COMPLETE

DECISION SUPPORT SYSTEM FOR THE BALTIC SEA BALLAST WATER MANAGEMENT

WP3.4 Report of the COMPLETE project

Matej David and Stephan Gollasch

CONTENT

EXECUTIVE SUMMARY

Decision Support Systems (DSS) are supporting tools enhancing a decision-making process. Decision-makers are faced with the difficulty of taking decisions especially on very complex issues. This usually needs input of large data sets and a timely decision process is required. DSSs are multi-faceted tools to provide decision makers with an instrument to (a) reduce uncertainties, (b) simplify and speed-up the decision process without losing essential information, (c) avoid subjectivism induced by the decision-maker and (d) guarantee transparency of the entire decision process. The DSS approach was introduced in Ballast Water Management (BWM) because of the selective BWM approach, which means that the appropriate BWM measures to take vary depending on the different levels of risk posed by the intended ballast water discharge, which also depends on the BWM feasibility in certain circumstances. More precisely, it was soon recognised that a supporting tool is needed to provide transparency and consistency on BWM requirement decisions with the aim to improve environmental protection and to lessen the BWM burden on vessels. The DSS process has several steps and starts with communication and data input, continues with risk assessment (RA), BWM decisions, vessel's action(s), and ends with a compliance monitoring and RA review process.

During the complete decision process, information needs to be exchanged with sources from the outside (e.g., vessel, other ports) and inside sources (e.g., vessel's particulars, compliance history). Therefore, adequate communication processes and data management is essential. When the required BWM measures were not conducted to the satisfaction of the Port State Authority (PSA), the BWM DSS endpoints range from discharging unmanaged ballast water to cases where vessels may be turned away.

According to the BWM Convention some vessels will continue with complying with the D-1 standard and conduct Ballast Water Exchange (BWE) as a BWM option until 2024, when the D-2 standard will be required for all vessels. In terms of the Baltic Sea, considering the BWM Convention required depth and distance from the nearest shore, BWE may be conducted mainly in the intercontinental shipping when crossing the ocean, or in the area of the Bay of Biscay. It should be noted that BWE in the Baltic Sea according to the BWM Convention is impossible to be conducted as the depth and distance requirements for BWE cannot be met, and Baltic countries decided not to designate any BWEA in the Baltic Sea. It was further agreed that BWE is not a BWM option for vessels sailing between the North Sea and the Baltic Sea although OSPAR has designated a Ballast Water Exchange Area (BWEA), but is to be used only for the intra-North Sea shipping. Therefore, this DSS excludes BWE for vessels on these routes as BWM option.

This report provides a detailed step-by-step BWM DSS model, also considering Baltic Sea specifics, BWM exceptions, exemptions (BWM Convention Regulation A-4) including Same Risk Area (SRA)

scenarios. We believe that this BWM DSS cannot work efficiently in paper format as the models and data management are too complex to be done manually, hence it would be best facilitated as an electronic online BWM DSS tool.

1. INTRODUCTION

Meeting ballast water management requirements is a complex task per se, but may be even more difficult when considering local specifics. The International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) provides globally unified prevention measures of species introductions, but as the ballast water issue is complex, the implementation of this convention is far from easy. This complexity becomes clear as more than 15 guidelines, other guidance documents or unified interpretations were needed, all in all with more than 500 pages of text, to support the (BWM Convention). In such a situation the end-users would largely benefit from getting help to get an overview of subjects to address. The here presented Decision Support System (DSS) is such a tool. The first BWM DSS was developed by David (2007), and then further developed during the EU wide project VECTORS (2011-2015) and the regional Adriatic Sea project BALMAS (2013-2016), on which this work is mainly based and taken further in COMPLETE project to consider the Baltic specifics and new subject developments. It should be noted that this BWM DSS has considered Baltic specifics on the BWM. Specifics dealt with by the Baltic countries mainly through HELCOM, which are referenced in this work, while there are other decisions which were not yet considered, hence these remain to be discussed and afterwards may be adapted when Baltic countries would take a different decision in the future. In 2016 IMO GloBallast recognised the need to have globally BWM supported by a Risk Assessment (RA) based BWM DSS. The review of other DSS conducted during COMPLETE did not result in any other BWM specific DSS developments. The below presented BWM DSS is heavily based on David and Gollasch (2015b) but we have not repeatedly cited this reference below as citations would become too numerous. Other figures were based upon other publication and those references were cited in the figure capture. Please note further that some of the figures are difficult to read and we included an Annex 1 to the report with all figures to zoom in for better readability.

The BWM Convention D-2 standard, which can be met by use of BWM system (BWMS), is being gradually implemented until 2024. All new vessels have to eventually meet the D-2 standard. Until the due date to meet the D-2 standard, existing vessels have to conduct Ballast Water Exchange (BWE) in open waters according to the D-1 standard. In detail this means that existing vessels built prior to 8 September 2017 have to meet the D-1 standard until their D-2 date of compliance. New vessels built on or after 8 September 2017 have to meet the D-2 standard when they enter into service. What existing vessels with a renewal survey[1] between 8 September 2017 and 8 September 2019 need to comply with is described in the following two cases. Case 1: if the previous renewal survey was between 8 September 2014 and 8 September 2017 they must comply with D-2 by their renewal survey. Case 2: if the previous renewal survey was before 8 September 2014 then D-2 compliance applies by the next renewal survey. Existing vessels with the renewal survey after 8 September 2019 have to meet the D-2 standard by their renewal survey. All vessels must meet the

[1] 'Renewal survey' refers to the IOPPC renewal survey under MARPOL Annex I.

D-2 standard by 8 September 2024. With this, some vessels may continue with BWE as the only BWM option until 8 September 2024.

The complexity of this subject is not only the result of the fact that eventually all vessels need to manage their ballast water. Under certain circumstances, vessels do not need to meet BWM requirements as stated in the BWM Convention. Besides RA based exemptions (BWM Convention Regulation A-4) and exceptions (BWM Convention Regulation A-3) to ensure e.g., (a) the safety of a ship, (b) discharge of ballast water for the purpose of avoiding or minimizing pollution incidents, (c) uptake and discharge on high seas of the same ballast water, the Same Location (SL) concept comes into play as under BWM Convention Regulation A-3 ballast water discharges from a ship at the same location where it was taken up is also excepted from BWM requirements. We recommend that SL mean the smallest practicable unit, i.e., the same harbor, mooring, or anchorage. An entire smaller port, possibly also including the anchorage, could be considered as a SL. For larger ports with a gradient of environmental conditions, SL should mean a terminal or a port basin (David et al. 2013). Another approach to exempt vessels from ballast water management requirements (BWM Convention Regulation A-4) refers some ships where the risk level of ballast water discharge is acceptable based on IMO G7 Guidelines on Risk Assessments (IMO 2017) and there is a Joint Harmonized Procedure (JHP) to be followed in the HELCOM/OSPAR area (HELCOM 2013, HELCOM/OSPAR TG Ballast 2016). Further, in certain areas, the same risk area (SRA) concept may apply (IMO 2017). In summary, the area which all selected species may be able to reach with their natural spread is seen as SRA in which no BWM requirement applies for vessels sailing only in such an area. As an example, a SRA may include several ports in close proximity in two or more neighboring countries along a coast line, across a strait, a bay or a river mouth (IMO 2017).

It is important to note that BWM Convention requirements for BWE cannot be met in the Baltic Sea as the depth and distance from nearest land conditions are absent. Therefore, HELCOM agreed, after having developed different BWE scenarios, not to recommend BWE in intra-Baltic shipping, for which the designation of a BWEA would be needed. Further, it was agreed that BWE can also not be done for vessels sailing between the North Sea and the Baltic Sea. Therefore, this DSS excludes BWE as a routine BWM option for vessels on these routes. However, vessels on the way to the Baltic navigating through areas where BWE is possible, e.g., in the intercontinental shipping when crossing the ocean or in the area of the Bay of Biscay, should do BWE and this is why BWE-related aspects are included in this DSS (OSPAR 2014, HELCOM 2014, 2016, 2019a, b, BSH 2019).

1.1 What is a decision support system?

In general, a Decision Support System (DSS) is a supporting tool to enhance a decision-making process (Bhatt and Zaveri 2002; David and Gollasch 2015a, b, c). DSSs use a combination of (a) models, (b) analytical techniques and (c) information retrieval to support the development and evaluation of appropriate decision alternatives (Adelman 1992; Sprague and Carlson 1982; Sojda

2007). DSSs are widely used today to support decision-making processes in different fields, including business, social and life sciences, medicine, politics, games, information technologies as well as transport (Marquez and Blanchar 2006), and they are also major components in environmental assessment, management and science (Denzer 2005).

Decision-makers frequently face the problem to make decisions on very complex issues, which may require large data inputs and a timely decision making process. DSSs are used by decision makers as a tool to reduce uncertainties (Graham and Jones 1988), and to simplify and speed-up the decision process without losing essential information. DSS further increase the transparency and reduce subjectivism in the decision making process.

1.1.1 Decision process and decision support system

One of the critical factors in the decision making process is subjectivism which is induced by the decision-making operator (Paradice 2006). This occurs mostly because different decision-makers have varying experience as well as knowledge levels and different background, skills, moods, etc. The use of DSS is important from this point of view, as, by principle, it eliminates subjectivity impacts of different decision-makers in the same process. This leads to more consistent results – i.e., decisions. Use of DSSs also ensures consistency of decisions taken by the same decision-maker. However, the DSS is exposed to subjectivity during its preparation and/or construction process. The decision-making process results may further be influenced by the authorities who order a DSS and this is sometimes almost anticipated, i.e., they like to achieve a certain result of their interest.

Another critical point is the transparency during a decision making process. DSS should be designed in a way that the decision models as well as the decision steps are transparent, which enables a review of the decision making process at any future moment in time. This becomes especially critical in cases when a DSS is used in a regulatory framework.

Any possible errors resulting from a decision making process should be known. Errors could occur in the view of exactness and accuracy. Here, exactness means that a step of the decision making process, or the process itself, under certain circumstances, e.g., lacking of data, data reliability, data precision, subjective impacts, could produce a biased and possibly false result. Accuracy means that the result of a step in the decision process, or the entire process itself, may show a certain discrepancy or deviation because of certain instances. Hence, the DSS has to result in exact answers with an acceptable accuracy.

1.1.2 Decision support system generic structure

DSSs may consist of different elements and structures depending on their application field and complexity (Denzer 2005). However, although DSS details may differ, their very generic framework

may be similar in several application fields and generally, it contains decisions and data management. Decisions include management decision steps and decision models (see Figure 1) which are representing the core elements of DSSs. The data management as DSS components requires databases for data retrieval and data storage.

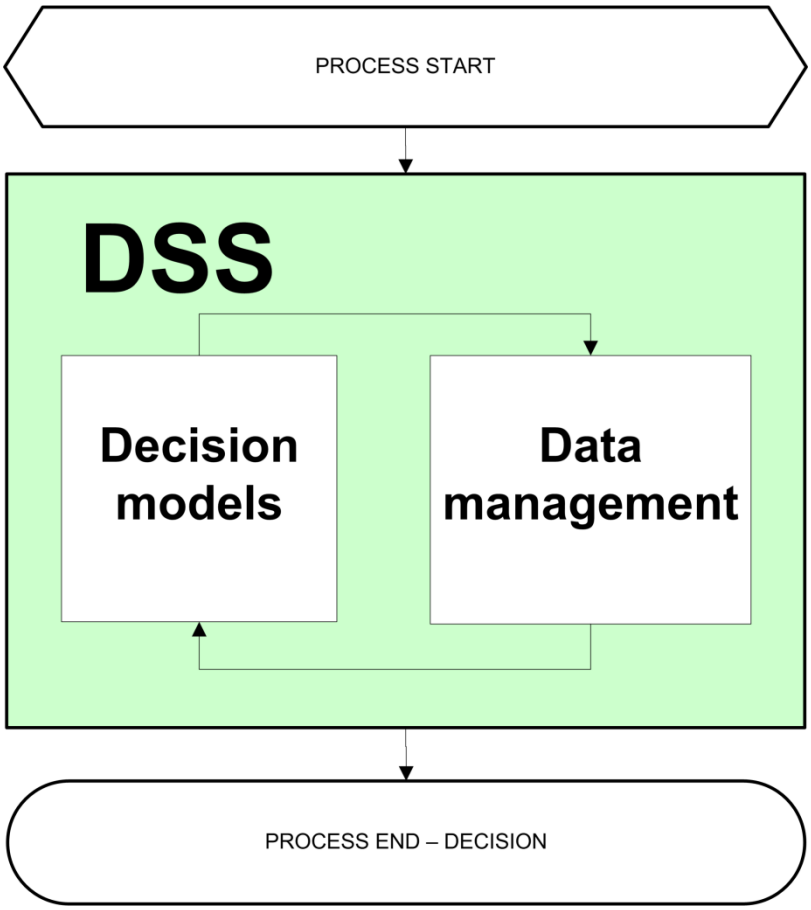

Figure 1 - Basic structure of a decision support system (DSS) showing how decision models and data management are related.

The integration of basic DSS elements is important when preparing a computer support architecture (Denzer 2005). As an example, the DSS focus and/or application may use different methodologies to support the decision making process as, e.g., multicriteria decision making (e.g., Vincke 1993), fuzzy logic (e.g., Ru and Eloff 1996; Ekel 2002; David and Malej 2002), neural networks and decision trees (David 2007). Once a computer model for a DSS process is prepared, it can also be used, with adaptations as appropriate, for other similar applications and hence facilitates the development of a new DSS.

2. BALLAST WATER MANAGEMENT DECISION SUPPORT SYSTEM

The DSS approach was introduced in BWM and its need primarily arose due to the introduction of the selective BWM approach. More precisely, DSS is a supporting tool which is needed to aid transparency and consistency when deciding on most efficient BWM requirements and further to lessen the burden on vessels (David 2007, David and Gollasch 2008, David et al. 2015a, b).

The RA result is the level of risk posed to the environment, which receives the ballast water and according to each level of risk identified different BWM measures may be applied. Please note that this BWRA is different from the RA for BWM exemptions and the need for data reliability and accuracy in BWRA can be acceptable to be lower than for RA for exemptions (David and Gollasch 2015a). As per this result, a "what to do" decision is provided by the DSS and followed by appropriate preventive BWM action. Monitoring of compliance with the BWM regime implemented (i.e., requested actions) is essentially needed. Further, compliance monitoring and the DSS effectiveness review also need to be conducted. Whenever necessary, corrective actions are to be taken (see Figure 2).

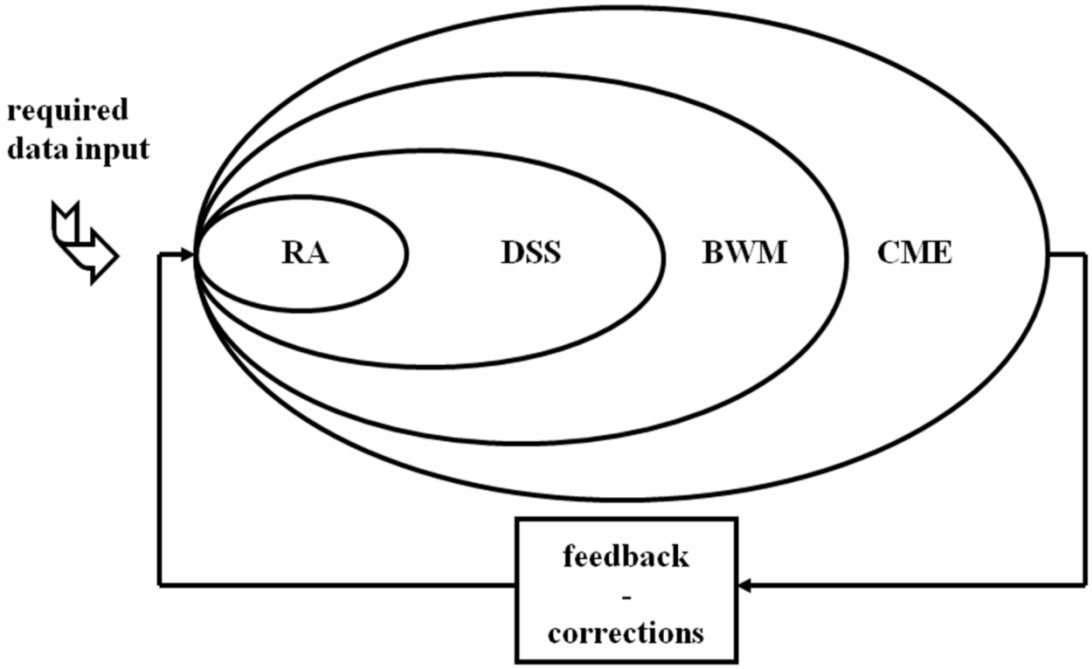

Figure 2 - The BWM process under the selective approach supported by the DSS (after David 2007).
BWM = Ballast Water Management, CME = Compliance Monitoring and Enforcement, RA = Risk Assessment.

While the RA result is a “simple” answer related to the level of risk, in the following steps a much more complex process is generated when a decision on “what to do” needs to be taken as a consequence of the RA result, vessel trustworthiness, adequate and feasible BWM options, etc. DSS is the essential core part or, in other words, the brain of the whole process.

2.1 The Ballast water management decision support system model

2.1.1 Model high level elements and sequences

The DSS process starts with communication and input of data, it continues with RA, BWM decisions, vessel’s action(s) and it ends with a compliance monitoring and RA review process. During the entire decision process an information exchange needs to occur with outer (e.g., vessel, other ports) and inner sources (e.g., vessel’s particulars, compliance history). Therefore, this process needs to be supported by adequate communications and data management (see

Figure 3).

One of the different critical issues is the position, situation and location of the vessels in relation to its ability to comply with required BWM measures. In view of this we created four situations a vessel may be facing:

Situation (1) - a vessel has left the last port of call and is enabled to conduct BWM on its intended route, and:

- has sufficient time and is also in a condition to conduct the requested BWM measure(s);
- conducts BWM measures according to the requirements posed and she enters the port with the permission to discharge ballast water.

Situation (2) – a vessel has left the last port of call but is unable to conduct BWM on its intended route, and she may already have arrived in the port of call but the port entry permit[2] is not yet issued, and:

- she did not manage the ballast water on board by a BWMS;
- she did not conduct BWM, but she complies with the requirements (in case the D-1 standard is required) because its intended route does not exit the 50 nautical miles from nearest land and 200 metres water depth limits to enable a BWE;
- she did not conduct BWM for other reasons;
- she is slowed down to conduct BWE and therefore complies with the requirements (currently unavailable in intra Baltic shipping);

[2] permit to start operations in a port, including anchorage, after having complied with port State requirements and submitted all required documents for port entry

- she would need to be sent outside the 50 nautical miles and 200 metres water depth limits, or use an alternative solution[3] to conduct BWM to comply with the requirements (currently unavailable in intra Baltic shipping);
- she, depending on the BWRA result, may be allowed to discharge unmanaged ballast water,
- she may be penalized, or
- she may not be allowed to discharge ballast water without having conducted BWM.

Situation (3) - the vessel has already arrived in the port of call and has received the port entry permit, and:

- she may be targeted for different levels of compliance control;
- if she is found non-compliant with BWM requirements and depending on the RA result, she may be allowed to (a) discharge unmanaged ballast water, (b) may be penalized, or (c) may not be allowed to discharge unmanaged ballast water.

Situation (4) - the vessel has received clearance[4] and left the port, and:

- her ballast water was sampled and was identified as non-compliant with BWM requirements. This non-compliance is communicated to (a) the vessel, (b) the vessel's administration, (c) the recognized organization responsible for issuing of the certificates, and (d) the next port of call; or
- her ballast water was sampled and was identified as compliant with BWM requirements. In this case no action is required.

Different conditions may apply when the vessel is under one of the following conditions:

- exception,
- exemption, or
- SRA.

In such situation, the vessel would report to PSA under which regime she operates and would proceed to the discharge of untreated ballast water. The vessel may be selected for CME procedure, in which verification of compliance with the exception, exemption, or SRA status and compliance with required conditions would be checked. In the case when non-compliance is identified, this is communicated to (a) the vessel, (b) the vessel's administration, (c) the recognized organization responsible for issuing of the certificates, and (d) the next port of call. When she is found non-compliant with BWM requirements and depending on the BWRA result, she may be allowed to (a) discharge unmanaged ballast water, (b) may be penalized, or (c) may not be allowed to discharge unmanaged ballast water.

[3] e.g., port reception facilities

[4] permit to leave the port after having complied with port State requirements and submitted all required documents for leaving the port

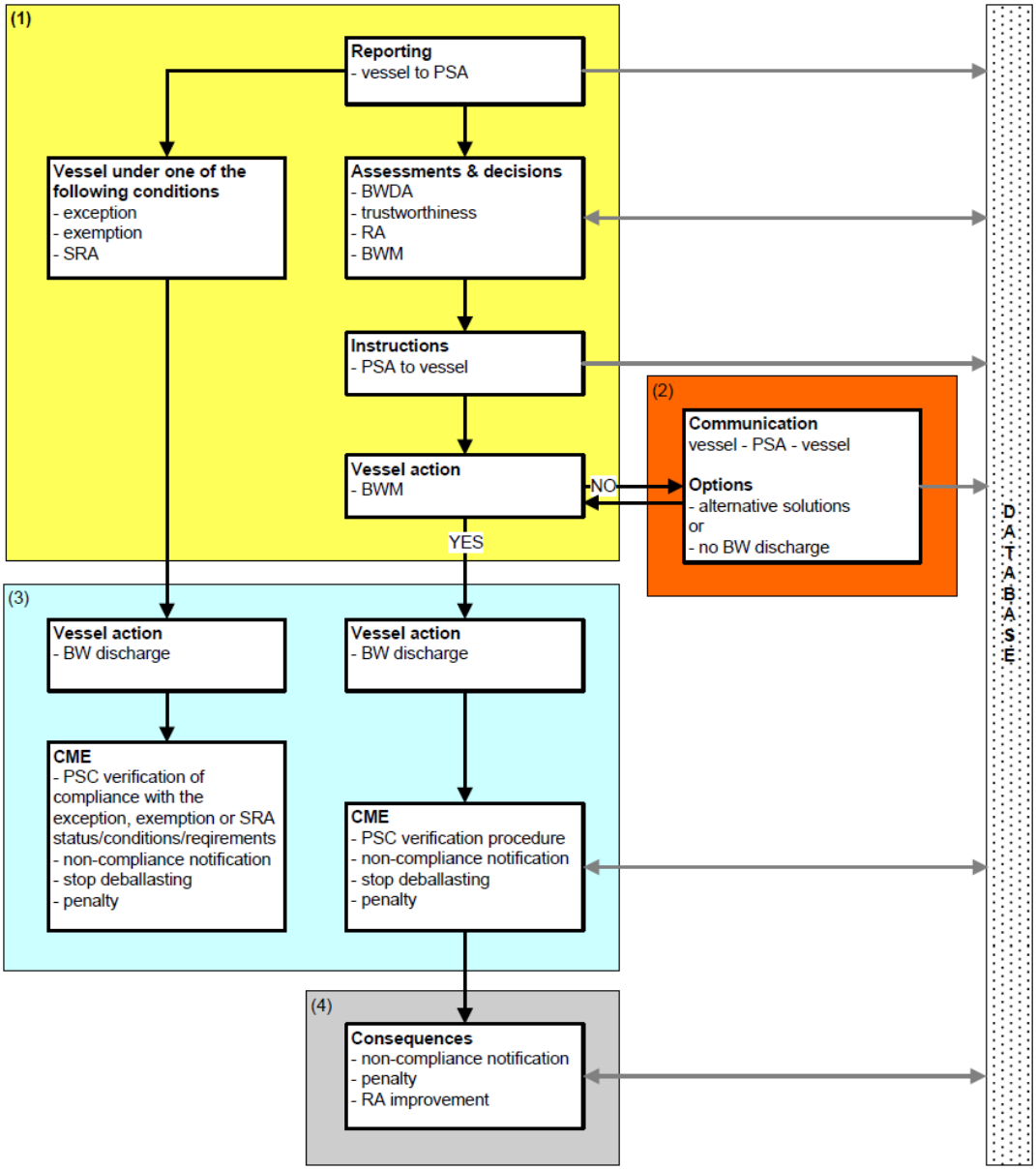

Figure 3 - DSS model high level elements. BW = Ballast Water, BWDA = Ballast Water Discharge Assessment, PSA = Port State Authority, PSC = Port State Control, SRA = Same Risk Area. Yellow box is Situation (1) - vessel is on the way to port of call, BWM enabled; orange box is Situation (2) - vessel is on the way to port of call or even entered the port, no BWM enabled and the port entry permit is not yet issued; light blue box is Situation (3) - vessel is in the port, the port entry permit is issued; and grey box is Situation (4) - vessel has left port of call.

The DSS integrates six basic elements:

- collection of data and the management process;
- the communication processes;
- the ballast water RA process;
- the BWM decision and action process;
- the compliance monitoring process; and
- the RA review process.

Each element has its own function and the structure of the DSS provides for their effective integration and further supports their independent functioning as well as their mutual interrelations.

2.1.1.1 Data collection and management process

The data collection process is of critical importance simply because decisions are based on these data; i.e., input of wrong data results in a wrong answer. This mostly relies on port States because the BMW Convention has no reporting requirements from vessels to ports regarding ballast water operations, but it only requires an on board BWM log book. Here two main aspects need to be considered, i.e., data availability and data reliability.

Considering data availability, correct data need to be made available at the right time. This means all data needed for the entire process to enable all decision taking are essential. This includes biological data on ballast water donor ports, environmental data from donor and recipient ports and the vessels data on previous reporting. It is important that the data are available timely to ensure that the vessel can conduct the requested BWM practice; i.e., time needed to conduct RA, take a decision on BWM requirements, communicate with the vessel, conduct BWM or take appropriate action.

Data reliability has qualitative and quantitative aspects. In the first place, this means that the data quality for the DSS input data is based on reliable sources. In terms of quantity, enough comprehensive data should be available to ensure statistically robustness.

Most of the data received from external sources as well the data from the decision process need to be managed properly, have to be safely stored and need to be accessible. This may be best arranged in a DSS database. Such a database would provide the DSS with the information needed, e.g., vessels particulars, vessels compliance history, HELCOM database on port conditions and data from port surveys, as well as it would also serve the needs of outer sources; e.g., sharing information with other stakeholders, provision of data for a DSS review process and also as back-up for a later review process of a single decision.

2.1.1.2 Communication processes

The communication process consists of communication pathways among the port State authority (PSA) and:

- the vessel;
- her administration;
- her recognized organization responsible for the issue of certificates
- her next port of call; and
- IMO.

The essentially needed communication requirements regarding BWM are established between PSA in the ballast water recipient port and the vessel intending to discharge ballast water as follows:

- the vessel intending to discharge ballast water submits the requested information as ballast water reporting form (BWRF) to the PSA;
- PSA communicates to the vessel the decision on the BWM requirements;
- other communication, e.g., in case the BWRF was not satisfactory completed or the vessel was unable to conduct the required BWM.

Should a vessel be found non-compliant with the BWM Convention requirements, PSA, which established the needs, has to communicate it to the related vessel, the vessel's Administration, the next port of call of this vessel and the recognized organization responsible for the issuing of certificates. Should additional BWM measures be implemented in, e.g., cases of a known epidemic or emergency situation, PSA needs to communicate this requirement to all vessels in the area(s) under their jurisdiction where vessels should not uptake ballast water and this ballast water uptake avoidance area(s) needs also be communicated to IMO.

In this subject the preferred communication pathway is likely via electronic options, fully or partially automated, e.g., via internet applications, email, fax, telex, vessels agents, telephone etc. Information exchange on paper is considered as impractical since the information flow would not work and would not be implemented into DSS in a timely manner.

2.1.1.3 Ballast water risk assessment (BWRA)

RA forms a core part of DSS triggering different decisions regarding:

- Required BWM practices;
- compliance monitoring needs; and
- levels of vessel inspection.

In RA based DSS, the decisions on appropriate BWM practices may rely on the results of the RA, e.g., high/very high risk – the vessel must conduct BWM and may take some additional measure (e.g., BWE with treatment[5]), medium risk – the vessel should conduct BWM, and in cases of low risk – the vessel also should conduct BWM, but in the situation of failure/inability the vessel may not be forced to conduct additional measures (see more details below in 2.1.1.4) and let proceed with operations without conducting BWM. The RA results are further critical for taking compliance monitoring decisions; i.e., targeting vessels for inspections, as well as taking decisions on the level of detail of an inspection, i.e., paper checks, indicative ballast water sampling (BWS), detailed BWS.

2.1.1.4 Ballast water management decisions and actions

Management decisions in this context are the required BWM practices, which are selected on the (a) basis of the RA result, (b) vessels trustworthiness, (c) if the BWM measures have already been undertaken and (d) their acceptability. Based on the BWRA result and the vessel's trustworthiness, she may also in the situation of failure/inability to conduct BWM the vessel may not be forced to conduct additional measures and let proceed with operations without conducting BWM. On the contrary she may also be exposed to additional measures according to the level of risk assessed. Possible additional measures, i.e., those in addition to the section B of the BWM Convention, include to (a) conduct BWE in addition to complying with the D-2 standard, (b) deviate from the intended route, (c) slow down to conduct full BWE, (d) treat ballast water with active substances before discharge, (e) discharge ballast water to a reception facility, or (f) do not discharge unmanaged ballast water at all.

2.1.1.5 Compliance monitoring and enforcement

Compliance monitoring focuses on the adequate and effective implementation of the required BWM practices by that port State. This process may be triggered in several cases, including suspected false ballast water reporting (e.g., ballast water discharge assessment (BWDA) result, vessels and/or crews trustworthiness), suspected non-compliance, RA (e.g., when high/very high risk ballast water has to be discharged), or by random vessel selection as part of a regular inspections process. A vessel selected for compliance monitoring will be inspected, and should she be non-compliant, the ballast water operation may be terminated, and the vessel may also be penalized.

2.1.1.6 Risk assessment review process

A RA review process has to be implemented which is critical for further improvements of the BWM DSS process and results. Such a review process should include a re-assessment of the RA procedure based on ballast water sampling results.

[5] Studies have shown that the greatest protection occurred when BWMS were used in combination with BWE, especially when the recipient port is of freshwater condition (Briski et al. 2015, First & Drake 2017, Paolucci et al. 2017).

2.1.2 Generic ballast water management decision support system model

In general, the BWM DSS process begins with the vessel to submit the required data for port entry, followed by BWRA and BWM, it ends with a monitoring process. Should it be necessary, results also in corrective actions of the process. Throughout the entire process a dynamic flow of information exchange is required and this should be supported by adequate communication processes and data management. Noting the variety of different situations and issues which may arise during each vessel call to a port (e.g., non-adequate or false reporting, non-ability to comply with required BWM measure(s), technical issues) the BWM DSS model was designed to cover all possibly predictable events, as well to respond rapidly. The generic model is presented in Figure 4, which is followed by the presentation and description of all detailed BWM DSS elements in sequence.

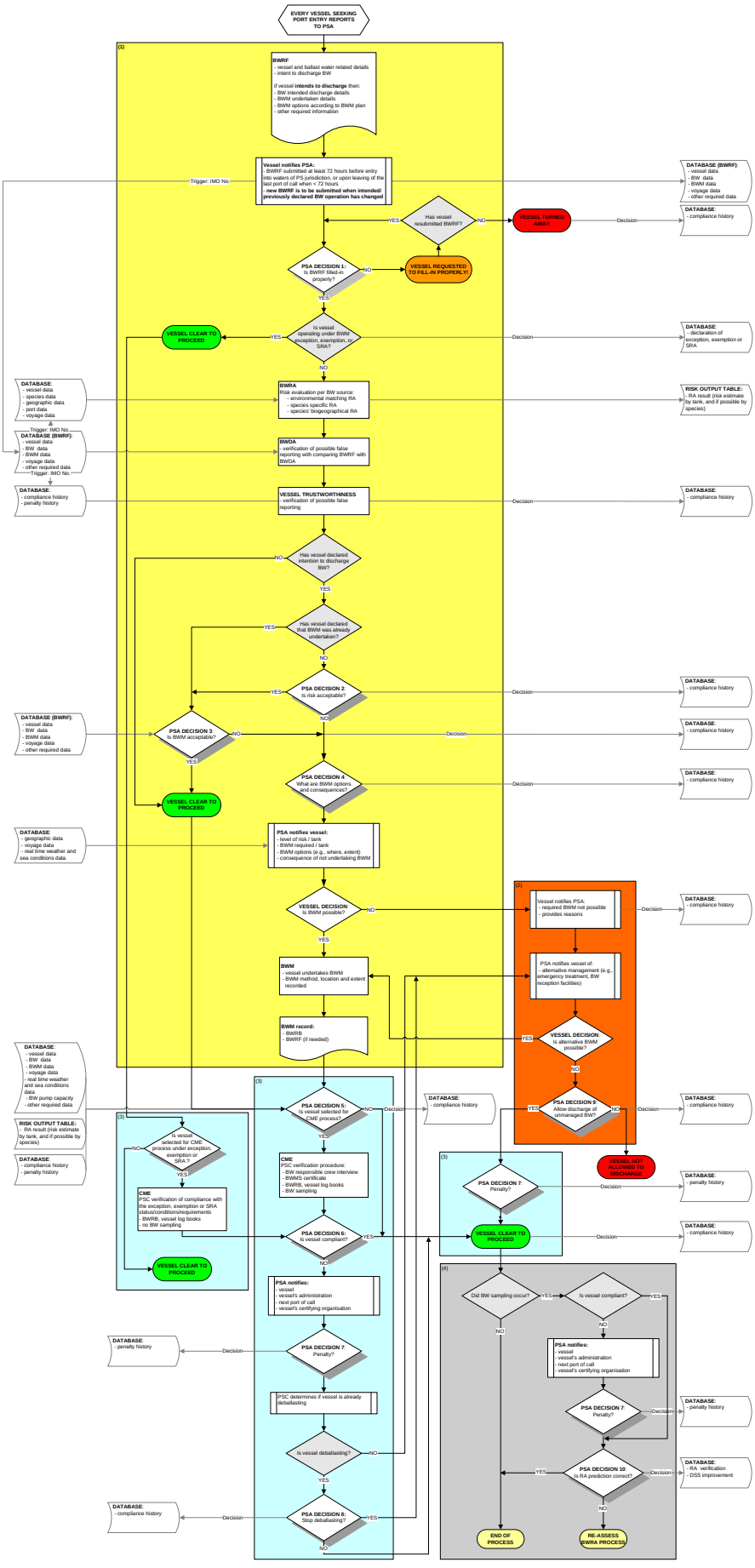
EVERY VESSEL SEEKING PORT ENTRY REPORTS TO PSA
(1)
BWRF
- vessel and ballast water related details
- intent to discharge BW
If vessel intends to discharge then:
- BW intended discharge details
- BWM undertaken details
- BWM options according to BWM plan
- other required information
Vessel notifies PSA:
- BWRF submitted at least 72 hours before entry into waters of PS jurisdiction, or upon leaving of the last port of call when < 72 hours
- new BWRF is to be submitted when intended/ previously declared BW operation has changed
Trigger: IMO No.
DATABASE (BWRF):
- vessel data
- BW data
- BWM data
- voyage data
- other required data
Has vessel resubmitted BWRF?
YES
NO
VESSEL TURNED AWAY
Decision
DATABASE:
- compliance history
PSA DECISION 1:
Is BWRF filled-in properly?
NO
VESSEL REQUESTED TO FILL-IN PROPERLY!
YES
Is vessel operating under BWM exception, exemption, or SRA?
YES
VESSEL CLEAR TO PROCEED
Decision
DATABASE:
- declaration of exception, exemption or SRA
NO
DATABASE:
- vessel data
- species data
- geographic data
- port data
- voyage data
BWRA
Risk evaluation per BW source:
- environmental matching RA
- species specific RA
- species' biogeographical RA
RISK OUTPUT TABLE:
- RA result (risk estimate by tank, and if possible by species)
Trigger: IMO No.
DATABASE (BWRF):
- vessel data
- BW data
- BWM data
- voyage data
- other required data
BWDA
- verification of possible false reporting with comparing BWRF with BWDA
Trigger: IMO No.
DATABASE:
- compliance history
- penalty history
VESSEL TRUSTWORTHINESS
- verification of possible false reporting
Decision
DATABASE:
- compliance history
Has vessel declared intention to discharge BW?
NO
YES
Has vessel declared that BWM was already undertaken?
YES
NO
PSA DECISION 2:
Is risk acceptable?
YES
NO
Decision
DATABASE:
- compliance history
DATABASE (BWRF):
- vessel data
- BW data
- BWM data
- voyage data
- other required data
PSA DECISION 3:
Is BWM acceptable?
NO
YES
Decision
DATABASE:
- compliance history
PSA DECISION 4:
What are BWM options and consequences?
Decision
DATABASE:
- compliance history
VESSEL CLEAR TO PROCEED
DATABASE:
- geographic data
- voyage data
- real time weather and sea conditions data
PSA notifies vessel:
- level of risk / tank
- BWM required / tank
- BWM options (e.g., where, extent)
- consequence of not undertaking BWM
VESSEL DECISION
Is BWM possible?
NO
YES
Decision
DATABASE:
- compliance history
(2)
Vessel notifies PSA:
- required BWM not possible
- provides reasons
PSA notifies vessel of:
- alternative management (e.g., emergency treatment, BW reception facilities)
VESSEL DECISION
Is alternative BWM possible?
YES
NO
PSA DECISION 9:
Allow discharge of unmanaged BW?
YES
NO
Decision
DATABASE:
- compliance history
VESSEL NOT ALLOWED TO DISCHARGE
BWM
- vessel undertakes BWM
- BWM method, location and extent recorded
BWM record:
- BWRB
- BWRF (if needed)
DATABASE:
- vessel data
- BW data
- BWM data
- voyage data
- real time weather and sea conditions data
- BW pump capacity
- other required data
RISK OUTPUT TABLE:
- RA result (risk estimate by tank, and if possible by species)
DATABASE:
- compliance history
- penalty history
(3)
Is vessel selected for CME process under exception, exemption or SRA ?
NO
YES
CME:
PSC verification of compliance with the exception, exemption or SRA status/conditions/requirements
- BWRB, vessel log books
- no BW sampling
VESSEL CLEAR TO PROCEED
(3)
PSA DECISION 5:
Is vessel selected for CME process?
NO
YES
Decision
DATABASE:
- compliance history
CME
PSC verification procedure:
- BW responsible crew interview
- BWMS certificate
- BWRB, vessel log books
- BW sampling
PSA DECISION 6:
Is vessel compliant?
YES
NO
PSA notifies:
- vessel
- vessel's administration
- next port of call
- vessel's certifying organisation
PSA DECISION 7:
Penalty?
Decision
DATABASE:
- penalty history
PSC determines if vessel is already deballasting
Is vessel deballasting?
NO
YES
PSA DECISION 8:
Stop deballasting?
YES
NO
Decision
DATABASE:
- compliance history
(3)
PSA DECISION 7:
Penalty?
Decision
DATABASE:
- penalty history
VESSEL CLEAR TO PROCEED
Decision
DATABASE:
- compliance history
(4)
Did BW sampling occur?
YES
NO
Is vessel compliant?
YES
NO
PSA notifies:
- vessel
- vessel's administration
- next port of call
- vessel's certifying organisation
PSA DECISION 7:
Penalty?
Decision
DATABASE:
- penalty history
PSA DECISION 10:
Is RA prediction correct?
YES
NO
Decision
DATABASE:
- RA verification
- DSS improvement
END OF PROCESS
RE-ASSESS BWRA PROCESS

Figure 4 - BWM DSS generic model. The yellow box is Situation (1) - vessel is on the way to port of call, BWM enabled; orange box is Situation (2) - vessel is on the way to port of call or even entered the port, no BWM enabled and the port entry permit is not yet issued; light blue box is Situation (3) - vessel is in the port, the port entry permit is issued; and grey box is Situation (4) - vessel has left the port (BWRA = Ballast Water Risk Assessment, BWRB = Ballast Water Record Book, BWRF – ballast water reporting form, SRA – Same Risk Area.

2.1.2.1 Vessel intended to enter a port

Each vessel seeking a port entry permit has to submit ballast water information requested by the PSA. This can be done via BWRF or electronic means, depending on PSA requirements. To implement selective BWM supported by BWM DSS, ballast water reporting in advance is crucial, hence it needs to be a mandatory requirement for port entry (see Figure 5).

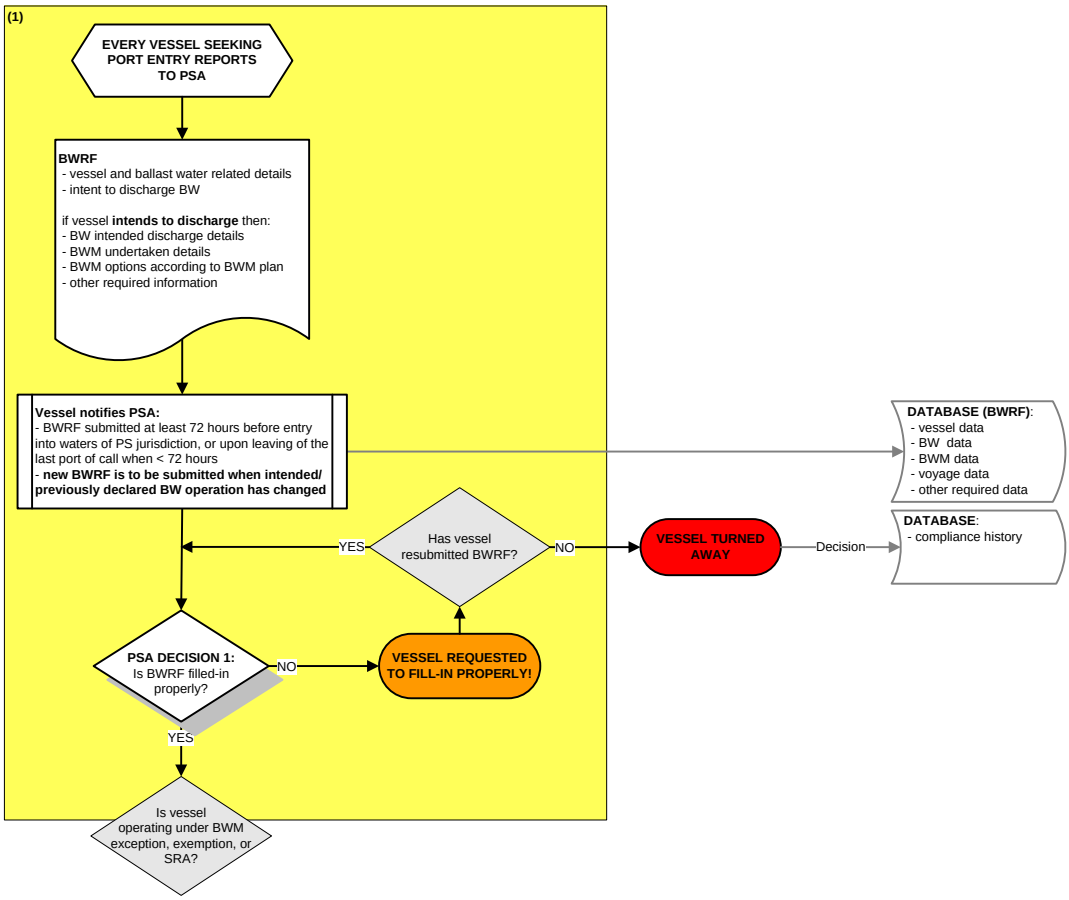

Figure 5 - BWRF submission process (PSA = Port State Authority).

BWRF need to be submitted 72 hours in advance of reaching the port State waters. In general, BWRF is best to be submitted as soon as possible; i.e., when the vessel crew knows what ballast water operations are to be expected in the next port of call. An early BWRF submission may not always be possible because two ports may be too closely located. In such a case the vessel submits the BWRF when leaving the last port of call. An early submission of BWRF is critical to give the PSA enough time to take a decision on the appropriate BWM measure(s), as well as for the vessel to be enabled

to conduct the required BWM practice. When the intended and/or previously declared ballast water operation has changed, a new BWRF is to be submitted to PSA.

2.1.2.1.1 Decision 1: Was BWRF filled-in properly?

As a prerequisite, BWRF has to be filled-in properly to start the DSS process. It is absolutely critical for the PSA, i.e., DSS, that all required data are available to enable proper BWM decision taking. However, omissions, mistakes, as well as false-reporting may be anticipated. For these reasons, the data provided need to be checked quantitatively as well as qualitatively. A vessel cannot obtain a port entry permit if she does not submit all data required (which is the same practice as for other required reporting). These cases are also registered in the “compliance history” database (see Figure 6).

In the first two steps the BWRF is checked to make sure that all required fields in the BWRF are filled-in properly and that the vessel’s basic data correspond with the IMO number. Should this not be the case, the BWRF should not be accepted and the vessel becomes automatically turned away. In case when an electronic BWRF submission system is used, this can be checked automatically and the BWRF is not submitted on paper.

In the third step the data submitted are further checked qualitatively (see Figure 6, grey box on the left).

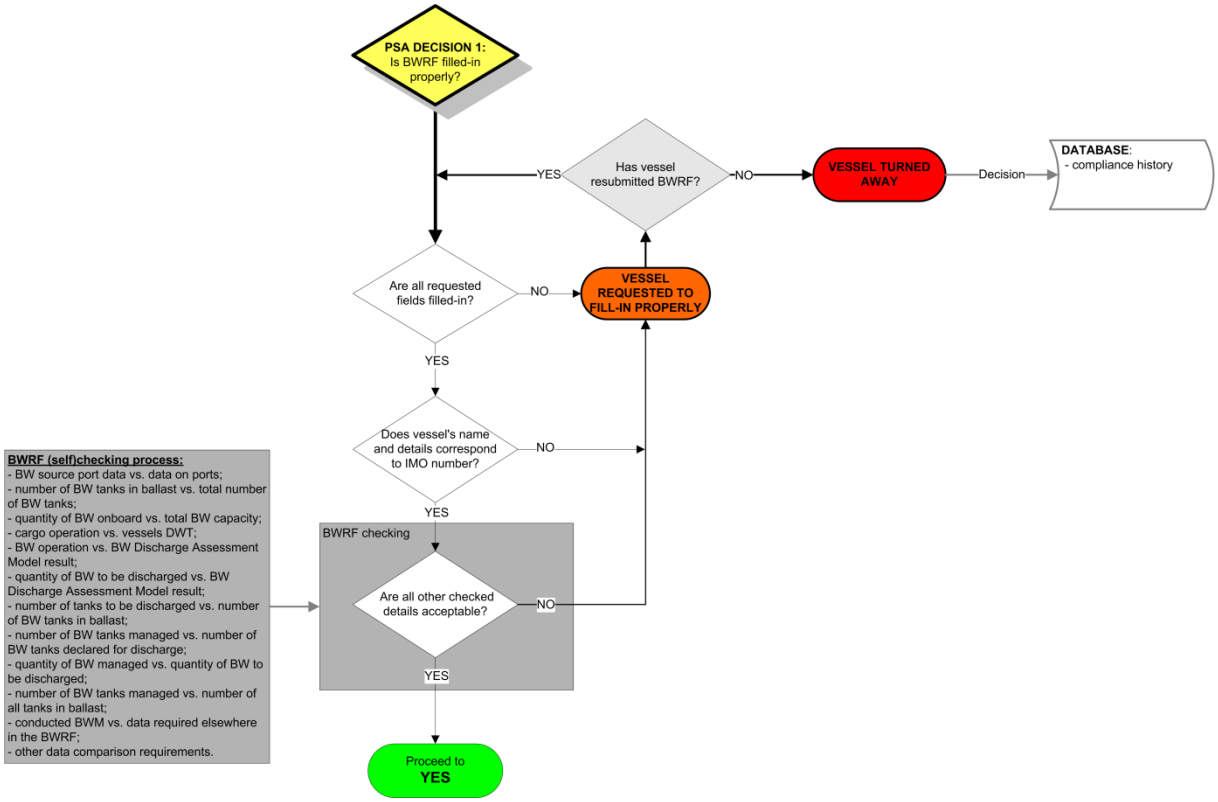

Figure 6 - Decision (1) on correct BWRF submission (DWT = Dead Weight Tonnage).

This checking process includes:

(1) Ballast water donor port data (e.g., UN LOCODE port code, name, geographical position) need confirmation to ensure correct source information of the ballast water intended to be discharged. This is important to assess different vessel voyage related data, and even absolutely critical for the RA data needs (biological and environmental data). The suggested triggering reference is the UN LOCODE port code. An electronic system may be implemented to check this information automatically and this may also be used for elementary port data checks. In case no UN LOCODE data are provided for the relevant donor port, the vessel needs to provide the donor port name (in English) with the geographical position.

(2) The number of ballast tanks declared as in ballast has to be compared with the vessel's total number of ballast tanks. Certainly, the declared number of filled ballast tanks can in no case be higher than the vessels total number of ballast tanks. This can easily be compared automatically by the electronic system, which may be programmed in such a way that it does not allow to enter a higher tank number of filled tanks compared to the total tank number in the BWRF.

(3) The on board quantity of ballast water has to be compared with the vessel's total ballast water capacity. The declared ballast water quantity on board can in no case be higher than the vessels total ballast water capacity. An electronic system can compare these numbers automatically so that

it is impossible to enter in the BWRF a higher amount of ballast water on board compared to the total ballast water capacity of the vessel.

(4) The vessel's cargo operation (i.e., the quantity in tons of cargo to be loaded or discharged) can in no situation be greater than the vessel's maximum dead weight tonnage (DWT) capacity[6]. In fact, the maximum cargo capacity is expected to be approximately 10 % lower than the maximum DWT capacity of the vessel. An electronic system can be used to compare these numbers automatically and it should not enable the user to enter a greater amount of cargo operation compared to the vessel's maximum DWT in the BWRF. This information is also of critical importance for the assessment (verification) of the expected (reported) ballast water operations in the related port, which is automatically carried out by the BWDA model.

A ballast water operation has to be expressed with the expected ballast water quantity to be discharged or which was loaded in the related port. The declared operation and the declared quantity of ballast water intended to be discharged, need to be compared with the BWDA model result. A mismatch in operation (i.e., no discharge was declared but the model shows a discharge) and in quantity (i.e., the model assessed ballast water quantity to be discharged is substantially higher than declared) triggers a suspicion that there is a reporting mistake, or even false reporting. However, it is not suggested that such a mismatch would automatically prevent the BWRF submission and the vessel is turned away, but this information will be used later as the trigger in the compliance monitoring process.

If a vessel has declared that it will discharge ballast water in a port, the number of ballast tanks intended to be emptied has to be compared with the total number of tanks in ballast. The declared number of ballast tanks to be emptied can in no case be higher than the number of tanks in ballast. Again, an electronic system can be used to compare these numbers automatically and it can be designed not to allow to enter a higher number of tanks intended to be emptied compared to the total number of tanks in ballast in the BWRF.

In cases when a vessel has declared that the ballast water intended for discharge was already managed, the number of managed ballast water tanks has to be compared with the number of ballast water tanks to be discharged. The declared number of managed ballast water tanks can be greater or lower compared to the number of ballast water tanks declared for the discharge. In practice it is not expected that a vessel conducts BWE for tanks not being intended for discharge. Hence a higher number of those BWE managed tanks is most likely a mistake. However, as a consequence of using BWMS (i.e., ballast water management to meet the D-2 standard), which

[6] i.e., vessel's carrying capacity, which includes cargo and all weights (e.g., fuel, ballast water, stores), crew and passengers that may be loaded onboard a vessel up to her permissible limits, which is regulated by IMO international conventions, mainly the Load Lines Convention.

treats ballast water on uptake, this would be a regular result. If the declared number of managed ballast water tanks is lower compared to the number of ballast water tanks declared for the discharge, it becomes necessary to confirm whether or not this is a mistake or if there are tanks with ballast water which need to be considered in the next steps by the RA process. The ballast tank numbers need to be compared as follows:

- if the number of managed ballast tanks is higher compared to the number of tanks declared for discharge, a submission of BWRF is allowed with no further questions;
- if the number of managed ballast tanks is lower compared to the number of tanks declared for discharge, the vessel has to correct this to have the same tank numbers, or she may declare the tanks which have not been managed, but are to be discharged (i.e.; number of tanks to be discharged = number of managed tanks to be discharged + number of unmanaged tanks to be discharged). Should these BWRF entries mismatch, then the BWRF should not be allowed to be submitted or should not be accepted by the PSA.

No matter which BWM method has been applied, it should be confirmed that tanks declared for discharge are those which were managed. The electronic system can compare this automatically to result in an appropriate action.

The managed ballast water quantity has to be compared with the quantity of ballast water to be discharged. In this analogue process, a comparison of the number of ballast water tanks managed versus the number of ballast water tanks declared for discharge is needed as described above. Therefore, the same procedure has to be applied using the “quantity of ballast water” instead of the “number of tanks”.

The number of managed ballast water tanks has to be compared with the number of all tanks in ballast. The number of ballast water tanks declared to be managed in no case can be greater than the total number of all tanks in ballast. The electronic checking system can compare these numbers automatically and should not allow a situation when a greater number of tanks with managed ballast water are submitted with the BWRF compared to all tanks in ballast.

The BWM conducted has to be compared with the data required elsewhere in the BWRF. Should a vessel have declared that she has already conducted BWM (also stating the BWM method used), there is a need also to report the number of managed tanks and further the quantity of ballast water managed. If BWE was used as BWM method, it needs to be stated where the BWE was carried out. The BWM method declared and additional information requirements need to be related quantitatively, i.e., all BWRF fields related need to be filled-in, when possible also qualitatively.

Since this is a generic BWM DSS model and noting that no simple “one size fits all” approach may be possible, it is foreseen that when DSS is applied, regional and national specific requirements

which need to be addressed may result in a need to add different 'other' data comparison requirements. Considering the present Baltic Sea area situation, conducting BWE in the Baltic Sea is not an option, and there are no designated BWEA, neither dedicated SRA nor SL. However, these may be dedicated in the future as especially the SRA concept seems to be of interest in certain countries (IMO 2018). BMW exemptions are considered under JHP (HELCOM 2013).

If a vessel reports the ballast water situation satisfactory, it enters into the next DSS process phase, in which she is being selected to enter the RA process.

2.1.2.2 BWM exception, exemption and SRA

Vessels that operate under BWM exceptions (BWM Convention Regulation A-3), exemptions (BWM Convention A-4), including SRA (G7 Guidelines), need to declare this, and are consequently to be cleared to proceed without conducting BWM.

Nevertheless, vessel may still be selected for CME process, which is specific for vessels under these regimes, i.e., different from the one described further down as Decision 5, which applies to all vessels under regular BWM requirements. In this CME process, PSC verifies vessels compliance with the exception, exemption or SRA status/conditions/requirements. This means that PSC would mainly check vessels documentation (BWRB, vessel log books), while ballast water sampling would not support this process as the vessel is not required to comply with the D-2 standard.

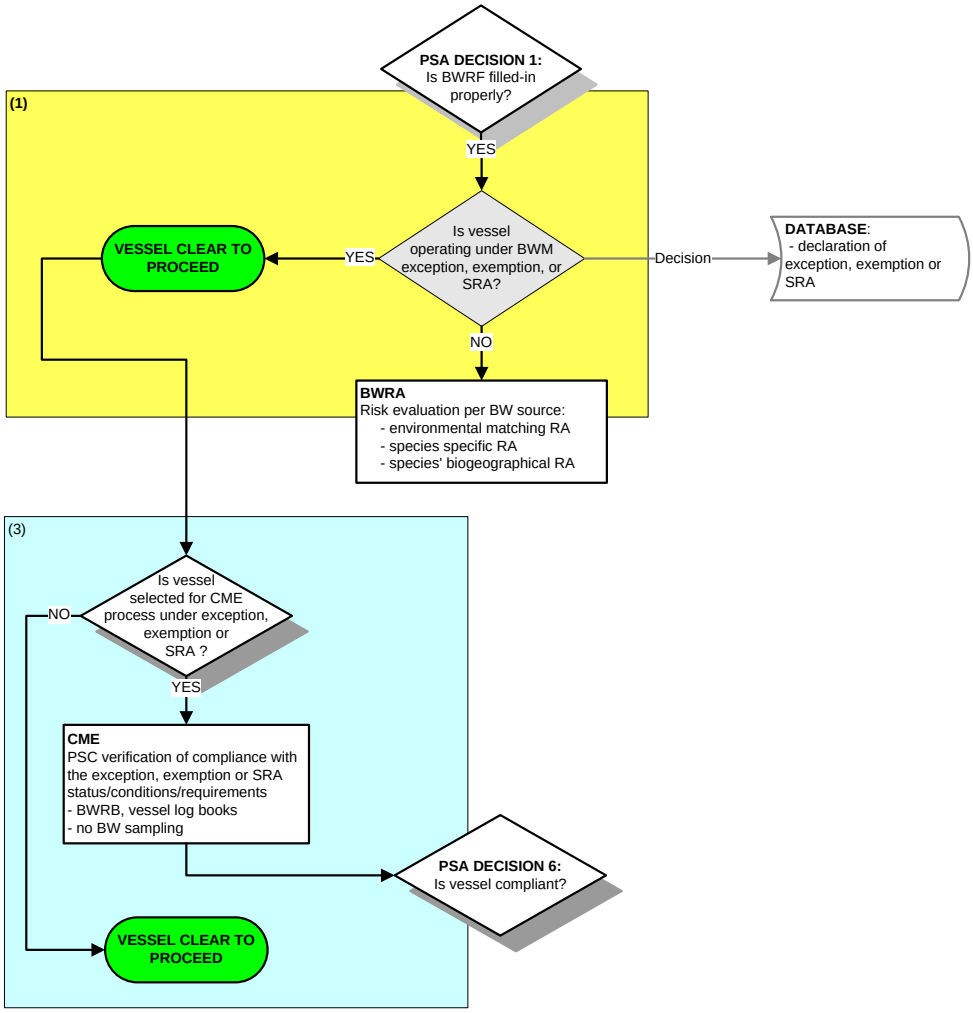

Figure 7 - Vessel that has successfully submitted BWRF and declared that is operating under BWM exception, exemption, or SRA is cleared to proceed without conducting BWM.

2.1.2.3 BWRA, BWDA and trustworthiness processes in the BWM

Vessels that intend to discharge ballast water, and do not fall under any of the exceptions, exemptions, SL or SRA regimes, need to conduct BWM and need to declare intended ballast water discharge per each tank from a different ballast water source, i.e., donor port. All vessels having declared ballast water onboard and having provided information to enable BWRA, i.e., ballast water donor port(s) information, will enter the BWRA process. BWRA result is an additional information for PSA to support their decisions mainly when BWM is not conducted properly, e.g., vessels with low risk and having an issue with conducting required BWM may be allowed to discharge their ballast water without further requirements, while vessels of high/very high risk may not be allowed to discharge not properly managed ballast water. Furthermore, vessels with higher risk ballast water may be selected for CME purpose. Vessels which have declared to have ballast water on board and have declared the donor ports/areas, will enter the BWRA process.

However, every vessel carrying ballast water and coming into a port has theoretically the potential to discharge ballast water. In view of possible false reporting, all vessels are checked with the BWDA model. The expected ballast water operation is assessed based on the foreseen or actual cargo operations and the vessel's particulars. PSA will be provided with the BWDA result and if the result disagrees with the ballast water declaration made by the vessel, the vessel will be targeted for CME.

All vessels are further checked for trustworthiness based on the history of vessel compliance with general and BWM requirements, and this information may support a decision to select not trustworthy vessels for CME.

Vessels that have declared that will not discharge ballast water will be cleared to proceed, but they will be always targeted for CME if the BWDA model disagreed with the BWRF. Vessels that have declared that will discharge ballast water are checked if BWM was already conducted in an acceptable way. When BWM is not acceptable, PSA will need to take a decision on what to do with such vessel (see Figure 8).

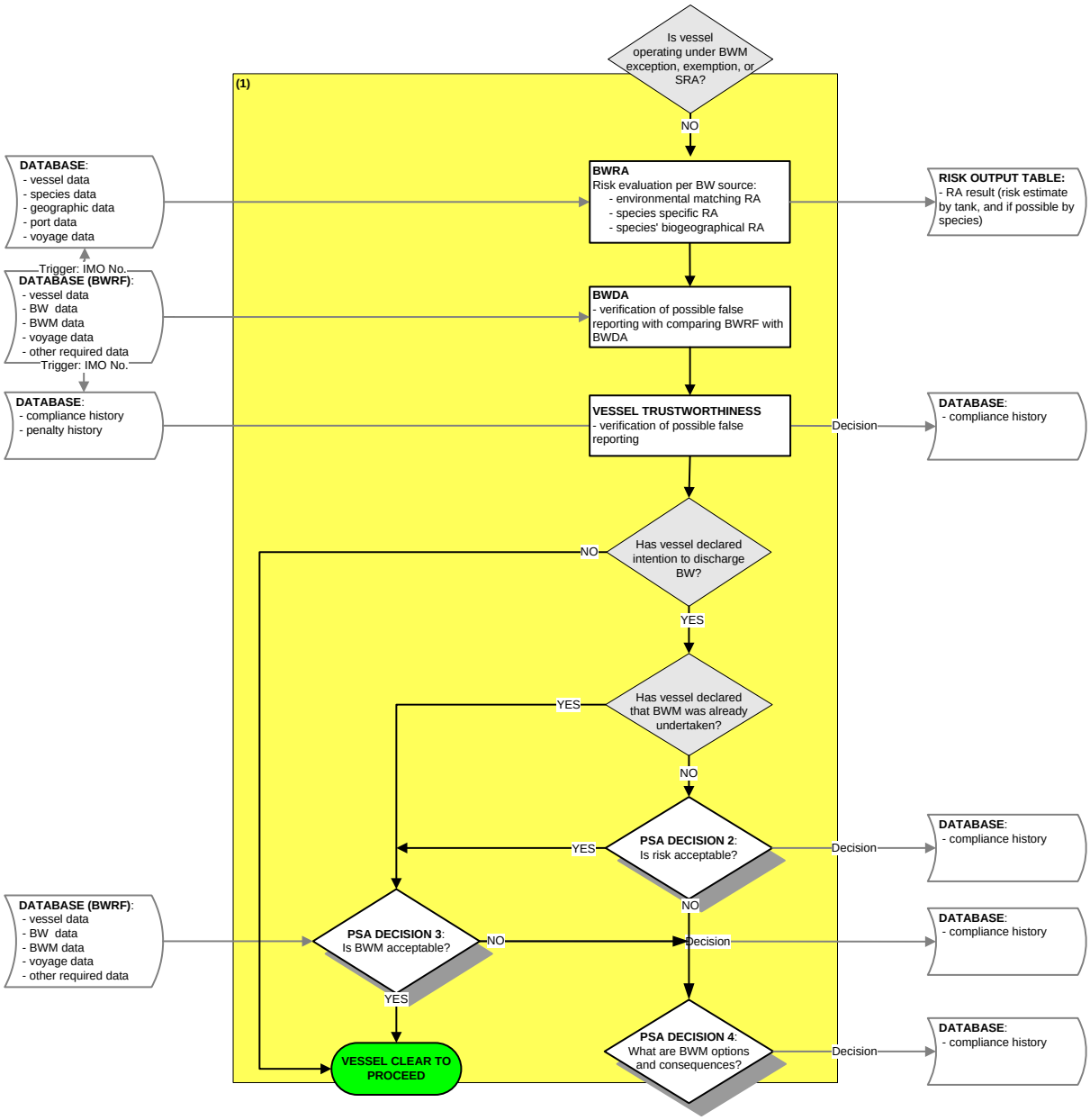

Figure 8 - Vessel that has successfully submitted BWRF are assessed for risk (BWRA), possible false reporting of discharge (BWDA) and for reporting and BWM action trustworthiness.

2.1.2.3.1 Ballast water risk assessment process

BWRA is undertaken to provide PSA with additional information on the risk posed by ballast water to be discharged. BWRA DSS model was prepared in line with principles and methods included in the G7 Guidelines (see Figure 9).

BWRA is an additional information, i.e., it is not related to any BWM Convention requirement hence not demanding any action, but mainly supporting decisions of the PSA on BWM and CME. Please note that this BWRA is different from the RA for BWM exemptions and the need for data reliability

and accuracy in BWRA can be acceptable to be lower than for RA for exemptions (David and Gollasch 2015a).

Minimum requirements/standards for the data reliability and accuracy for this BWRA process needs to be regionally agreed. Considering that the donor ports (and other ports where vessels ballast) are spread worldwide it is in practice very difficult to expect that would need to have the same quality of data for all donor ports like for BWM exemptions JHP. As a general principle, all donor ports outside the Baltic region may be considered as other regions, which contain non-indigenous species (NIS), which are by the basic principle considered in RA as HAOP species. According to the IMO G7 guidelines, LMEs are suggested as seas divisions/sea areas. Target species would be selected by the HELCOM TG Ballast according to the agreed selection criteria (Gollasch et al. 2020).

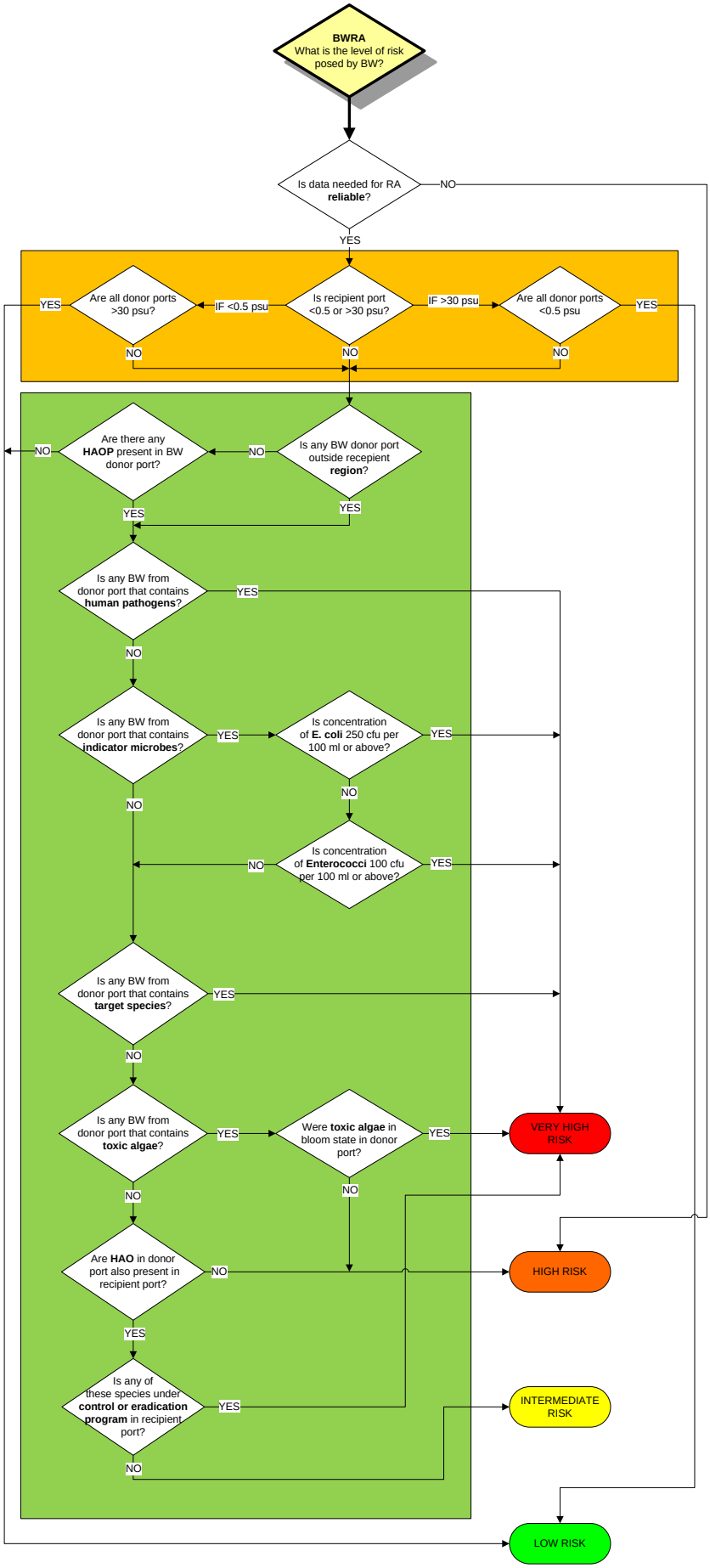

Figure 9 - BWRA model resulting in four different risk levels. The orange box area is the environmental matching RA process, in the green box area is the species-specific RA process.

2.1.2.3.2 Decision 2: Is the risk acceptable?

For the purpose of this BWM DSS, the BWRA model is applied to assess the level of risk for selective BWM measures. Very high, high or intermediate risk levels are deemed as unacceptable in this BWM DSS process (see Figure 10).

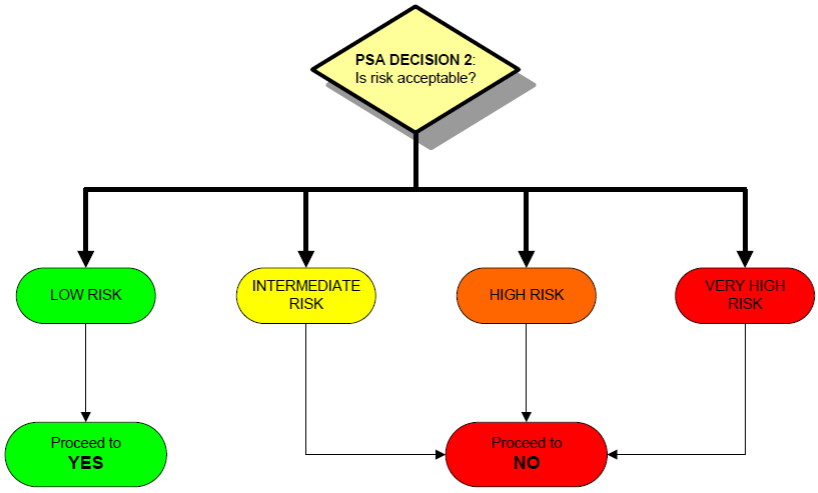

Figure 10 - Decision (2) on whether or not the risk posed by the ballast water intended for discharge is acceptable.

2.1.2.3.3 Verification of correct reporting of ballast water operation with a ballast water discharge assessment (BWDA) model

A Ballast Water Discharge Assessment (BWDA) model was developed (David et al. 2012) to assess ballast water operations for each vessel arrival to the port, and with this an overall assessment for the past, as well as future ballast water discharges could also be conducted. Possible other correlations that would offer reliable results and that would be based on easily available data (i.e., data regularly collected from a port or maritime authority on each vessel arrival) were studied. Ballast water processes on board vessels were studied to identify possible correlations among ballast water operations and basic vessel operations and dimensions. Experience of the authors in the field of vessel operation triggered the idea on the possible correlation between the cargo and ballast operation, and vessels DWT. Cargo and ballast water operations of different types of vessels were studied to identify possible patterns and correlations. The cargo operation of a vessel in relation to her DWT was found as the key component for assessing the amount of ballast water discharged in a port.

The following information is needed to apply the David et al. (2012) BWDA model:

- vessel's cargo operation (i.e., cargo loading, discharge or both) for each call to the port;
- type of cargo;
- quantity of cargo in tons; and
- vessel's DWT in tons.

The model was further tested on the BALMAS BWDA data and further developed to consider also vessel type to increase the reliability on a vessel-to-vessel basis assessment.

Figure 11 - Ballast Water Discharge Assessment (BWDA) model for assessment of correct reporting of ballast water discharge (David and Gollasch, 2016).

2.1.2.3.4 Verification of vessel trustworthiness

The main reason for introducing trustworthiness in this process is the human factor. It is commonly known that false reporting happens and that it is very difficult to survey it. There are also several other reasons, some of the outstanding are that the vessels Safety Management System (SMS) is not well implemented, so that a limited level of crew skill and sometimes also ignorance by the crew could happen. These, however, are critical for proper maintenance and safe functioning of vessel systems.

Trustworthiness is focussed on the compliance history of the vessel. False BWM reporting may trigger low trustworthiness lifelong or time dependent, i.e., it may be valid for a certain period of time, e.g., 10 years. The BWM vessel compliance history and general compliance is time dependent (see Figure 12).

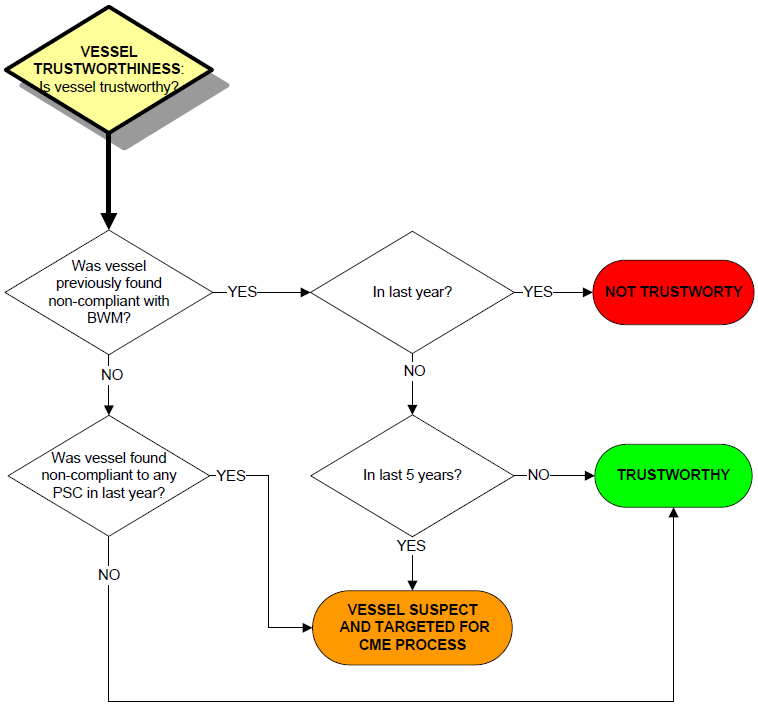

Figure 12 - Decision on vessel trustworthiness.

2.1.2.4 Decision 3: Is the ballast water management acceptable?

When vessels have declared that BWM was already conducted, this needs to be compared with the current port State BWM requirements. The decision relies on the BWRF information provided.

All ballast water tanks which are intended for discharge have to be managed and the BWM method applied is generally accepted in cases when it meets the requirements of the BWM Convention and/or when the BWM requirements by the port State are met. It is further important that the vessel follows procedures and requirements of the BWMS manufacturer and the classification society (see Figure 13).

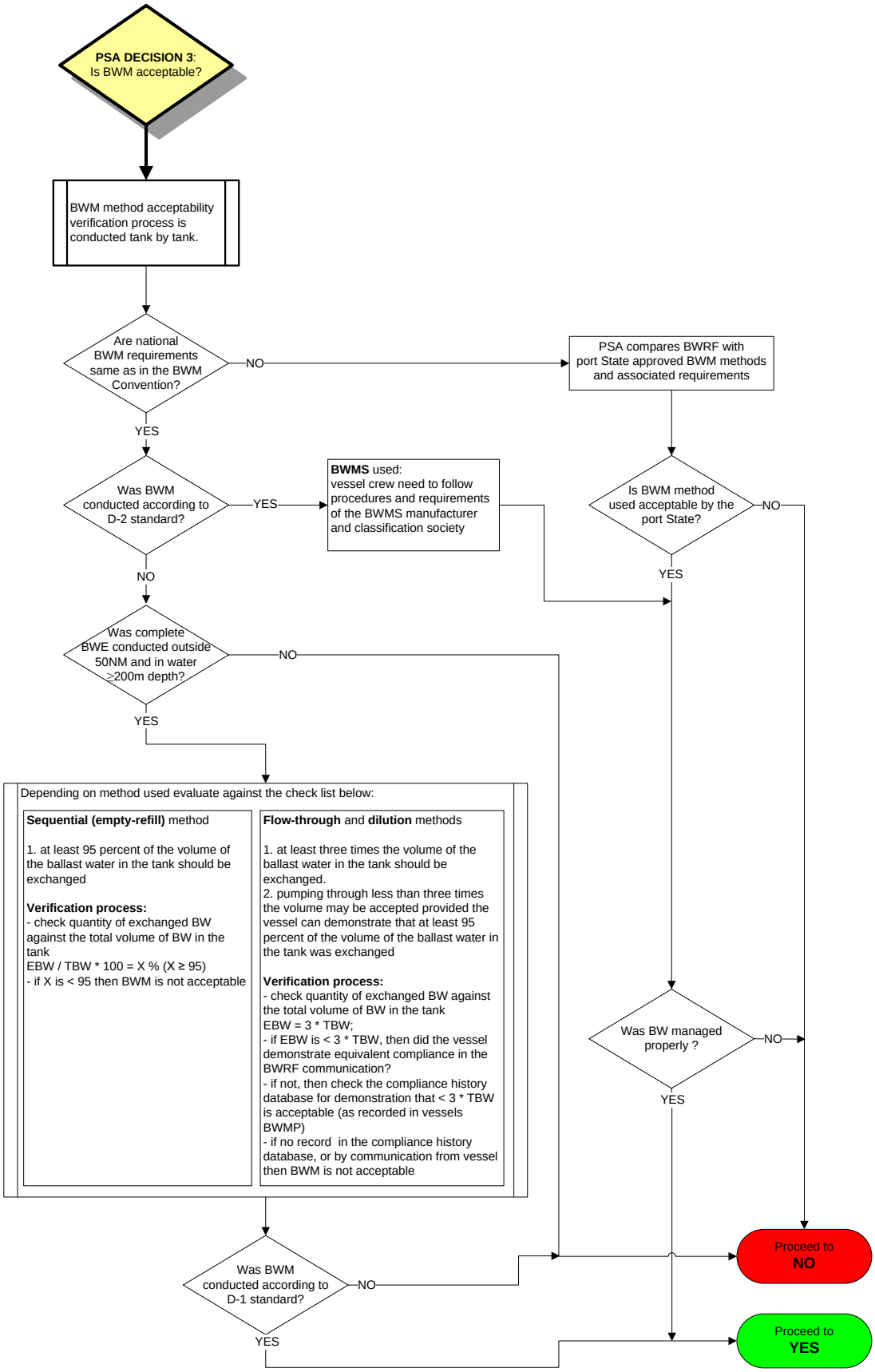

Figure 13 - Decision (3) on acceptability of BWM. BWE = Ballast Water Exchange, BWMP = Ballast Water Management Plan, BWMS = Ballast Water Management System, D-2 standard = D-2 standard of the BWM Convention, Reg. B4 and D-1 standard = Regulation B4 and D-1 standard of the BWM Convention, EBW = Exchanged Ballast Water, TBW = Total Ballast Water.

2.1.2.5 Ballast water management process was not successful

Every vessel, other than those excepted or exempted needs to conduct BWM. However, for any reason of failure to do so, and when knowing BWM was not successful/conducted properly, the vessel needs to report this to PSA. There may be different situations when a vessel may be unable to conduct BWM (e.g., the vessel route is too close to the shore, in cases of bad weather and sea conditions, problems with the BWMS).

On the other side, PSA may not accept the BWM measures conducted. In such situations, the vessel and PSA have to try to find a solution to the situation. This includes a BWM method selection, which is feasible (for the vessel) and acceptable (to the PSA), if any, and which is selected according to the level of risk posed, and this is followed by consequences if the required BWM measure was not applied.

In those instances, the PSA has to decide whether to allow the vessel to discharge unmanaged ballast water or if some alternative option should be used (when available), or to retain the ballast water onboard, or, but only in most critical situations, to turn the vessel away. All these decisions are dependent on the level of risk posed by the ballast water intended for discharge, by the BWM options the vessel had and by the availability of alternative BWM options (see Figure 14).

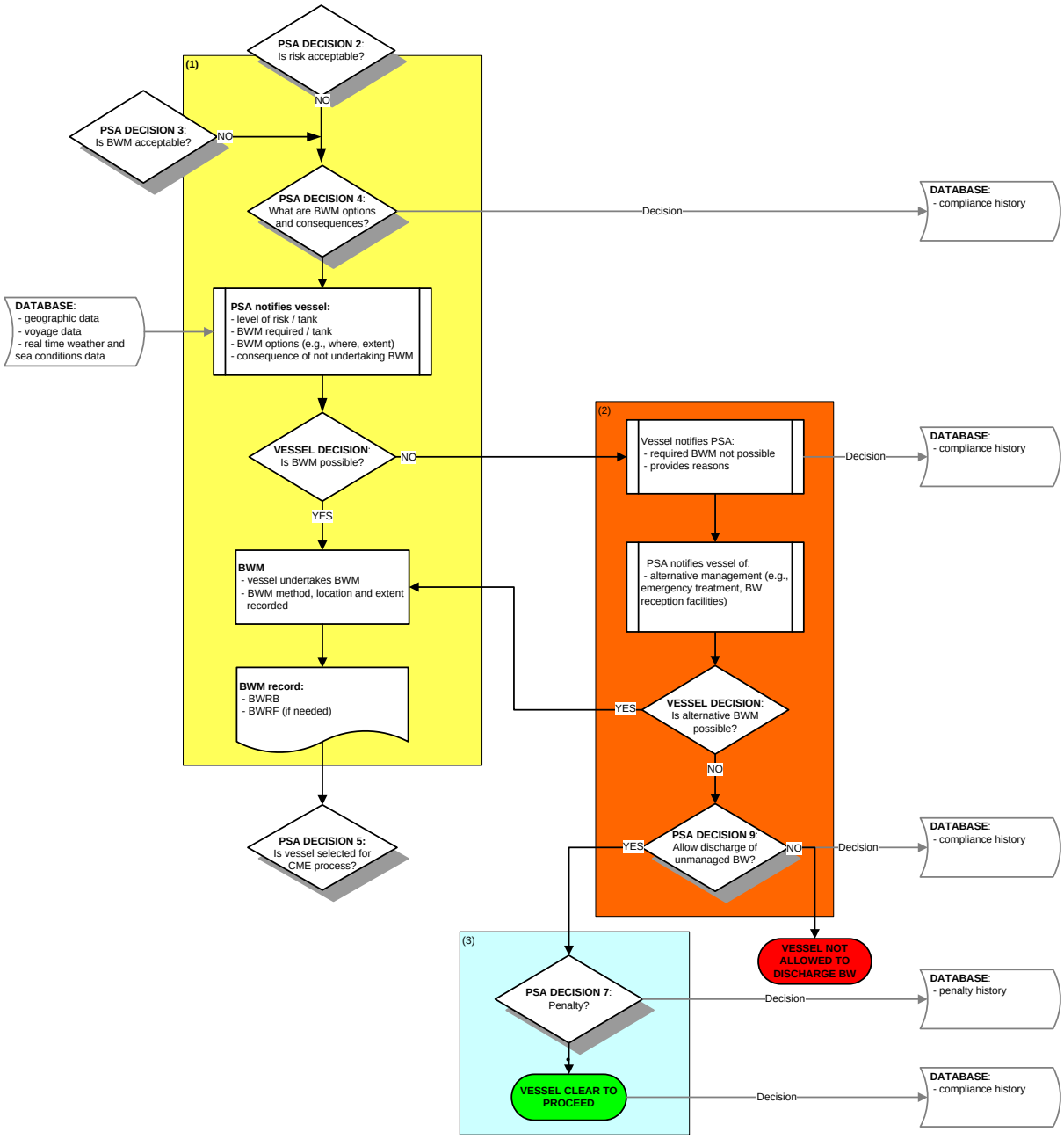

Figure 14 - BWM process.

2.1.2.6 Decision 4: What are ballast water management options and consequences?

Retaining ballast water on board the vessel is considered as the primary BWM option in this situation. This is a feasible option for some limited vessel types with smaller ballast water capacities and especially in cases when a vessel is only partially loading. If ballast water operations are necessary, the vessel might pump ballast water from one tank to another without any discharge to the port. If this is impossible, ballast water has to be managed.

Vessels, which manage their ballast water according to the BWM Convention D-2 standard, are clear to proceed. If a vessel has no BWMS installed, then, in certain areas, but excluding the Baltic Sea (IMO 2008b, 2009), BWE would need to be carried out as minimum BWM measure. Should the vessel be capable to properly conduct BWE on her intended route[7] and for all the ballast water intended to be discharged, and the port State accepts the BWE method, then the vessel does BWE and is clear to proceed. If not, then the use of BWEA or alternative options have to be considered according to the risk level posed. As also no BWEA was designated in the Baltic Sea alternative options need to be studied, need to be available, and need also to be feasible for vessels. Alternative BWM options include reception facilities of ballast water, which may be made available in the port, or an alternative discharge area may be determined as more appropriate for the discharge of unmanaged ballast water. In cases when a ballast water reception facility can be made available, the vessel needs to have additional piping installed enabling discharge of ballast water to such a facility. Should none of these alternative BWM options exists, as currently in the Baltic Sea, no vessels in intra Baltic shipping and neither ships sailing from North Sea ports to the Baltic Sea are required to conduct BWM until they need to meet the D-2 standard (HELCOM 2019 a, b). In contrast, for vessel in intercontinental shipping when crossing the ocean, or in the area of the Bay of Biscay BWE would be a BWM option. However, under certain circumstances only partial BWM can be conducted on the intended route this may be then continued and finalised with an alternative method. Here, partial BWM means that on the intended route a proper BWM is conducted only on a limited number of tanks, e.g., BWE according to the D-1 standard is conducted for as many tanks as possible but, as an example, could only be completed for four out of eight tanks intended for discharge. The remaining four tanks are then left for alternative BWM options and some ballast, if necessary, may also be retained on board.

The BWM options and consequences are shown in Figure 15.

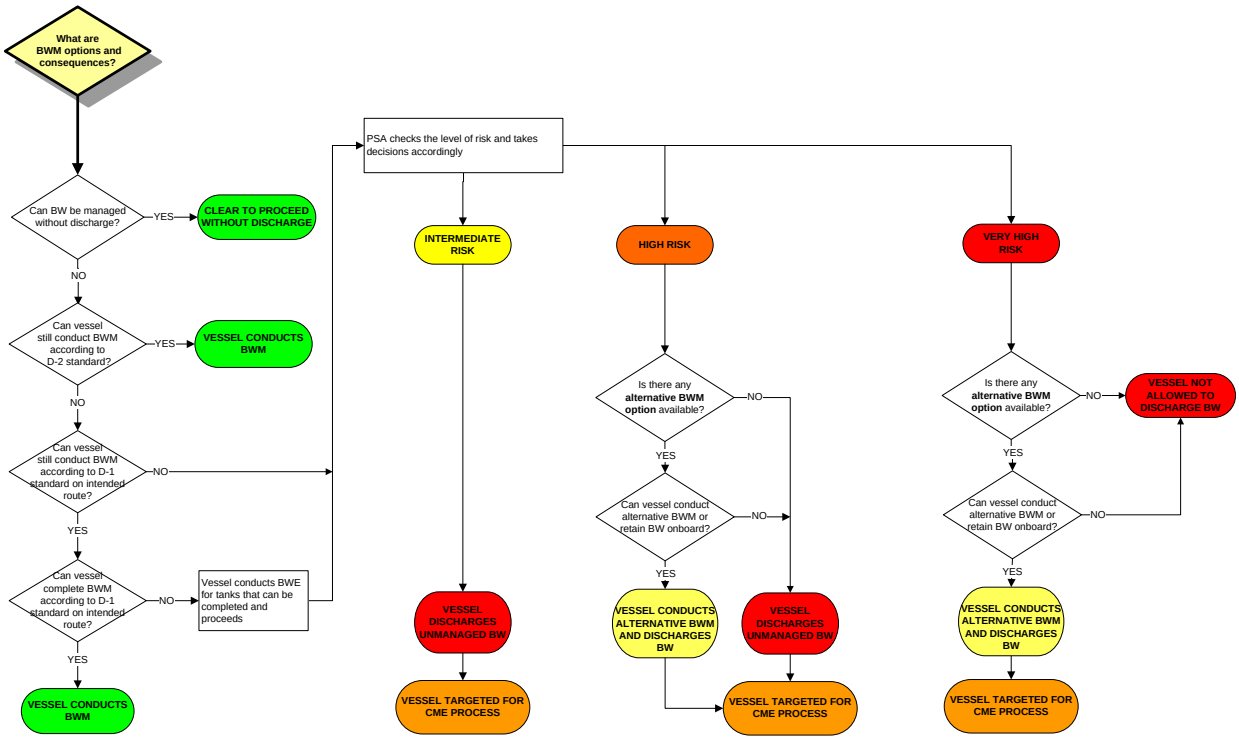

Figure 15 - Decision (5) on BWM options and consequences.

After the BWM action was completed and the vessel has undertaken (or not) the required BWM practice, she may be selected for a process to verify compliance with BWM requirements, i.e., the compliance monitoring and enforcement (CME) process.

2.1.2.7 Compliance monitoring and enforcement

The CME process is intended to back-up the management process and to support the complete implementation of the BWM Convention as well as any further port State BWM requirements. Each vessel, which is allowed to enter a port, may be selected for compliance monitoring. In cases when it can be shown that a vessel is non-compliant, but she has already entered the port and also started deballasting, she may be stopped from deballasting and may be requested to take alternative BWM measures. The compliance monitoring process is followed by a penalty process for non-compliant vessels. Depending on the time when non-compliance is identified/confirmed a penalty may be applied to a non-compliant vessel when she is still in the port or even when she has already left the port. A vessel may be found non-compliant when she is in the port, e.g., when a valid BWMS certificate is lacking, or the non-compliance may be confirmed when the vessel has already left the port, e.g., when BWS for compliance monitoring was carried out, but the sample analyses took longer than her stay in the port (see Figure 16).

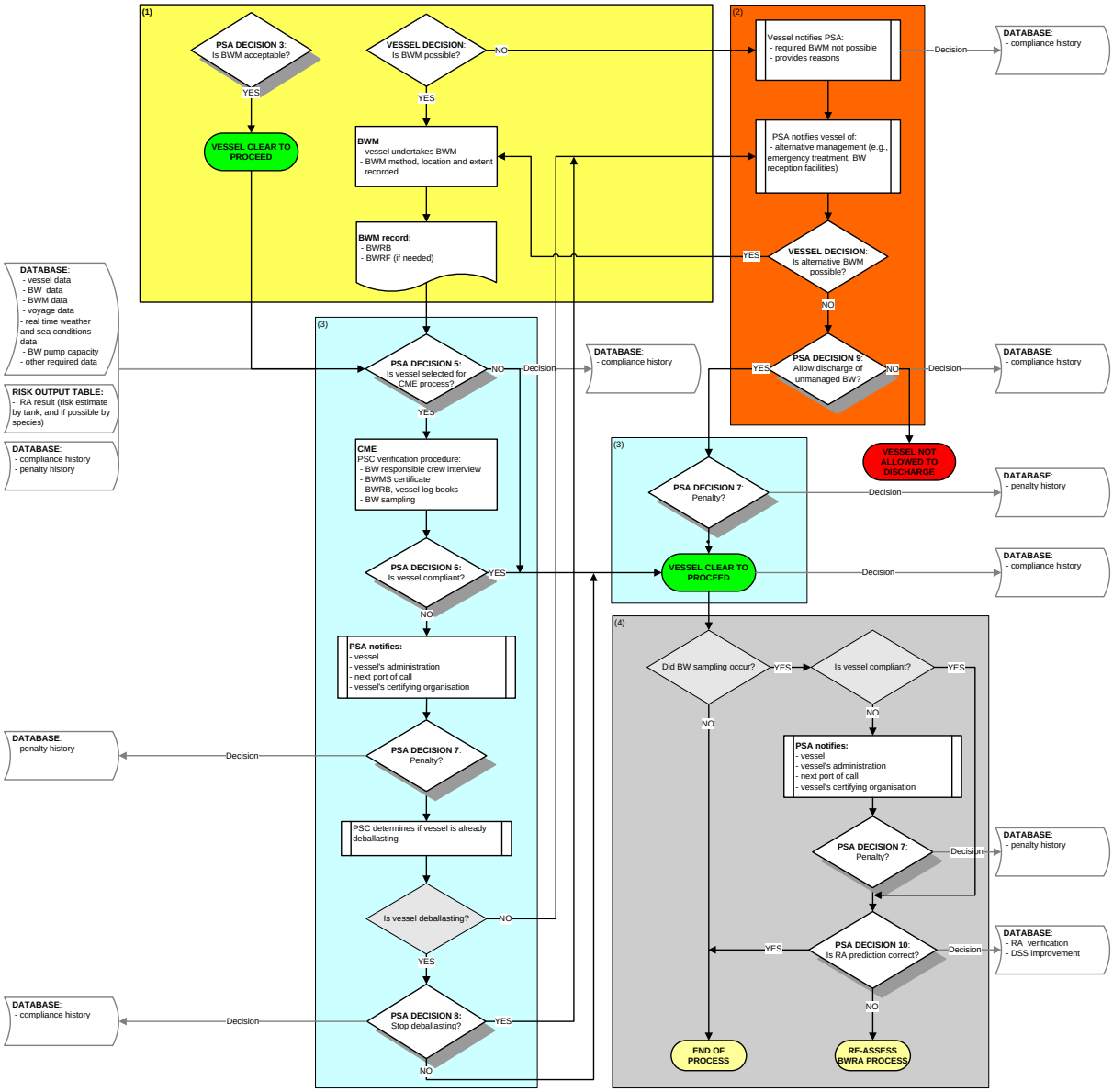

Figure 16 - Compliance monitoring and enforcement process. (see Annex 1).

2.1.2.8 Decision 5: Vessel selected for compliance monitoring and enforcement process?

The CME process is conducted by PSC and starts with the selection of a vessel. If PSC has a separate BWM CME programme in place, a random selection with a minimum number of vessels to be targeted, may be conducted. However, if no BWM specific programme is implemented, then PSC may select a vessel for the BWM CME process while carrying out an inspection as per the already implemented regular vessel inspection programme. Further to such a programme, BWM specific elements to trigger the CME process were identified. According to the BWM Convention, the verification process has two levels and triggering elements have been grouped accordingly. Each of these trigger the compliance monitoring process directly or randomly. A vessel which is targeted by

the selection process enters the CME process. According to Article 9 of the BWM Convention, a vessel to which the BWM Convention applies may be subject to inspection in any port or offshore terminal of the port State that is party to the BWM Convention. The purpose of such an inspection is determining whether or not the vessel is in compliance with the BWM Convention. Every state has to provide for an effective verification process to support the effective implementation of the BWM measures.

The two levels of the verification process are the "initial inspection" and the "detailed inspection". The main differences of the two levels are the triggering elements and the consequences for the vessel during the inspection process.

The initial inspection does not require special justification for its triggering elements and as such can be understood as part of the basic and regular PSC inspection process. This inspection is divided into a simple paper inspection and BWS for compliance. The simple paper inspection includes:

- a verification that there is a valid BWMS certificate on board the vessel[8]; and
- an inspection of the BWRB.

BWS for compliance has basically two different approaches:

- BWS for salinity (D-1 standard compliance); and
- BWS for compliance with the D-2 standard (indicative and detailed).

BWS for salinity is generally used for a verification of the BWE process, and specifically for the verification of the RA process in cases when a decision taken was based on environmental matching salinity. The BWS D-2 standard compliance requires the analyses of viable aquatic organisms present in the ballast water.

BWS for compliance should be carried out according to the Guidelines for ballast water sampling (G2) (IMO 2008a), also considering its related guidance documents (IMO 2013, 2015). It should be noted that according to the BWM Convention BWS may occur anytime, with or without other checks. Further, IMO agreed on a two to three year trial period after BWM Convention entry into force, during which sampling and sample processing experience is gained, which will likely result in an update of the sampling guidance document.

If BWS is conducted as part of the vessel inspection, she shall not be unduly delayed for the time required to analyse the ballast water samples taken.

[8] If valid, it shall be accepted.

Further, PSC may also decide to undertake a detailed inspection when a ship:

- has no valid BWMS certificate; or there are
- clear grounds to believe that:
    - a certificate review results in the situation that the condition of the vessel or its equipment does not correspond substantially with the particulars of the certificate; or
    - the master or the crew are unfamiliar with essential shipboard BWM procedures, or these procedures were not implemented; or
- the vessel is carrying improperly filled BWRB; or
- there is no designated officer for BWM on board.

The detailed inspection includes, as appropriate:

- the inspection of all required documents and log books;
- the inspection of the vessel (*e.g.*, BWMS); or
- BWS for compliance.

In cases when a PSC decides to carry out the detailed inspection, ballast water shall not be discharged from that vessel until it is proven that it can discharge ballast water without risks of harm to the environment, human health, property or resources (see Figure 17).

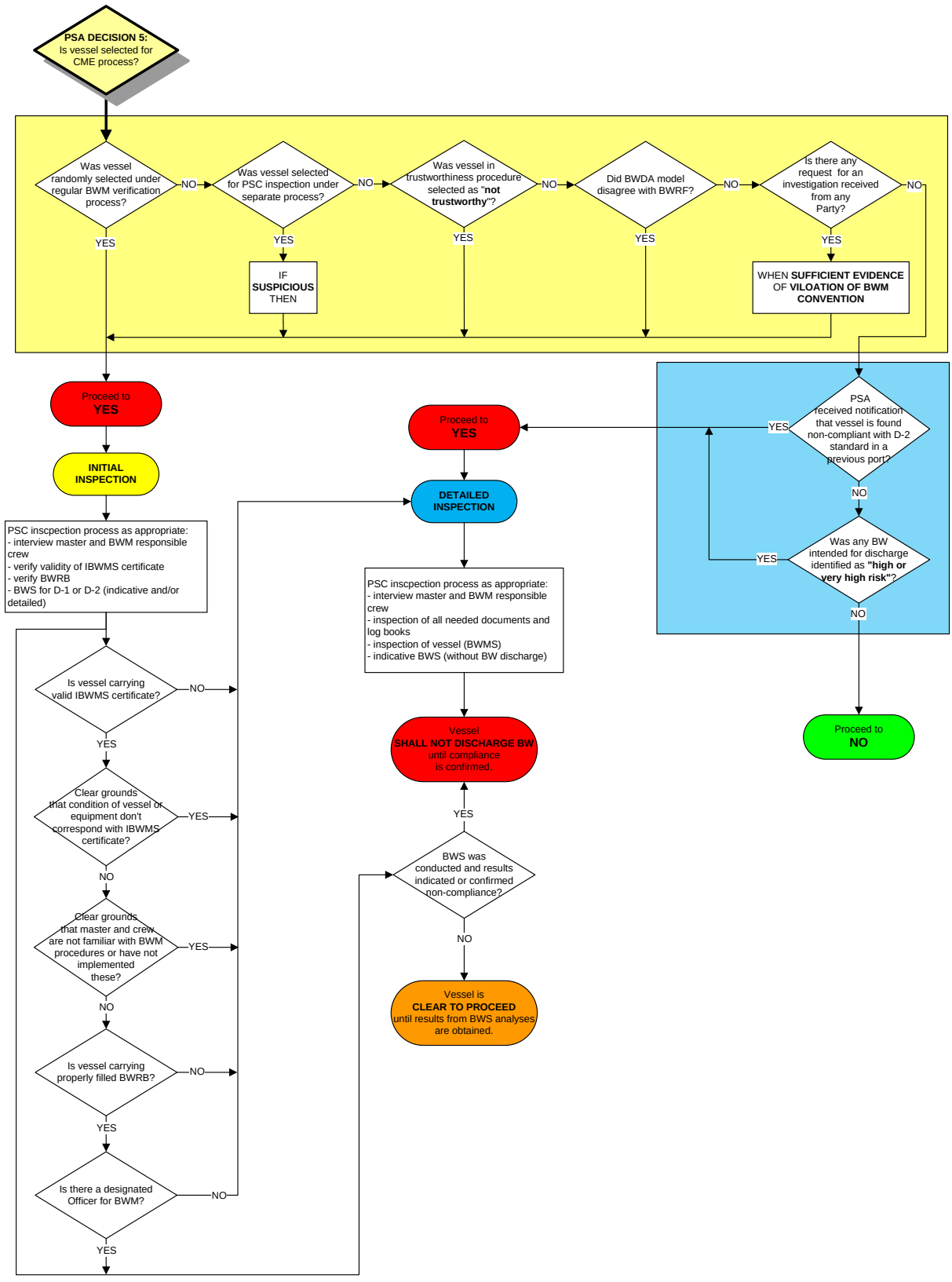

Figure 17 - PSA decision (5) on vessel selection for CME process, including the two different levels of inspection according to the BWM Convention, i.e., so called initial and detailed inspection. The light yellow box includes elements that trigger the initial inspection; the light blue box includes elements that directly trigger the detailed inspection. (see Annex 1).

2.1.2.9 Decision 6: Is the vessel compliant?

PSC has inspected if the vessel has complied with the BWM requirements and when doing so PSC (a) checks if the vessel is carrying a valid BWMS certificate, (b) checks if the conditions of the vessel and the BWMS are in line with the BWMS certificate, (c) interviews the BWM responsible crew members to evaluate if they are familiar with BWM procedures and if these procedures were implemented (see Figure 18).

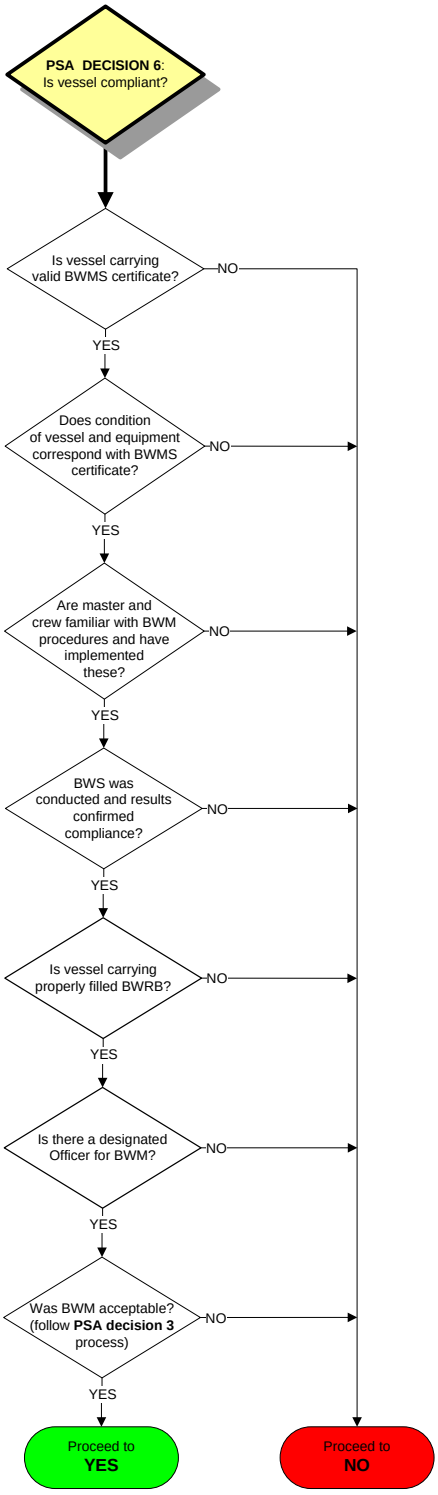

Figure 18 - PSA decision (6) on vessels compliance with the BWM requirements.

2.1.2.10 Decision 7: Penalty?

National legislation needs to include provisions to prevent unwanted impacts caused by discharges of HAOP with ballast water. Further, the legislation needs to cover unlawful actions of vessels flying their flag (i.e., Flag State) as well as for those vessels navigating in their jurisdictional waters (i.e., port State). The penalty process in DSS presented here is focussed only on port State requirements.

If a violation was detected, the PSC should evaluate whether or not national legislation has provided for such an act and has to proceed accordingly. Should a vessel be penalised, this needs to be recorded in the database of penalty history. The sanctions implemented should be of adequate severity to discourage further violations (see Figure 19).

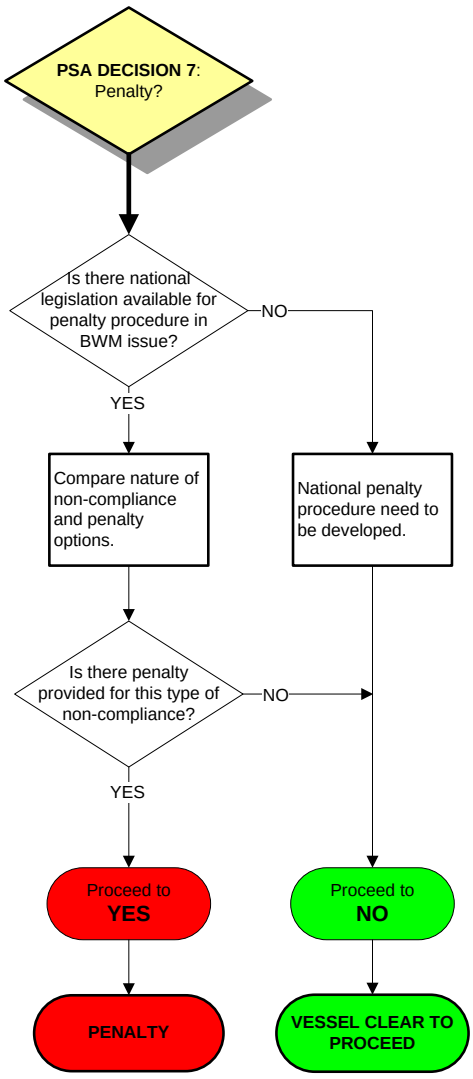

Figure 19 - Decision (7) on issuing a penalty to the non-compliant vessel.

2.1.2.11 Decision 8: Stop deballasting?

In cases when a vessel is found non-compliant with BWM requirements, PSC may decide to stop deballasting and this decision is basically related to the risk level posed by the ballast water intended for discharge.

If a vessel has already started deballasting non-compliant ballast water and the risk posed is unacceptable, this vessel will be stopped from deballasting (see

Figure 20).

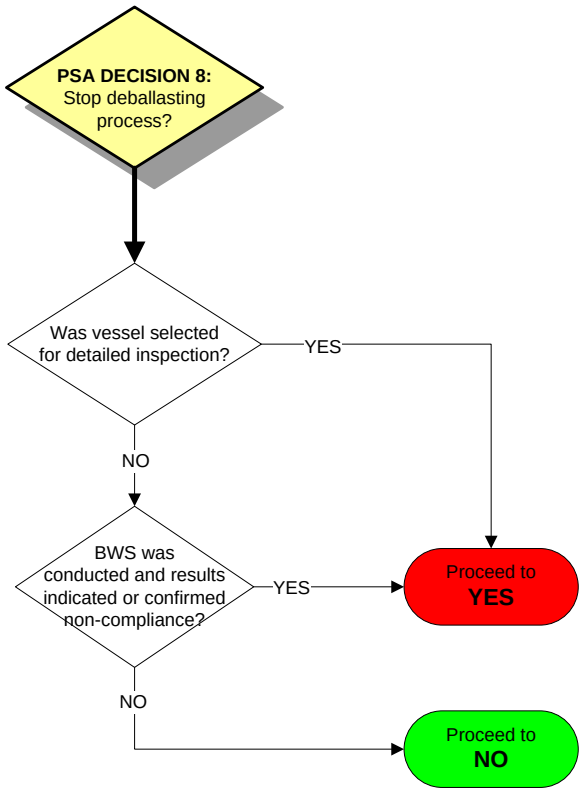

Figure 20 - Decision (8) on stopping a vessel to deballast.

Should a vessel be required to stop deballasting, the PSA authority will notify that vessel on possible alternative BWM options available. If feasible, the vessel should conduct alternative BWM options.

2.1.2.12 Decision 9: Allow discharge of unmanaged ballast water?

To allow discharges of unmanaged ballast water is a position where no “regular” or alternative BWM options were implemented as currently in the intra-Baltic shipping until 2024 when it will be required to meet the D-2 standard. A vessel in this situation, which reflects the current Baltic Sea situation, would:

- have declared to carry unmanaged ballast water on board which is intended for discharge;
- have done everything in her capability to comply with the BWM requirements;
- have been unable to conduct the requested regular BWM practice; as well as
- have been unable to conduct alternative BWM practices.

PSA needs to decide whether or not to allow such a vessel to discharge unmanaged ballast water in the port or if she needs to be turned away. Such a decision should certainly be taken according to the risk posed by the ballast water intended for discharge. However, for the general practice and effectiveness of BWM measures it is also important to take into account that the vessel did everything in her capability to comply with the BWM requirements. In this situation the PSA should check:

- the BWM requirements according to the legislation;
- the vessels' BWM options according to the BWM plan;
- the intended route;
- the voyage duration and other conditions;
- the vessels capability to conduct alternative BWM options; and
- the BWRA result.

In cases when a vessel took all measures to comply with the BWM requirements, including alternative BWM options, the level of risk posed by the ballast water intended for discharge needs to be evaluated. If the ballast water was assessed as with very high risk, the vessel should not be allowed to discharge ballast water. However, in cases when the risk level was assessed as intermediate or high, the vessel may still be allowed to discharge ballast (see

Figure 21). In the intra-Baltic as well as North Sea-Baltic Sea shipping BWE is not required, no BWEA is designated in the Baltic Sea, and no BWM RA is implemented, hence ballast water (of all risk levels) can freely be discharged until 2024 when D-2 is required for all vessels. However, all vessels are encouraged to routinely treat ballast water with BWMS when available. Further, vessels arriving via an area where BWE is possible to be conducted in line with the BWM Convention requirements, i.e., in intercontinental shipping when crossing the ocean or in the area of the Bay of Biscay, BWE should be conducted.

Certainly, it should be understood that these are only minimum criteria. It will be up to each PSA to make a decision whether or not a more stringent approach has to be applied and possibly not to allow discharges of unmanaged ballast water that was assessed as high risk or even intermediate risk; this would be desirable especially when considering BWM from an environmental perspective.

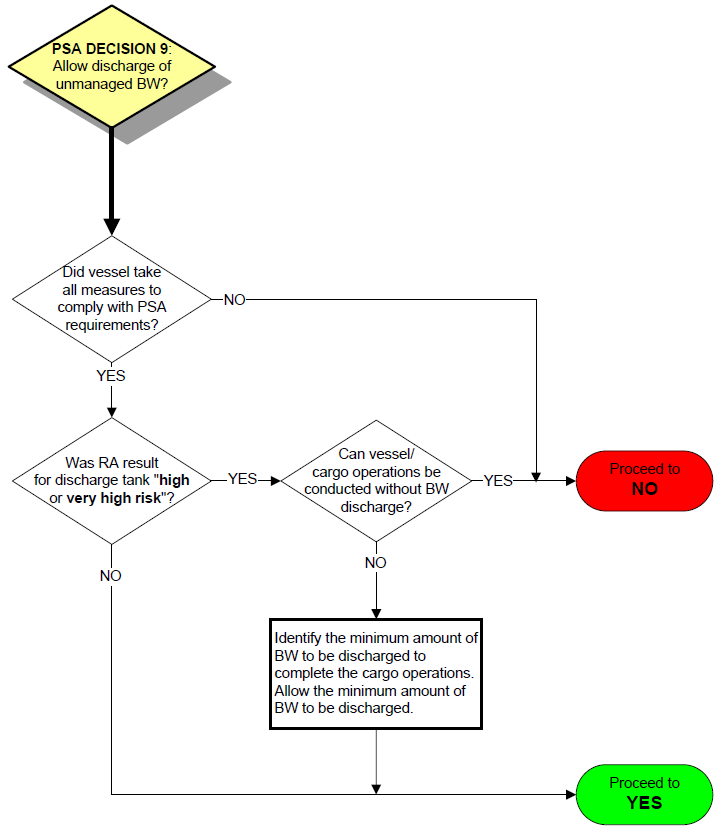

Figure 21 - Decision (9) on allowing or not a vessel to discharge unmanaged ballast water.

Noting the above explained scenarios (see Figure 17), PSC may end up in a dilemma. This occurs in the cases when ballast water, which is intended for discharge, is identified as of high or very high risk condition. From an environmental protection standpoint, i.e., the view with which the BWM Convention was drafted, no such ballast water should be discharged to the environment until it was shown that can do so without presenting a threat of harm to the environment, human health, property or resources. However, use of RA is not explicitly stipulated for this purpose.

As a compromise we have limited the situation where vessels, which could have done BWE in, e.g., intercontinental shipping when crossing the ocean, or in the area of the Bay of Biscay, should not discharge ballast water to high and very high risk situations and only for those ships were compliance with the D-2 standard is not confirmed. As no high or very high risk ballast water should be permitted to be discharged to the port, no detailed ballast water sampling is enabled for this compliance check as this could be done only during discharge with samples taken from an in-line sampling point close to the discharge point from the vessel. However, indicative ballast water sampling can be done with a sample taken from the tank directly, i.e., without discharging ballast water. In case this indicative sampling results does not indicate or give clear grounds for non-compliance with the D-2 standard, ballast water can be discharged and during the discharge a detailed sample may be taken to confirm the indicative sampling result. Should the indicative

sampling indicate or give clear grounds for non-compliance with the D-2 standard, the ballast water cannot be discharged to the environment until compliance is confirmed. Should it be impossible to document compliance and no ballast water reception facilities can be used and neither any emergency treatment with active substances can be done, this ballast water shall not be discharged according to the BWM Convention unless a regional agreement was reached requiring a different scenario as, e.g., in the Baltic Sea. However, when all options for managing ballast water on the vessel and in the port were considered and consumed, and no BWM option is available, then the minimum amount of ballast water necessary for the vessel to complete the intended operation in the port may be allowed to be discharged. This is clearly against environmental protection principles, hence Parties would need to consider to provide in the future for some option to manage high or very high risk water in such cases.

2.1.2.13 BWRA review process

BWRA is a relatively new working field and it is therefore recommended to be improved over time. This improvement should be based on new knowledge and information which becomes available by experience over time. Especially the BWS compliance results may be a very valuable source of information to be used for the BWRA review process, and new findings may support BWRA improvements (see

Figure 22).

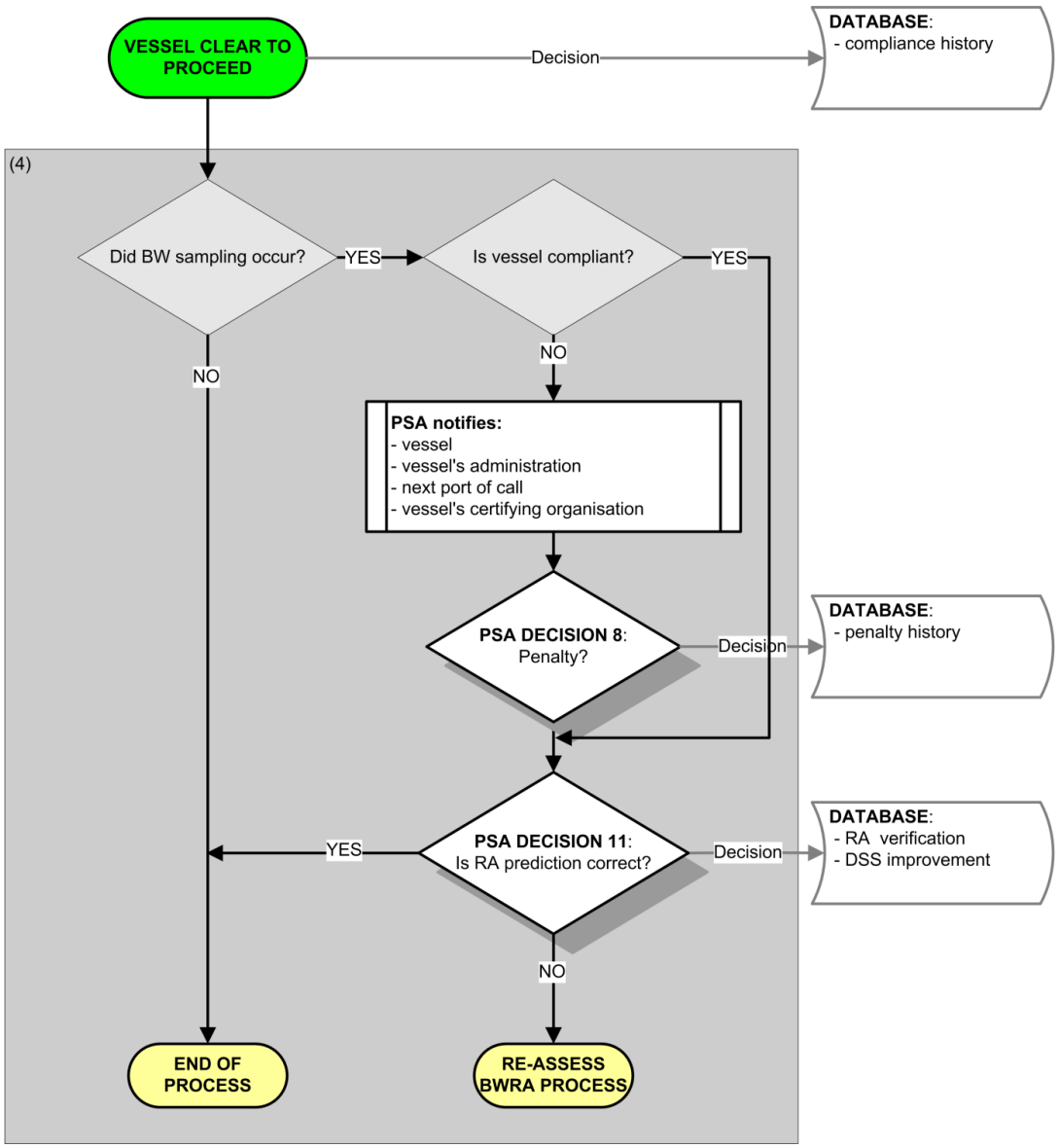

Figure 22 - The BWRA review process.

2.1.2.14 Decision 10: Is the risk assessment prediction correct?

To evaluate if the RA prediction process was correct is based on the comparison of the BWRA result with the BWS result. BWS may be carried out in different ways (a) just for salinity, (b) it may encompass biological analysis focussed on the presence of viable organisms as per the D-2 standard, or (c) may also include the identification of HAOP. In cases when only a salinity test was conducted, then the results may only be used for the review of the BWRA which was based on environmental matching. In contrast an identification of HAOP is needed for a complete BWRA review (see Figure 23).

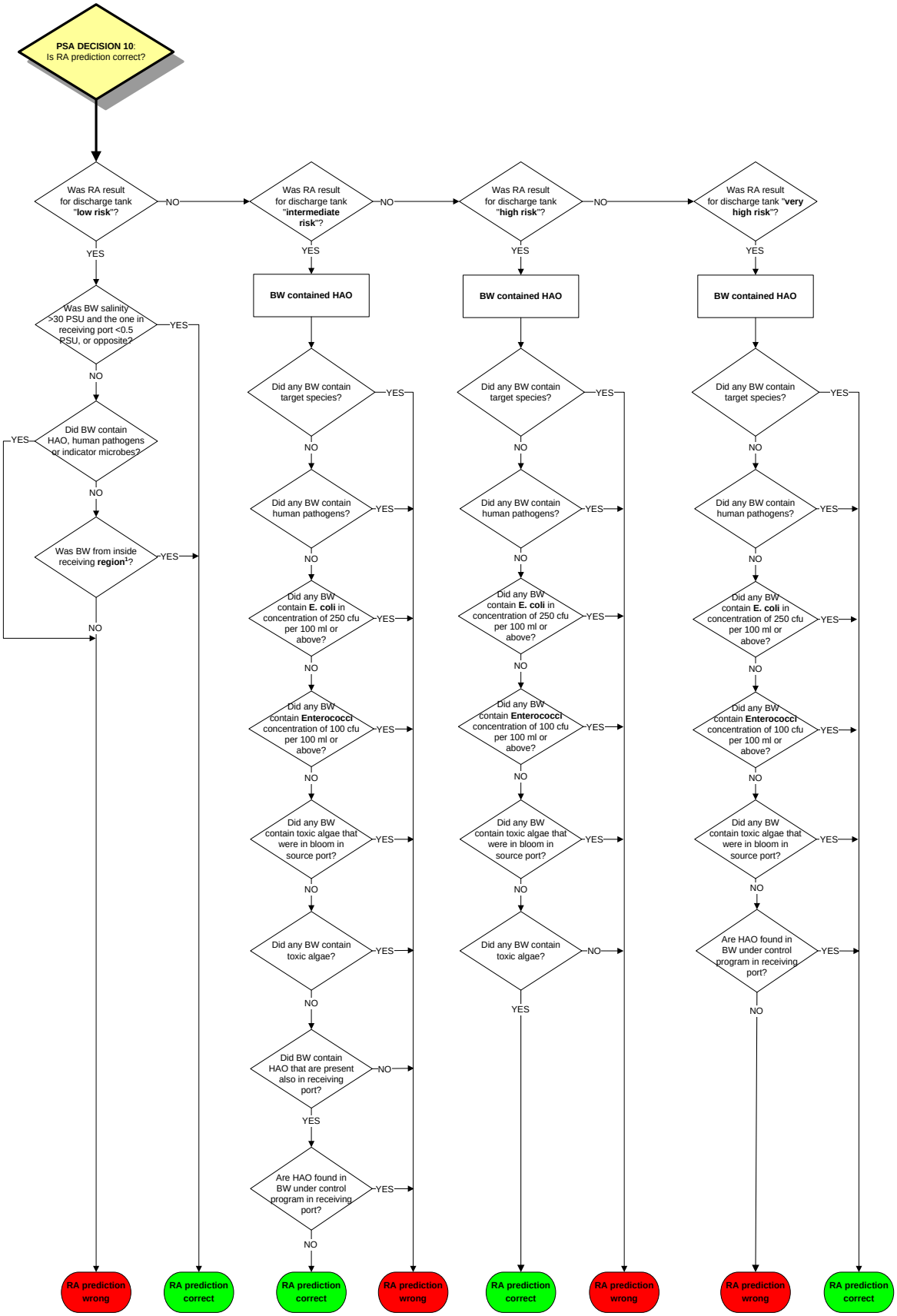

Figure 23 - Management decision (10) on correctness of the RA result. BW = ballast water, PSU = Practical Salinity Unit, HAO = Harmful Aquatic Organisms, region[1] = region means Adriatic Sea (see Annex 1).

2.1.2.15 End-points of the DSS

The selective approach in the BWM process based on DSS may result in one of the following situations:

- a vessel is turned away because she has not submitted the required data;
- a vessel does not need to discharge ballast water;
- a vessel may not need to conduct BWM as she is under BWM exception, or exemption;
- a vessel may conduct BWM in advance;
- based on BWRA a vessel may need to conduct additional measures when high risk is identified, or may have more relaxed requirements in the case of low risk and inability/failure to conduct BWM;
- a vessel requested to conduct BWM may be able to comply with the requirements or not;
- a vessel requested to conduct BWM may do it properly or not;
- a vessel may be selected for CME;
- a vessel may be allowed to discharge unmanaged ballast water;
- a vessel was able to comply with BWM requirements, but did not conduct BWM at all so that she is turned away;
- a vessel was able to comply with BWM requirements, but did not conduct BWM properly so that she is turned away;
- a CME sampling reveals that BWM standards are not met so that the deballasting has to be stopped; or
- a vessel which is found in non-compliance may be penalized.

In addition to the decisions relating to BWM, a re-assessment of the RA procedure is addressed in the DSS process, which is important for further improvements of RA results.

3. RECOMMENDATIONS FOR BALTIC BWM DSS IMPLEMENTATION AT NATIONAL AND TRANSNATIONAL LEVELS

DSSs provide decision makers with a tool to reduce uncertainties and to simplify and speed-up the decision process as well as to avoid subjectivism induced by the decision-maker and to guarantee transparency of a decision process. The DSS approach has been introduced in the BWM field and the need primarily arose with the introduction of the selective BWM approach. More precisely, it was recognised that a supporting tool is needed to aid transparency and consistency when deciding on BWM requirements to achieve better environmental protection and lessen burden on vessels.

The DSS process starts with communication and data input, continues with RA, BWM decisions, vessel's action(s), and ends with monitoring and review processes. Throughout the entire decision process information needs to be exchanged with outer (e.g., vessel, other ports) and inner sources (e.g., vessel's particulars, compliance history), and therefore needs to be supported by adequate communication processes and data management. When required BWM actions were not conducted properly the BWM DSS endpoints range from situations where unmanaged ballast water can be discharged to cases where vessels may be turned away.

Shipowners are encouraged to take a pro-active approach and to install and operate BWMS routinely, even before meeting the D-2 standard of the BWM Convention is required for all vessels. The entry into force of the D-2 standard, which basically forms the grounds for using BWMS, has been postponed different times, and now some vessels may continue with BWE until 2024. In the case of Baltic Sea related shipping, i.e., vessels calling to Baltic Sea ports, these come from different parts of the world, and there is also intensive intra-Baltic shipping. Vessels sailing across the oceans are, considering also weather conditions, mainly able to conduct BWE. Vessels sailing from South Europe, Black or Caspian Sea, Middle East and Africa may conduct BWE in the Bay of Biscay (IMO 2008b, 2009), while BWE is not an option in the intra-Baltic and North Sea/Baltic Sea shipping (HELCOM 2019 a, b). In the Baltic the BWM Convention depth and distance requirements for BWE cannot be met, Baltic countries decided not to designate any BWEA in the Baltic Sea, BWMS are not (yet) required to be installed and operated on board of all vessels, and ballast water reception facilities are absent while also vessels are not designed to make use of these facilities. With this BWE is not a BWM option in the Baltic Sea. In contrast, OSPAR agreed on a BWEA in the North Sea to be used for intra-North Sea shipping only (OSPAR 2014, BSH 2019). Noting that OSPAR sees this approach as risk reducing measure in intra-North Sea shipping, we recommend HELCOM and OSPAR countries to consider this BWEA also for shipping between the North and Baltic seas as a risk reducing measure rather than doing nothing.

The shortcomings of BWE as the main BWM option highlight the need for use of BWMS. However, we recommend to reconsider that BWE may be used in the future also in a, to be determined, Baltic Sea BWEA as a contingency measure in cases where BWMS fail to work properly.

It is further of interest that studies have shown that the greatest protection occurred in when BWMS were used in combination with BWE in higher saline waters when the recipient port is of freshwater condition (Briski et al. 2015, First & Drake 2017, Paolucci et al. 2017). Therefore, BWE may also play a role in the future after the D-2 standard applies, including in the intra-Baltic shipping, as an additional measure, especially when RA indicates high risk ballast water to be discharged.

We believe that this BWM DSS cannot work efficiently in paper format as the model is too complex to be efficiently used manually. Other DSS studies concluded also that complex decisions are best facilitated with an online DSS (e.g., Denzer 2005, de Kok et al. 2009). Therefore, it is recommended to develop an online electronic tool as a next step to implement the BWM DSS in an interactive format with an intuitive user interface. Such an electronic system may also support the user by, e.g., providing for correct reporting, identifying false BWM reports of ships, conducting BWRA, supporting selection of necessary BWM measures and vessels for CME, etc.

The BWM DSS would at best need to be applied EU-wide (Paris MoU area) and set-up as an electronic system to allow fast and accurate reporting from vessels, exchange of information among countries authorities and vessels, and provide fast and accurate decisions on BWM requirements. Such an online electronic DSS should be developed in close consultations with various stakeholders and envisaged end-users and this may be the result of a COMPLETE follow-up project. We recommend that EMSA as the responsible EU body for shipping should support and coordinate the implementation of a EU-wide BWM approach, making use of the work done in earlier research projects like VECTORS, BALMAS and now in COMPLETE. It is recommended to use the BWM RA and BWM DSS presented here, which strictly follow the provisions of the BWM Convention and its supporting guidelines, considering also the EU specifics. Further, non-EU countries which are bordering European seas should be encouraged to engage with the implementation of common EU BWM requirements, i.e., as a pan-European application.

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