappearing NIS is higher than the number of newly introduced NIS, i.e. reflecting a good status. Should there be measures to eradicate unwanted species or NIS in general (e.g. cleaning pontoons in marinas); the Inventory Parameter can monitor the effectiveness of these measures and can provide additional information on management effectiveness at the regional and/or local level.

9.3 Monitoring and reporting requirements

Monitoring methodology

Common HELCOM monitoring of relevance to the indicator is described in the HELCOM Monitoring Manual in the programme topic: Non-indigenous species.

NIS monitoring is aimed to address all biotic components as NIS may belong to any trophic level and be found in various man-made as well as natural habitats. Non-indigenous species are occasionally detected in regular biological monitoring programmes, previously described e.g. in the COMBINE manual. Some national differences in the sampling strategies exist, thus causing some discrepancy in the predicted detection rate of new NIS arrivals. Despite differences between the countries a homogenized strategy for NIS detection should be pursued including also port monitoring.

Current monitoring

The monitoring activities relevant to the indicator that are currently carried out by HELCOM Contracting Parties are described in the HELCOM Monitoring Manual monitoring concepts table.

Prior to 2012 and the HELCOM ALIENS 2 (HELCOM 2013a) and BALSAM projects, only Estonia had monitoring of NIS in the vicinity of the port and there was no monitoring inside the actual port area. Since 2012 Estonia has carried out annual port surveys. In 2009 Germany established an annual "Rapid Assessment Survey" (RAS) to improve monitoring on non-indigenous species in ports in 2009 and extended the sampling referring to the

HELCOM/OSPAR protocol in 2016 (eRAS). Sampling was conducted in ports of various countries during the ALIENS projects, but the continuation has been dependent on the available resources. All data on the presence of NIS in ports in the Baltic Sea are currently available online.

Description of optimal monitoring

The well-established COMBINE monitoring programme, which has comprehensive quality control, is currently used for records of presence-absence of NIS in a given area, for certain taxonomic groups covered by the programme. However, while the HELCOM joint programme itself is far from sufficient both temporally and spatially (fixed sampling stations) to obtain the required information on NIS, there are certainly several elements which are very useful to exploit for NIS monitoring purposes. A variety of targeted approaches and methods have been and are being developed, which may complement, and ultimately improve NIS monitoring. These include rapid assessment surveys, monitoring of Marine Protected Areas, molecular methods (for target species, in biofouling and in ballast water), automated image analysis, public involvement (citizen science) and impact assessments. These and other emerging approaches should be considered for integration in the holistic NIS monitoring programme.

Shipping and boating are considered to be primary vectors for the introductions of new NIS into the Baltic Sea. Implementing port surveys regularly in the whole Baltic Sea would greatly increase the confidence of the indicator. The best option for a regular and regionally harmonized monitoring of NIS is the HELCOM/OSPAR protocol for the execution of port surveys (HELCOM, 2013b). The protocol has been tested in several Contracting Parties and proposed for inclusion in several national monitoring programmes. In addition leisure boat marinas should be monitored.

According to the protocol, sampling should be conducted at least twice annually (spring bloom and summer maximum) in minimum every five years to monitor the port areas and also for the purpose of granting ballast water management convention (BWMC) exemptions. During the intermediate period, reviews should take place (not more frequent than annually) based on any new information on the basis of the exemption granted including but not limited to: presence of non-indigenous species, introduction pathways for NIS, changes in physical conditions in the port.

To ensure a good detection rate of new NIS the shallow water habitats should be added to ongoing biological monitoring programmes. In these littoral areas a higher monitoring effort is needed for fish, crustaceans, mussels, snails, macroalgae and plants e.g. with habitat traps and fouling plates. Currently NIS data from monitoring is backed up with opportunistic studies and research.

10 Data

The data and resulting data products (e.g. tables, figures and maps) available on the indicator web page can be used freely given that it is used appropriately and the source is cited. The indicator should be cited as following:

HELCOM (2023). Trends in arrival of new non-indigenous species. HELCOM core indicator report. Online. [Date Viewed], [Web link]

Result: Trends in arrival of new non-indigenous species

Data: Trends in arrival of new non-indigenous species

There is a strong scientific community in the Baltic region studying NIS and a shared database (AquaNIS) compiling information from scientific papers and national studies. The approach has good prospects to give an indication of the success of management measures to minimize the introduction of non-indigenous species. It has harmonized targets in the Baltic Sea.

Data used in the indicator originates from the AquaNIS database, scientific publications, and national experts.

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12 Archive

This version of the HELCOM core indicator report was published in April 2023:

The current version of this indicator (including as a PDF) can be found on the HELCOM indicator web page.

Earlier versions of this indicator are available at:

HOLAS II component- Core indicator report – web-based version July 2017 (pdf)

Trends in arrival of new non-indigenous species HELCOM core indicator 2018 (pdf)

13 References

AquaNIS. Editorial Board, 2015. Information system on Aquatic Non-Indigenous and Cryptogenic Species. World Wide Web electronic publication. www.corpi.ku.lt/databases/aquanis. Version 2.36+. Accessed 2022-09-30.

Black, K.D. (ed.), 2001: Environmental impacts of aquaculture. Sheffield Academic Press, Sheffield.

EC, 2007: Council Regulation (EC) No 708/2007 of 11 June 2007 concerning use of alien and locally absent species in aquaculture. Official Journal of the European Union, 17pp

EC, 2008: Directive 2008/56/EC of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union, 22pp

EU, 2014: Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species.

Galil, B.S., 2007: Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. Mar Poll Bull 55:314–322.

HELCOM, 2007: HELCOM Baltic Sea Action Plan.

HELCOM, 2021: HELCOM Baltic Sea Action Plan–2021update.

HELCOM, 2013a: HELCOM ALIENS 2- Non-native species port survey protocols, target species selection and risk assessment tools for the Baltic Sea. 34 pp.

HELCOM, 2013b: Joint HELCOM/OSPAR Guidelines on the granting of exemptions under the International Convention for the Control and Management of Ships' Ballast Water and Sediments, Regulation A-4.

HELCOM and Baltic Earth, 2021: Climate Change in the Baltic Sea 2021 Fact Sheet.

Hellmann, J. J., Byers, J. E., Bierwagen, B. G., & Dukes, J. S. 2008. Five potential consequences of climate change for invasive species. Conservation Biology, 22, 534–543

Holopainen R, Lehtiniemi M, Meier HEM, Albertsson J, Gorokhova E, Kotta J, Viitasalo M 2016: Impacts of changing climate on the non-indigenous invertebrates in the northern Baltic Sea by end of the twenty-first century. Biol Invasions. DOI: 10.1007/s10530-016-1197-z

ICES, 2005: ICES CODE of Practice on the Introductions and Tranfers of Marine Organisms 2005, 30pp

ICES, 2013: ICES Advice 2013, Book 1. OSPAR special request on review of the technical specification and application of common indicators under D1, D2, D4, and D6. Available at: http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2013/Special%20requests/OSPAR_3-2013.pdf

IMO, 2004: International Convention for the Control and Management of Ships' Ballast water and Sediments, 2004. IMO document BMW/Conf/36, 38pp

Lockwood, J.L., Hoopes, M.F., Marchetti, M.P., 2007: Invasion Ecology. Wiley-Blackwell, Malden, MA, USA.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M., Bazzaz, F.A., 2000: Biotic invasions: causes, epidemiology, global consequences, and control. Ecol. Appl., 10, 689–710.

Minchin, D., Olenin, S., Daunys, D., Panov, V. 2008: Pathways of aquatic alien species in Europe: modes, trends and future spread. – ALARM (GOCE-CT-2003-506675) Project Deliverable 1.3.1.: 18 pp.

Occhipinti-Ambrogi Anna, Global change and marine communities: Alien species and climate change, Marine Pollution Bulletin, Volume 55, Issues 7–9, 2007, Pages 342-352, ISSN 0025-326X, http://dx.doi.org/10.1016/j.marpolbul.2006.11.014.

Ojaveer, H. & Kotta, J., 2014: Ecosystem impacts of the widespread non-indigenous species in the Baltic Sea: literature survey evidences major limitations in knowledge. Hydrobiologia DOI 10.1007/s10750-014-2080-5.

Ojaveer H, J Kotta, O Outinen, H Einberg, A Zaiko, M Lehtiniemi 2021. Meta-analysis on the ecological impacts of widely spread non-indigenous species in the Baltic Sea. Science of The Total Environment 786, 147375

Olenin, S., Minchin, D., Daunys, D. & Zaiko, A. 2009: Pathways of Aquatic Invasions in Europe. Atlas of Biodiversity, Chapter 6, p. 132.

Pyke, C. R., Thomas, R., Porter, R. D., Hellman, J. J., Dukes, J. S., Lodge, D. M. & Chavarria, G. 2008. Current practices and future opportunities for policy on climate change and invasive species. Conservation Biology 22: 585–592.

Rahel, F. J. & Olden, J. D. 2008. Assessing the effects of climate change on aquatic invasive species. Conservation Biology 22, 521–533.

Reise, K. , Lackschewitz, D. , Buschbaum, C. , Waser, A. M. , Wegner, M. and Thieltges, D. W. 2021. Effects of introduced marine species on biodiversity and ecosystem functions in the Wadden Sea, 15th International Scientific Wadden Sea Symposium, Online, 30 November 2021 - 2 December 2021.

Ruiz, G.M., Carlton, J.T., Grosholz, E.D., Hines, A.H. 1997: Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent, and consequences. Integr. Comp. Biol., 37, 621–632.

Sambrook, K., Holt R.H.F., Sharp R, Griffith, K., Roche R.C., Newstead R.G., Wyn G., Jenkin, S.R. 2014. Capacity, capability and cross-border challenges associated with marine eradication programmes in Europe: The attempted eradication of an invasive non-native ascidian, *Didemnum vexillum* in Wales, United Kingdom. Marine Policy, (48), 51-58.

Stachowicz, J. J., Terwin, J. R., Whitlatch, R. B., & Osman, R. W. 2002. Linking climate change and biological invasions: Ocean warming facilitates nonindigenous species

invasions. Proceedings of the National Academy of Sciences of the United States of America, 99, 15497– 15500.

Williams, F., Eschen, R., Harris, A., Djeddour, D., Pratt, C., Shaw, R.S., Varia, S., Lamontagne-Godwin, J., Thomas, S.E., Murphy, S.T., 2010: The economic cost of invasive non-native species on Great Britain. CABI Project No. VM10066.

Wolff, W.J., Reise, K. 2002: Oyster imports as a vector for the introduction of alien species into northern and western European coastal waters. In: Invasive aquatic species of Europe. Distribution, impacts and management (Leppäkoski, E., Gollasch, S., Olenin, S. eds.), 193-205.

Zaiko, A., Lehtiniemi, M., Narščius, A., Olenin, S. 2011: Assessment of bioinvasion impacts on a regional scale: a comparative approach. Biological Invasions DOI 10.1007/s10530-010-9928-z]

14 Other relevant resources

General information about NIS can be found in the Baltic Sea Environment Fact Sheet (BSEFS) 'Biopollution index' that gives more information of the impacts and the BSEFS 'Observed non-indigenous and cryptogenic species in the Baltic Sea' that gives more information on how the baseline was derived. For more species specific NIS information the BSEFS 'Abundance and distribution of Marenzelleria species', 'Abundance and distribution of Round goby' and 'Abundance and distribution of the Zebra mussel' can be referred to.