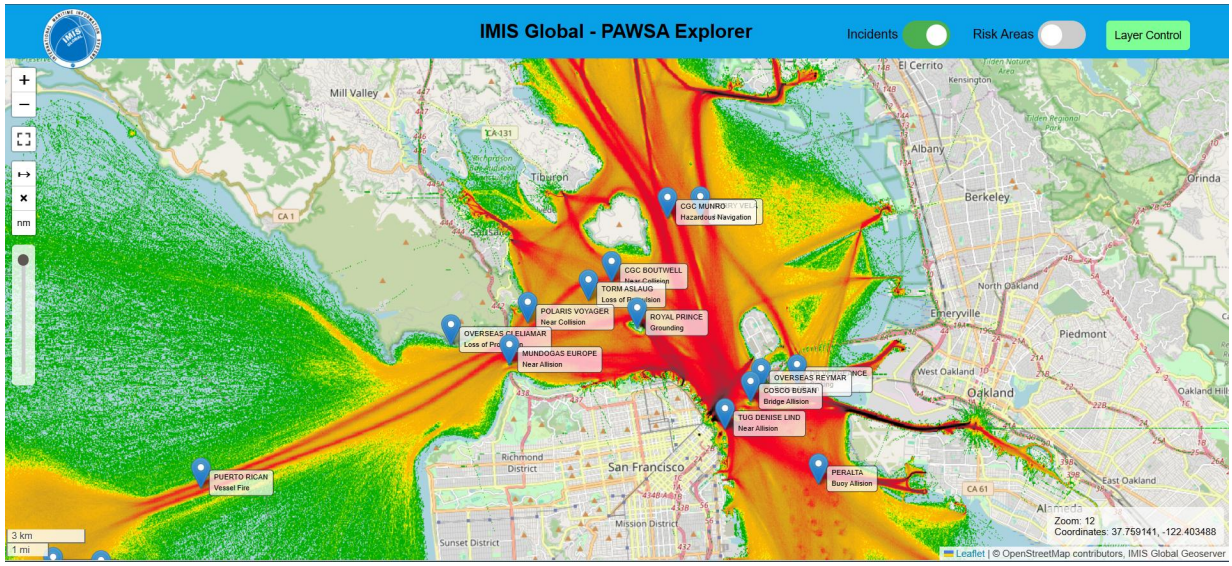
Marine Exchange of the San Francisco Bay Region

Port and Waterways Safety Assessment (PAWSA)
IALA Waterways Risk Assessment Program (IWRAP)
Workshop Report

San Francisco

Version 2.0



Executive Summary

Risk identification and mitigation are and have been ongoing activities within the United States Coast Guard Sector San Francisco area of responsibility. In support of that overall safety improvement activity, a formal Port and Waterways Safety Assessment (PAWSA) for the San Francisco Bay area and significant tributaries was conducted in Oakland, California on 15 – 17 April 2025, coordinated by the Marine Exchange of the San Francisco Bay Region. In addition, an assessment of risk using the IALA Waterways Risk Assessment Program (IWRAP) was carried out.

The workshop was attended by, as noted on a daily basis:

- 04/15/5025 – 87 participants,
- 04/16/2025 – 39 participants, and
- 04/17/2025 – 36 participants.

Attendees represented commercial mariners; regulatory authorities; maritime training institutes; highway, commuter rail, and bridge officials; tunnel, pipeline, and cable engineers; recreational waterways users; commercial fishing experts; and other stakeholders. The workshop participants had access to innovative tools to enable interaction with the data and data analysis carried out in advance of the workshop. The 'PAWSA Explorer' supported active participation by all attendees.

A previous PAWSA for San Francisco, conducted in 12 – 13 August 2008, included a portion of the waterway addressed by this report.

A Waterway Risk Model, incorporating 24 risk factors associated with both the causes and the effects of waterway casualties, was used throughout the workshop to guide discussions and numerical assessments. That model was originally conceived by a United States Dialog Group on National Needs for Vessel Traffic Services and subsequently has been refined based on experience gained during the 40+ PAWSA workshops that preceded this San Francisco session.

The PAWSA process includes a series of 'books' that are completed to provide a structured approach to identifying the hazards in the waterway, risks, existing mitigation measures and additional mitigation measures. The focused approach uses a 'baseline' risk level to then identify where future initiatives may be suitable to mitigate identified risks.

Through further refinement of the assessment, areas that require further consideration and identified, which are then assessed in a final 'book'. The outcomes of the 2025 San Francisco PAWSA are highlighted in this report in Section 3.

The workshop also included a series of focused discussion sessions to support the analysis of risk including:

- Review of the area using the PESTEL (Political, Economic, Social, Technological, Legal and Environmental) and SWOT (Strengths, Weaknesses, Opportunities and Threats) assessment tools;
- Identification of hazards and risks within the San Francisco Bay area;
- Identification of past incidents and near misses;
- Development of a mind map on existing and possible future mitigation measures;
- Identification of developments at the local, national and international level that may affect safety of navigation, the safe and efficient movement of vessel traffic in the area and the protection of the environment, the port area and adjacent shore infrastructure.

The results of these discussion sessions supported deeper understanding of the challenges and opportunities in the area to assist in the completion of the PAWSA workbooks.

Based on extensive discussions during the workshop, concentrations of risks were noted by the participants in five locations:

- Central San Francisco Bay
- South San Francisco Bay and Federal Anchorage areas
- Southampton Shoal, Richmond Outer Harbor, and Richmond Inner Harbor
- San Pablo Bay to the mouths of the Petaluma River and Napa River
- Oakland Bar Channel, Oakland Outer Harbor, and Oakland Inner Harbor
- Carquinez Strait and Suisun Bay
- Sacramento-San Joaquin River & Delta region

The PAWSA San Francisco participants concluded that additional risk reduction actions were needed with respect to five of the twenty-four risk factors in the Waterway Risk Model across the five main categories of Vessel Conditions, Traffic Conditions, Navigational Conditions, Waterway Conditions, Immediate Consequences, Subsequent Consequences. When reviewing the twenty-four risk factors with additional mitigation measures, the participants identified eight of the twenty-four risk factors had a trend of 'rising' or 'maybe (rising)'.

- Vessel Conditions: Deep Draft Vessel Quality (rising); Small Craft Quality (rising)
- Traffic Conditions: Volume of Small Craft Traffic (may be rising) Traffic Mix (rising); Congestion (rising)
- Navigational Conditions: Obstructions (rising)
- Waterway Conditions: Dimensions (may be rising)
- Immediate Consequences: all elements identified at 'balanced'
- Subsequence Consequences: Aquatic Resources (risking)

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Figures and Tables

1. Background

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The list of participants for the workshop is provided in Annex A.

A previous PAWSA for San Francisco, conducted in 12 – 13 August 2008, included a portion of the waterway addressed by this report. The schedule for the workshop is provided in Annex B.

In addition to the use of PAWSA, the workshop provided an opportunity to explore concepts of risk factors through a series of focused workshop sessions. The activities included the review of the waterway area through both a PESTLE (Political, Economic, Social, Technological, Legan and Environmental aspects) and a SWOT (Strengths, Weaknesses, Opportunities and Threats); identification of hazards in the area; discussion on incidents and near misses; listing of mitigation measures (existing and possible); and an overview of focus activities – current and future.

During the workshop the participants had an opportunity to interact with data related to shipping activities and incidents through a tool called 'PAWSA Explorer'. This tool was developed specifically to assist participants in their discussions.

To support the quantitative elements of the assessment, the IALA Waterway Risk Assessment Program (IWRAP) was introduced. Participants had an opportunity to influence the use of IWRAP through identification of areas for analysis and assessment.

Noting the unique opportunity presented by the workshop, participants provided input on the development of a revised PAWSA tool (PAWSA Next Generation, or PAWSA Mk. IV). Noting the developing nature of this tool, the results of PAWSA Next Gen are not included in this report.

1.1. Keynote Presentation

Dr. Emery Roe, former Senior Research Associate at the Center for Catastrophic Risk Management, UC Berkeley, provided a keynote presentation focused on managing systemwide risks in real time.

The presentation highlighted the criticality of understanding systemwide failure scenarios, and associated risk estimates, when looking at transportation infrastructure in the San Francisco Bay area. As part of the 'take home' message, Dr. Roe stressed that high reliability management isn't just about crunching numbers to predict failures. It's about cultivating a mindset that actively prevents complacency, sharpens judgment, and keeps options open, even in high-risk environments. He noted that the most effective strategies aren't just technical fixes or statistical models; they involve leadership, organizational culture, and real-time adaptability. This underlines the need to embed resilience into everyday operations so that when challenges arise, they don't derail everything.

In his presentation, Dr. Roe referenced previous work carried by himself and Paul Schulman, looking at the four performance modes and major systemwide risks – the options variety vs system volatility matrix:

		System Volatility	
		High	*Low*
Options Variety	*High*	Just-in-time performance: risk of misjudgment, with too many variables at play	Just-in-case performance: risk of inattention and complacency
	Low	Just-for-now performance: risk of losing options, with lack of maneuverability and cascading error	Just-this-way performance: risk of failure in complying with command and control requirements

Source: Roe and Schulman (2008, 48).

Two key implications were highlighted:

1. The interconnected systems are being reliably managed to the extent that their respective major systemwide risks are being managed.
2. The interconnections between transportation infrastructures pose a special kind of risk management for their respective reliability professionals and any shared team situational awareness.

1.2. Formal Safety Assessments

The Formal Safety Assessment (FSA) is a process for supporting decision making, making use of risk analysis and cost benefit assessment. The five steps of the FSA process are shown in Table 1 below. They focus on the general principles of risk assessments, including identifying a cost-benefit assessment[1] for the risk control options, also known as mitigation measures. It also lists some key questions addressed in each step, and outputs that are obtained by executing the different phases.

FSA aims to achieve a balance between various technical and operational issues, including the human element, maritime safety and protection of the marine environment, and costs. The International Maritime Organization first adopted FSA in 2002, through *MSC/Circ.1023/MEPC/Circ.392*, recommending the use of FSA for the maritime sector. The current version of the procedure is described in *MSC-MEPC.e/Circ.12/Rev2*.

1 The cost-benefit assessment is not included in the PAWSA workshop process; rather, it is a step that is taken by the authority or organisation sponsoring the PAWSA to facilitate an effective response to the outcomes of the workshop.

Table 1 – Steps within the Formal Safety Assessment Process

Step	Name	Key question	Outputs
1	Hazard identification	What might go wrong?	A list of all relevant potential accident scenarios with potential causes and consequences
2	Risk analysis	How likely is the risk to occur? If it happens, how severe would be the consequence	Estimation of likelihood and consequences of the potential accident scenarios, ranking of these scenarios
3	Risk control options	Can matters be improved?	Potential measures to reduce the likelihood of occurrence of the identified risks, or limit their consequences should they occur
4	Cost-benefit assessment	What would it cost? How much better would it be?	Costs associated with the different risk control options, and an assessment of how cost-effective they are compared to how much they reduce the risk
5	Decision-making recommendations	What actions should be taken?	Documented information about the hazards, their associated risks and the cost effectiveness of alternative risk control options is provided to decision makers

1.3. IALA Risk Management Tools

IALA Recommendation R1002 Risk Management for Marine Aids to Navigation (a normative Recommendation of IALA Standard 1010 AtoN Planning and Service Requirements) recommends the use of risk management and IALA risk management tools when assessing the risks in waterways, as part of the decision-making process for Marine Aids to Navigation.

IALA Guideline 1018 (G1018) – Risk Management (edition 4, June 2022) provides an overview of the risk review and assessment process to be undertaken for the provision of Aids to Navigation (AtoN) and Vessel Traffic Services (VTS).

G1018 notes that a Formal Safety Assessment (FSA) methodology has been recommended by the International Maritime Organization (IMO) for use by maritime authorities2. The IMO Safety of Life at Sea Convention (SOLAS) Chapter V, Regulations 12 and 13, refer to the provision of aids to navigation and establishment of VTS where the volume of traffic and/or the degree of risk justifies the provision of such services. SOLAS Chapter V, Regulation 10 refers to ships' routing and Regulation 11 refers to Ship reporting systems.

The IALA approach to risk assessment fits within an overall approach for risk management, as noted in G1018 (Figure 1). The approach presented by IALA aligns with the International Standards on Risk Management *ISO 31000.*

The risk process used by IALA is based on standard risk assessment and mitigation approaches.

2 IMO MSC-MEPC.2/Circ.12/Rev.2, Revised guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process, https://wwwcdn.imo.org/localresources/en/OurWork/Safety/Documents/MSC-MEPC%202-Circ%2012-Rev%202.pdf

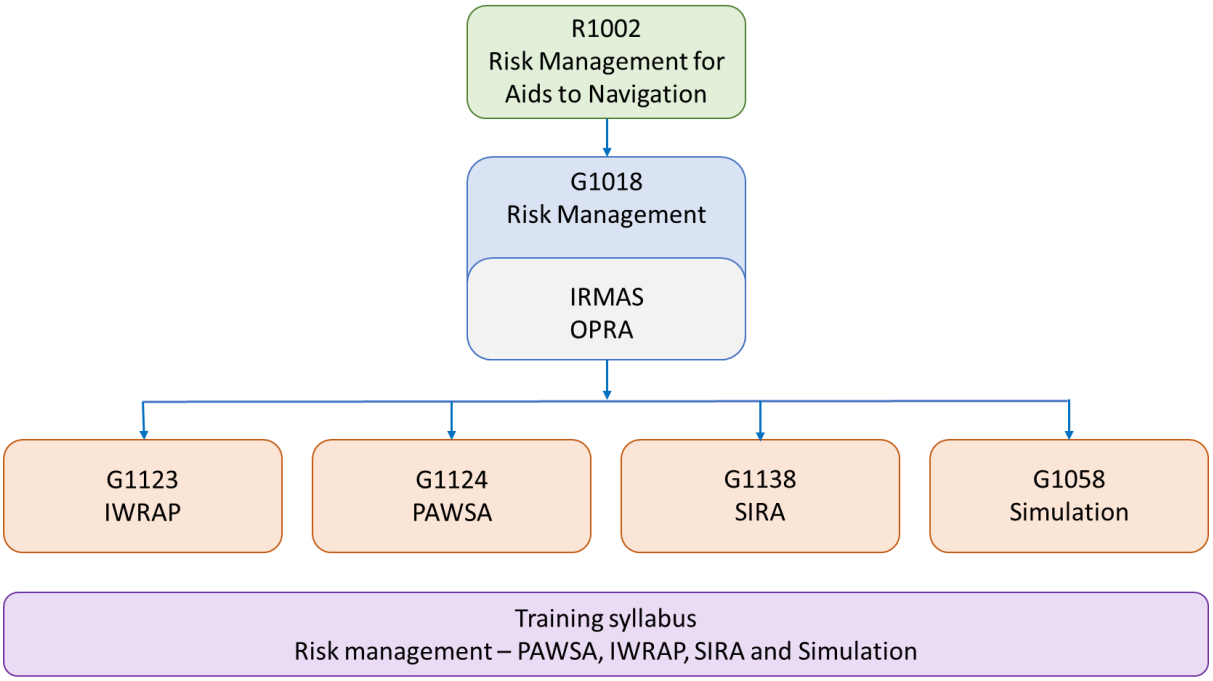


Figure 1 – Overview of IALA Risk Management toolbox and associated documents

1.4. Acronyms and Initialisms

Within this document the following acronyms or initialisms are used.

Acronym/Initialism	Expansion / Definition
AI	Artificial Intelligence
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AtoN	Aid to Navigation (external to the vessel – buoys, lights, etc.)
CCTV	Closed Circuit Television
COLREGS	Collision Regulations (The International Regulations for Preventing Collisions at Sea, 1972)
FLIR	Forward Looking Infrared (camera)
FMCW	Frequency Modulated Continuous Wave (Radar)
FSA	Formal Safety Assessment
GIS	Geographic Information System
GSM	Global System to Mobile Communications
IALA	International Organization of Marine Aids to Navigation (formerly International Association of Marine Aids to Navigation and Lighthouse Authorities)

Acronym/Initialism	Expansion / Definition
IALA C0103-1	IALA VTS Operator Course – C0103-1 (note, VTS Supervisor course is C0103-2, VTS on-the-job Training is C0103-3, etc)
IHO	International Hydrographic Organization
IMT-2030	International Maritime Telecommunications 2030 (development of technology to support communications such as 5G, 6G)
IMO	International Maritime Organization
ITU	International Telecommunication Union
Navaid	Navigational Aids (on board the vessel, as opposed to AtoN that are external to the vessel)
NETHOW	Natural, Environmental, Technical, Human, Operational and Waterway complexity (hazards)
PESTLE	Political, Economic, Social, Technology, Legal, Environmental
RNA	Regulated Navigational Area
S-100	IHO Universal Hydrographic Data Model to support digital data exchange. Include S-100, S-200, S-400. (an ISO 19100-based geospatial standard)
SECOM	Secure Communications (Standard IEC 63173-2:2022
SIRA	Simplified IALA Risk Assessment
SOLAS	International Convention for the Safety of Life at Sea
SRS	Ship Reporting System
SWOT	Strengths, Weaknesses, Opportunities, Threats
TSS	Traffic Separation Scheme
VTS	Vessel Traffic Services

2. Overview of Risk and Risk Assessment Activities

The Risk Assessment workshop followed a structured approach including full group discussions, syndicate table discussions, and completion of the PAWSA workbooks.

During the workshop, participants had the opportunity to use the PAWSA Explorer (Figure 2) to engage with the prepared heat maps (vessel density charts), past incident data and reports, reference material and workshop documents.

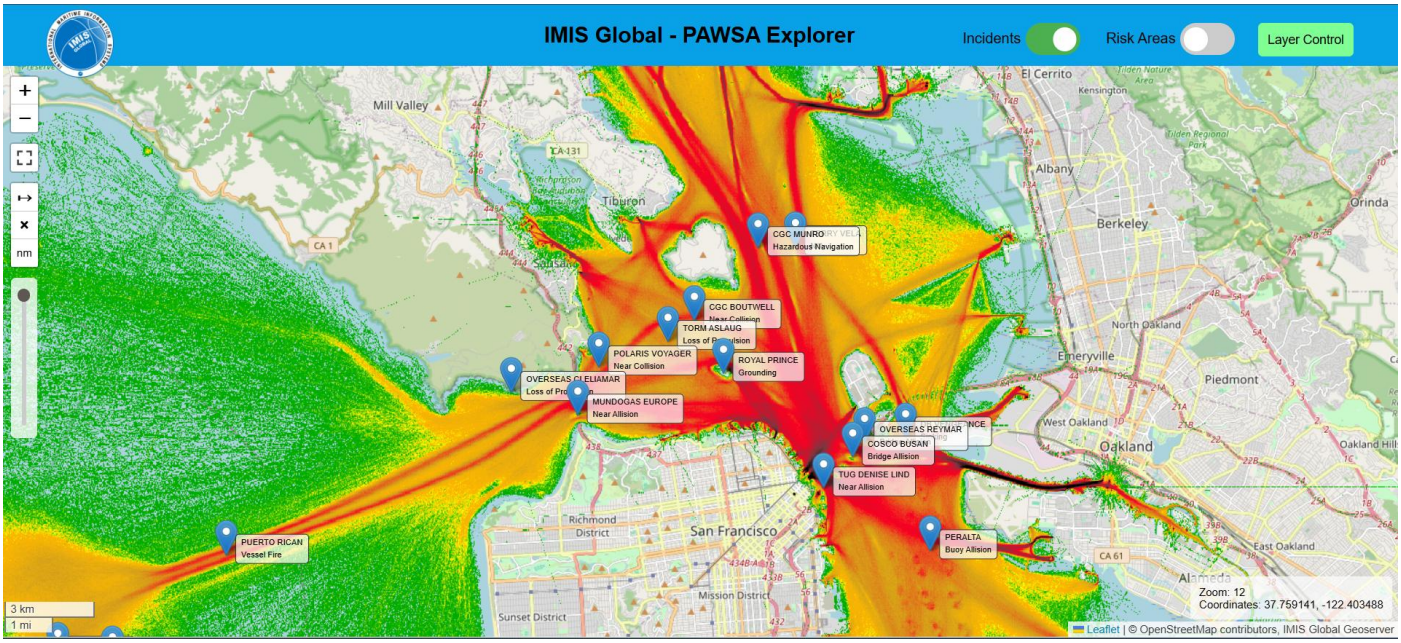


Figure 2 – PAWSA Explorer Tool

The results of these discussion sessions supported deeper understanding of the challenges and opportunities in the area to assist in the completion of the PAWSA workbooks.

2.1. Discussion Session 1

Syndicate table discussions were integrated into discussion sessions as well as full group sessions to share and discuss results. The focused group discussions included:

- Review of the area using the PESTLE (Political, Economic, Social, Technological, Legal and Environmental) and SWOT (Strengths, Weaknesses, Opportunities and Threats) assessment tools;
- Identification of hazards and risks within the San Francisco Bay area;
- Identification of past incidents and near misses;
- Development of a mind map on existing and possible future mitigation measures;
- Identification of developments at the local, national and international level that may affect safety of navigation, the safe and efficient movement of vessel traffic in the area and the protection of the environment, the port area and adjacent shore infrastructure.

2.1.1. Scanning the Horizon

Using the SWOT and PESTLE review tools, the workshop identified key opportunities and challenges related to maritime transport within the San Francisco Bay area. The outcomes of the assessments are provided in Table 2 and Table 3.

Some identified opportunities include technological developments; automated systems and future infrastructure developments to support sustainability initiatives; solid shipping initiatives across diverse commodities.

Some identified challenges include aging workforce/reduction of qualified maritime workforce; mismatch between existing infrastructure and vessel size/power; aging infrastructure – bridges and other infrastructure; lack of understanding of the maritime industry more broadly within society.

Table 2 – SWOT Analysis

Strengths	Opportunities
▪ Solid VTS Team ▪ Maritime community that cares ▪ Well established infrastructure, access to dredges, resources and tools ▪ Diverse maritime communities and commodities ▪ Adoption of advanced technologies	▪ Policy and regulations (review, revise) ▪ Technology / Technological alignment across the board ▪ Labor association interaction ▪ Intermodal connectivity
Weaknesses	**Threats**
▪ Lack of interest in the maritime industry ▪ No trade school to back the industry ▪ Capacity to meet future demand ▪ Mismatch between existing infrastructure and growth size ▪ Overall - aging CA maritime support group	▪ Lack of incoming workforce ▪ Funding challenges – existing funding may not be sustained / need for additional funding ▪ Constraints of policy and regulations / changing policy and regulations ▪ Aging bridges and other transportation and other infrastructure ▪ Impact of maritime incident on other aspects of the transport chain (and vice-versa)

Table 3 – PESTLE review

Political	Technological
▪ New regulations ▪ Political inconsistencies ▪ Fuel access ▪ Politically driven infrastructure changes ▪ Tariffs ▪ Increased regulations ▪ International port agreements ▪ Clean energy/sustainability initiatives (political climate drives energy decisions & funding)	▪ Changes in technologies ▪ AI adoption ▪ Shore power technology ▪ Electronic aids to navigation (AtoN) and navigational aids ▪ Energy infrastructure – current may not meet the needs for the future ▪ New Communication technologies ▪ Clean energy/sustainability initiatives (feasibility & operational sustainability)
Economic	**Legal**
▪ Cost for material in the US - hindering competition ▪ Good shipping with diverse commodities ▪ Large impact on other industries ▪ Large impact on the energy economy ▪ Economic interstate commerce impact ▪ Competition for available resources ▪ Clean energy/sustainability initiatives (cost-basis for development)	▪ Lawsuits and liability ▪ Accountability measures ▪ Enforcing current navigation rules
Social	**Environmental**
▪ Lack of understanding of the maritime industry ▪ Maritime industry reputation – impact tourism ▪ Disadvantaged community impacts	▪ Hazmat release ▪ Environmental sensitive areas – protected species ▪ Changes to the Endangered Species Act ▪ Aquatic resource impacts of over-fishing/over-exploitation/congestion ▪ Shore power/air quality ▪ Population density around the port ▪ Clean energy/sustainability initiatives (lithium ion disasters/incidents = negative impact on aquatic resources)

Recommendations:

1. *The outcomes of the SWOT and PESTLE analysis developed during the PAWSA workshop process be reviewed and, if required, revised to ensure accurate representation of the waterway reviewed.*
2. *A SWOT and PESTLE review is carried out on a regular basis, for example, annually.*

2.1.2. Hazards Identification

During the workshop the concept of 'hazards' and 'risks' were clarified, noting that:

- Hazard – a source or situation with the potential to cause harm
- Risk – the likelihood of harm actually occurring, combined with the consequence (Risk = Likelihood X Consequence)

Based on this, the workshop created a list of Hazards within the area, based on the IALA structured assessment process that looks at Natural, Environmental, Technical, Human, Operational and Waterway complexity hazards (NETHOW - Table 4). In addition, Marine Spatial Planning activities were considered.

Table 4 – Hazards identified using the 'NETHOW' model

<table>
<tr><th>Natural</th><th>Economic</th></tr>
<tr><td>(i.e.) Significant Weather events, fog
Great Shake/Earthquake/geography changes
Tsunami
Fog
Wind events
King Tide
Major Storm events
Sea level rise
Wildfires
Flooding
Shifting Sludge
Whales
Algae bloom
Temp changes</td><td>(i.e.) Commercial shipping; Tourism
Political changes
Agriculture/Oil
Tourism/Cruise
Hazardous material shipments
Commerce changes
Supply chain challenges
Population changes</td></tr>
<tr><th>Operational</th><th>Waterway</th></tr>
<tr><td>(i.e.) Under Keel Clearance, Air draught, Procedures
Bridge Operations
Underwater infrastructure
Dredge ops
VTS control
ATON
Regulation Changes
Environmental Regulation
Fuel changes
Fish window for construction
Fishing gear/seasons
Oil spill
Communication procedures
Bridge incident response (HAZMAT/collision)</td><td>(i.e.) Recreational boating; Commercial shipping
Traffic density
Ferry
Complexity of waterway
Currents
Shoaling
Fishing
Sailing
Recreational
Larger events (races)
Tunnel
Bridges
Pipelines
Anchorages
Marine Mammals
Channels
Bottom type
Derelict vessels</td></tr>
</table>

Technical	Human
(i.e.) Vessel breakdowns • Power supply • Fuel changes • Control systems • Loss of power • Loss of GPS • ATON off station • Cyber security • Bar pilots • Aging infrastructure • Vessel size/growth • Communications infrastructure	(i.e.) Health / wellbeing (fatigue, pandemics) • Experience • Fatigue • Psychological • Workforce availability • Human error • Knowledge • Distractions • Language barriers • Bad actor • Navigational skill/knowledge • Non-compliance- Safety/regulations • Development of / Increased use of AI-Unmanned vessel (MASS)
Marine Spatial Planning	**Other?**
(i.e.) Nature reserves; aquaculture • Marine sanctuary • Economic zone • Traffic separation • RNA (Regulated Navigational Area) • Wind power • Whales, when present within the zone	• Lack of contingency planning/options • Public sentiment • Unknown unknowns • Increased HAZMAT risks/volatility • The BART tunnel / other underwater features

In addition to the hazards identified within the NETHOW framework, a full group discussion on underwater features results in the development of a mind map (Figure 3).

Recommendations:

3. *The hazards identified during the PAWSA be reviewed and revised, as may be necessary.*
4. *To support an ongoing approach to effective risk assessment, the hazards in the waterway area are reviewed on a regular basis, noting changes in shipping activities; ship size and power; technological developments and use of the waterway.*

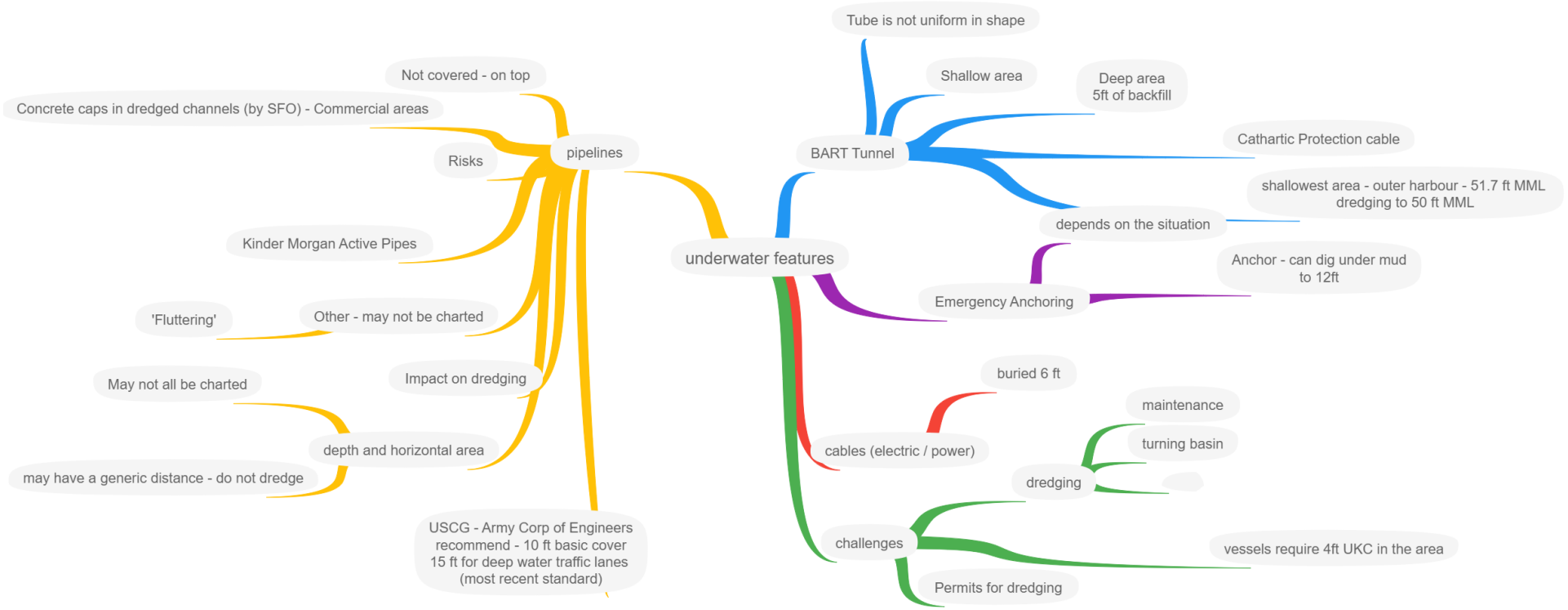


Figure 3 – Underwater Features Mindmap

2.1.3. Incidents and Near Miss Overview

In preparation for the workshop a number of incidents and near-misses were identified and provided in a geo-referenced manner on the PAWSA explorer. During the workshop these were reviewed, and additional items were noted as appropriate. These were identified on the charts to provide a graphic representation of the incidents which supported detailed review during the PAWSA workbook activities. (see Annex E)

In addition to the incidents and near misses identified in the reference booklet (see Annex F), areas of risk including past or potential incidents were noted.

2.1.4. Mitigation Measures Mindmap

A detailed mitigation measures mindmap was created. This map is best viewed in the software program, with an image of the completed mindmap provided in Annex D.

A summary of selected risk mitigation measures as discussed during the workshop and as presented in the mindmap is provided in Table 5.

Table 5 – Overview of risk mitigation measures

Mitigation Measure	Current	Possible future opportunities
Legislative framework	• Many agencies with strong regulatory structure • Licensing • Regulations for dredging • Qualified persons • Incident reporting / NTSB • MARAD / Federal maritime commission • Membership in IMO / IALA (international best practice)	• Create one-stop shop for consolidated information • Implement enhanced training and stronger licensing for recreational craft • Actively monitor use of VHF and enforce correct use of the radio spectrum
Emergency Response	• Emergency/contingency planning • Vessel response plan • Interagency approach	• Implement multi-modal response (drills / emergency response; tabletop exercises)
Vessel Traffic Services	• Training / procedures • Existing equipment • Sensors (AIS, Radar, CCTV, VHF radio) • National structure / international reference (SOLAS V/12, Res.A.1158(32)) • Monitoring / managing ship traffic	• Review regulatory framework to ensure compliance with IMO Resolution A.1158(32), noting structure within the resolution of Contracting Government, Competent Authority and VTS Provider. • Update training noting IMO A.1158(32) and the revised IALA model course structure. • Enhance VTS equipment and sensors noting developments in the Decision Support Tool (DST); Radar technology (including FMCW radar)

Mitigation Measure	Current	Possible future opportunities
		meteorological, hydrographic and optical sensors. • Implement digital data transfer solutions including technology (i.e. VDES, IMT-2030); S100 data exchange formats; Secure communications (i.e. SECOM standard)
Marine Exchange	• Coordination • Monitoring • Sensors / equipment	• Increase training of operational personnel to reflect IALA model course C0103-1 (VTSO) • Enhance equipment / sensors
Charts/Hydrographic Surveys	• Updated / timely surveys • Dredging activities • Army corps of engineers	• Increase surveys • Address challenges of wrecks/debris • Identify options to use digital tools to support awareness
Infrastructure / Bridges	• Bridges with nav marking / physical barriers	• Review in light of increased vessel sizes / kinetic energy • Note possible issue of 'hardening' up the bridges, could affect ability to withstand earthquake
Education	• Marine Exchange • Boater safety course • Maritime academies	• Implement greater outreach to small craft including the provision of education • Increase / implement Marine mammal education programs • Develop and implement workshops regarding safety of navigation and importance of water transportation. • Review and increase the use of physical signs • Develop online apps to support water safety aspects.
Pilotage	• Training and Licensing • Medical Assessment • Continuing education • Use of PPUs	• Provide additional technology support • Increase awareness, and possible implementation of international developments in pilotage.

2.1.5. Focus activities – current and future developments

The discussion on focus activities included reviewing developments in ship types and sizes, changes in fuel, analogue vs digital communications, infrastructure developments, etc.

The results of the discussion are provided in Table 6.

Table 6 – Current and Future Developments

Activity	Implications for safety of navigation / port operations	Expected timing for implementation (0-2 yrs, 2-5 yrs, 5-10 yrs, longer term)	Comments
Evolving fuel types	Spills, fires, response, impact beyond waterways	5-10	Potential environmental impact due to release
Lithium-Ion batteries	Containment, impact to other stakeholders	Shorter implementation timeline 0-2yrs	Class D fire training for first responders
Aging infrastructure replacement	Larger ships, analog communication systems,	Ongoing	Identify and implement a schedule to address
AI influence on operations	Assisting with risk assessment modeling – reliance by crews while operating vessels	Long term	Standardized, Approved formatting.

Recommendations:

5. *Based on the results of the discussion on current and future developments affecting the waterway area, identify suitable areas for further review and development to address aspects of evolving fuel types, challenges faced through the carriage and use of lithium-ion batteries, aging infrastructure and the influence of AI on port operations.*
6. *To support an ongoing approach to effective risk assessment, the hazards in the waterway area are reviewed on a regular basis, noting changes in shipping activities; ship size and power; technological developments and use of the waterway.*

3. PAWSA Workshop Activities

PAWSA is based on the principles set out in the IALA G1018 on risk management and defines risk as the product of two factors – the probability (or likelihood) of an undesirable incident occurring multiplied by the anticipated severity of the potential long and short-term impact (or consequence) if the incident does occur.

As a qualitative tool, PAWSA is exploratory and the analysis seeks a deeper understanding of why a certain phenomenon occurs, its associated consequences, and the potential effectiveness of additional mitigation measures. PAWSA provides a systematic approach to the identification of major waterway safety hazards, estimated levels of risk, and the evaluation of potential risk mitigation measures so that selected measures can be implemented to reduce such risk.

The output from PAWSA indicates whether the risk in a waterway is either:

1. Acceptable and that no further work is needed unless changes occur in significant criteria, such as the traffic pattern or types of vessels using that waterway; or

2. Not acceptable but the risk control options necessary to make the risk level of the waterway acceptable have been identified adequately; or
3. Not acceptable and more detailed study is necessary to enable the risk control options that will make the risk level of the waterway acceptable to be identified adequately.

3.1. Geographic Area

The geographic bounds of the waterway area identified for the review are identified in Figure 4.

These were defined as:

- Pacific Ocean approaches to San Francisco Bay within a 38-mile radius of Mt. Tamalpais.
- San Francisco Bay including the South Bay down to Redwood City and the Central Bay north into San Pablo and Suisun Bays including Mare Island Straits and Carquinez Straits.
- The navigable portions of the Sacramento and San Joaquin Rivers in The Delta, including the Ports of Sacramento and Stockton.

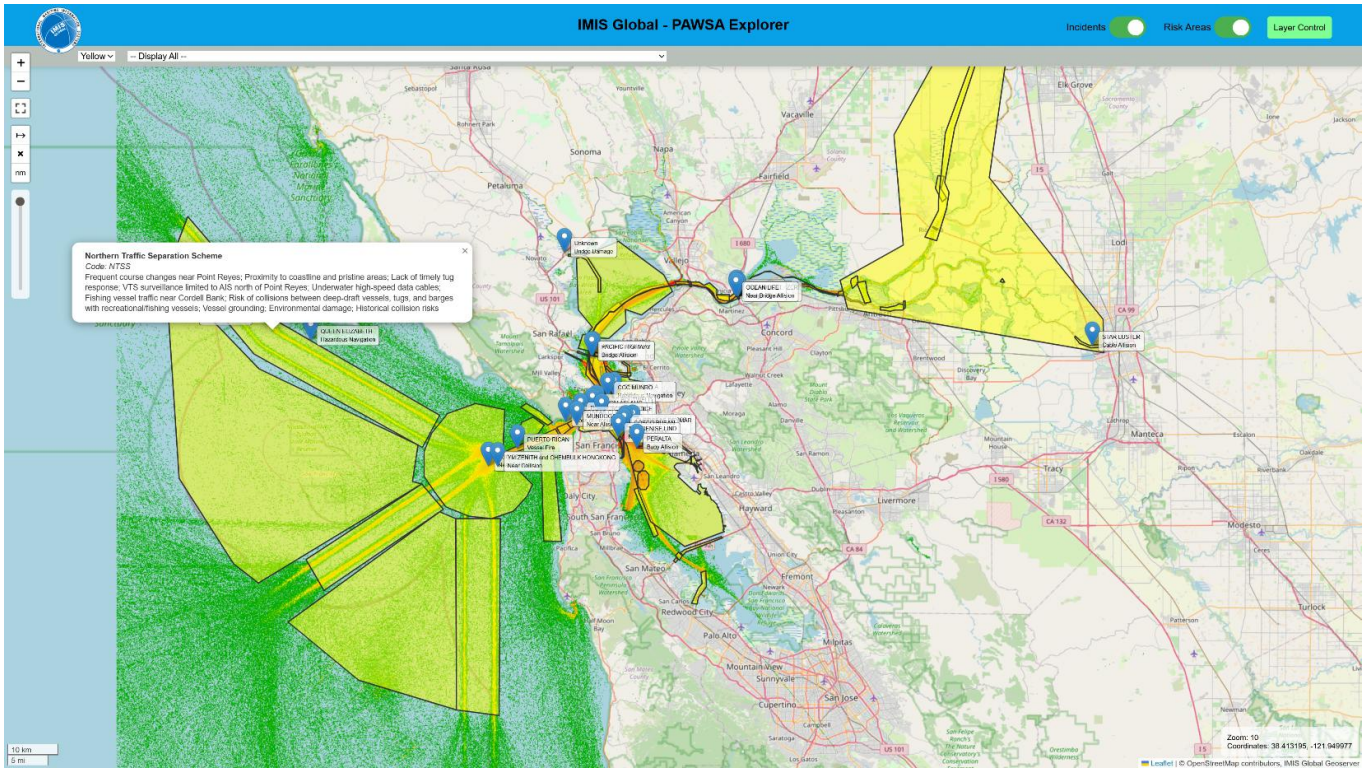


Figure 4 - PAWSA GIS Explorer

3.2. PAWSA Mk II Overview

The SFMX PAWSA Workshop used the IALA PAWSA Mk II structure, within a broader three-day workshop process. The use of the IALA workbooks provided an opportunity to evaluate risk and potential mitigation measures through expert input.

During the workshop, waterway users and stakeholders discuss and estimate risks levels for 24 different risk factors, organized into six risk categories, collectively termed the Waterway Risk model as presented in Figure 5.

Waterway Risk Model					
Vessel Conditions	**Traffic Conditions**	**Navigational Conditions**	**Waterway Conditions**	**Immediate Consequences**	**Subsequent Consequences**
Deep Draft Vessel Quality	Volume of commercial traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
Commercial Fishing Vessel Quality	Traffic mix	Visibility Restrictions	Bottom Type	Hazardous Material Release	Aquatic Resources
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic

Figure 5 - PAWSA MKII Waterway Risk model – categories and risk factors

The PAWSA process includes a 5 'book' process to obtain expert judgments on the level of waterway risk for each factor in the Waterway Risk Model. The process also addresses the effectiveness of existing and possible future intervention actions for reducing risk in the waterway.

Once the 'teams' for the workshop have been identified, the first step is to assess the level of team expertise, which then is used to weigh the input on the following books. This is done using 'Book 1'.

Book 2 identifies the collaborative approach to 'risk', providing aggregate risk factor rating scales, which are then used within the following activities to assess baseline risk levels, mitigation measure effectiveness and additional mitigation measures. (Books 3-5).

An overview of the five main steps used in the PAWSA MKII process are described in Figure 6.

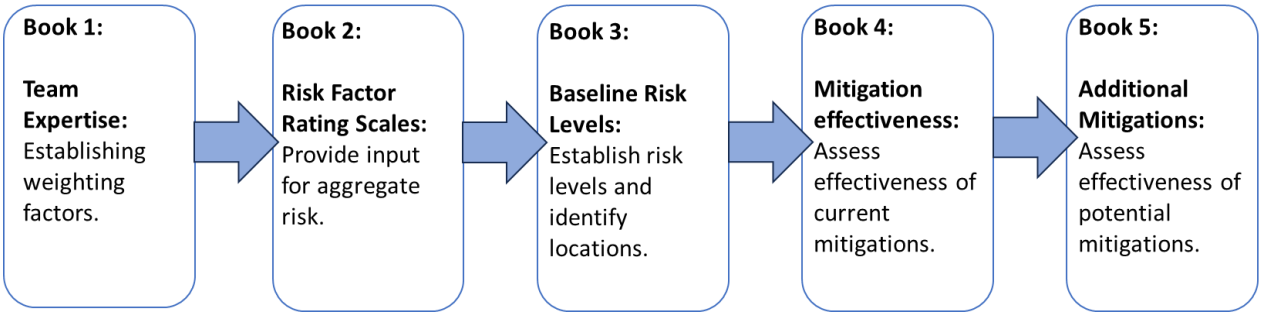


Figure 6 - PAWSA Workbooks

3.2.1. Details of PAWSA workbooks

1. *Book 1 – Teams Expertise*

    a. At the start of the PAWSA workshop, the maritime experts and waterway users participating in the workshop are divided into teams with similar expertise. There is no expectation that each participant will be equally knowledgeable in all 24 risk factors being assessed, therefore, the relative level of expertise of each team is determined.

    b. The results of Book 1 are used to weight each team's input in all other Books.

2. *Book 2 - Risk Factor Rating Scales*

    a. Measurement scales are established for each of the 24 risk factors in the Waterway Risk model. Book 2 is only developed if the historically developed measurement scales do not characterize the range of possible conditions that affect risk within the waterway for each risk factor. Otherwise, the default values are used.

    b. Book 2 develops the four-point rating scale for each risk factor. Specifically, the output from Book 2 is the four levels of risk described for each of the 24 risk factors. That is:

        i. *"A Value"* - The lowest level of risk describing the best-case situation.

        ii. *"D Value"* - The highest level of risk describing the worst-case situation.

        iii. *"B and C Values"* - Two intermediate risk level descriptions also are given – the "B" and "C" values.

3. *Book 3 - Baseline Risk Levels*

    a. The measurement scales developed in the second step are used to determine the levels of risk within the waterway due to each risk factor. In this step, the existing mitigation measures applied to reduce risks in the waterway *are not considered.* Book 3 is used to determine a baseline risk level value for every risk factor in the Waterway Risk model. In summary:

        i. It uses the same four qualitative descriptors for each risk factor as were used in Book 2 (i.e., Values A, B, C and D).

        ii. The risk level values that are produced by Book 3 are not intended to take into account any actions already implemented to reduce risk in that waterway (i.e., before any mitigation measures).

4. *Book 4 - Mitigation Effectiveness*

    a. The existing mitigation measures used to reduce risks within the waterway, as well as their effectiveness in reducing the level of risk for each risk factor, are assessed. The result is the present level of risk, considering the existing mitigation.

    b. Book 4 is used for two purposes

        i. To evaluate the effectiveness of existing mitigation strategies in reducing the risk level for each factor in the model (i.e., the present risk level).

        ii. To determine whether the risk mitigation strategies already in place adequately balance the resulting risk level, or not

5. *Book 5 - Additional Mitigation*

    a. For those risk factors that are not adequately mitigated or balanced by the existing mitigation measures, additional mitigation measures are identified and their effectiveness in reducing the levels of risks are assessed. Book 5 is used to focus discussion on those risk factors where the present risk level is not well balanced with existing mitigation measures.

    b. This serves as a starting point for evaluating the possible effectiveness of new mitigation strategies. The output from Book 5 displays:

        i. Which category most teams have chosen.

        ii. How much risk improvement would result from the ideas put forward as new mitigation strategies.

iii. Which category was judged to be the most effective.

3.3. San Francisco Bay Area PAWSA Books

The outcomes of the PAWSA are presented in a series of 'books' to reflect the overall PAWSA process.

The outcomes of Books 1 – 3 provided the basis for the developments of baseline risk levels (Book 3, Figure 7); verification of mitigation effectiveness (Book 4, Figure 8) and, where required, identification of additional interventions (Book 5, Figure 9).

Baseline Risk Levels					
Vessel Conditions	**Traffic Conditions**	**Navigational Conditions**	**Waterway Conditions**	**Immediate Consequences**	**Subsequent Consequences**
Deep Draft Vessel Quality	Volume of Commercial Traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
1.9	4.6	2.9	4.8	8.1	9.0
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
2.2	5.5	4.4	5.8	8.8	6.8
Commercial Fishing Vessel Quality	Traffic Mix	Visibility Restrictions	Bottom Type	Hazardous Materials Release	Aquatic Resources
4.4	5.2	3.8	5.1	8.8	3.9
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic
3.3	4.1	3.9	8.2	6.3	6.9

Figure 7 – Results of Book 3 – Baseline Risk Levels

Mitigation Effectiveness												
Vessel Conditions		Traffic Conditions		Navigational Conditions		Waterway Conditions		Immediate Consequences		Subsequent Consequences	
Deep Draft Vessel Quality		Volume of Commercial Traffic		Winds		Visibility Impediments		Personnel Injuries		Health and Safety	
1.9	2.1	4.6	3.9	2.9	2.9	4.8	4.4	8.1	5.8	9.0	6.5
RISING		Balanced		Balanced		Balanced		Balanced		Balanced	
Shallow Draft Vessel Quality		Volume of Small Craft Traffic		Water Movement		Dimensions		Petroleum Discharge		Environmental	
2.2	2.1	5.5	4.3	4.4	3.8	5.8	5.5	8.8	5.0	6.8	5.9
Balanced		Maybe		Balanced		Maybe		Balanced		Balanced	
Commercial Fishing Vessel Quality		Traffic Mix		Visibility Restrictions		Bottom Type		Hazardous Materials Release		Aquatic Resources	
4.4	4.1	5.2	5.2	3.8	3.7	5.1	4.9	8.8	5.4	3.9	4.3
Balanced		RISING		Balanced		Balanced		Balanced		RISING	
Small Craft Quality		Congestion		Obstructions		Configuration		Mobility		Economic	
3.3	4.2	4.1	4.3	3.9	4.1	8.2	5.6	6.3	5.6	6.9	6.6
RISING		RISING		RISING		Balanced		Balanced		Balanced	

Figure 8 – Book 4 – Mitigation Effectiveness

Additional Interventions												
Vessel Conditions		Traffic Conditions		Navigational Conditions		Waterway Conditions		Immediate Consequences		Subsequent Consequences	
Deep Draft Vessel Quality		Volume of Commercial Traffic		Winds		Visibility Impediments		Personnel Injuries		Health and Safety	
Enforcement		Coordination / Planning		Balanced		Balanced		Balanced		Balanced	
2.0	Caution	3.6	Caution								
Shallow Draft Vessel Quality		Volume of Small Craft Traffic		Water Movement		Dimensions		Petroleum Discharge		Environmental	
Balanced		Voluntary Training		Balanced		Waterway Changes		Balanced		Balanced	
		4.2	Caution			5.4	Caution				
Commercial Fishing Vessel Quality		Traffic Mix		Visibility Restrictions		Bottom Type		Hazardous Materials Release		Aquatic Resources	
Rules & Procedures		Enforcement		Balanced		Balanced		Balanced		Voluntary Training	
3.9		4.8	Caution							3.9	Caution
Small Craft Quality		Congestion		Obstructions		Configuration		Mobility		Economic	
Voluntary Training		Radio Communications		Other Actions		Balanced		Balanced		Balanced	
4.1		4.1	Caution	3.7	Caution						

Figure 9 – Book 5 – Additional Interventions

3.4. Analysis of outcomes from PAWSA Books

A summary analysis is provided within the body of this report, with detailed analysis for each waterway category with a risk 'rising' or 'maybe (rising)' rating is provided in Annex A.

3.4.1. Book 3 Assessment – Baseline Risk Levels

The baseline risk levels identified that the existing deep draft and shallow draft vessel quality do not pose any critical risks within the waterway areas (Figure 7).

Risks that were noted as being high or extreme (rating of 7.7 or above) were:

- Waterway Conditions – Configuration
- Immediate Consequences – Personnel injuries; Petroleum discharge; Hazardous materials release
- Subsequent Consequences – Health and Safety

3.4.2. Book 4 Assessment – Mitigation Effectiveness

Through further assessment, the trends within the baseline risk levels were further assessed, resulting in refined assessment as presented in Book 4 (Figure 8).

- Vessel Conditions – deep draft vessel quality and small craft quality – risk is rising
- Traffic Conditions – Traffic mix and traffic congestion – risk is rising; volume of small craft traffic may have rising risk level
- Navigational Conditions – Obstructions – risk is rising
- Waterway Conditions – Dimension of the waterway may have rising risk level
- Immediate consequences – for all categories the mitigation measures balance the risk levels
- Subsequent consequences – Aquatic resources – risk is rising.

3.4.3. Book 5 Assessment – Additional Mitigation Measures

Based on both rising and potentially rising risk levels, as identified in Book 4, the PAWSA teams identified additional mitigation measures. The results of book 5 include indication of additional measures and reassessment to verify if the participants then feel the additional measures balance the risk element.

The Risk Improvement is the expected reduction in risk when taking the actions specified by the participants. A green Balanced indicates that no intervention is needed because risk in the waterway was judged to be well balanced by existing mitigations. A yellow Caution indicates a consensus alert meaning there was a difference between the most effective general strategy and the general strategy most selected by the participants for additional action(s).

During the discussions following the presentation of Book 5 the potential new mitigation measures were discussed, noting the outcomes from the discussion on mitigation measures as presented in the mindmap (Annex D).

When comparing book 4 and book 5 (Figure 10), the core areas for further review include:

- Vessel Conditions – further review for Deep Draft Vessel Quality
- Traffic Conditions – further review for all factors, noting the changes in vessel volumes, traffic mix and congestion within the waterway.
- Navigational Conditions – further review for Obstructions
- Waterway Conditions – further review for Dimensions
- Immediate Consequences – no further review indicated
- Subsequent Consequences – further review for Aquatic Resources

The intervention categories are defined as:

Category	Definition
Voluntary Training	• Establish voluntary programs to educate mariners on topics related to waterway safety (Rules of the Road, regional maritime knowledge, voice radio procedures, AIS procedures, ship handling, etc.)
Rules & Procedures	• Review rules, policies, and procedures to ensure all are adequate for today's maritime domain. • Consider federal and state regulations, regional safety-related policies, and procedures, mariner licensing to include recreational operators, necessary training and education.
Enforcement	• More actively enforce existing rules and policies. • Take action for alleged rules of the road violations, increase vessel inspections.
Nav / Hydro Info	• Improve the quality of and more effectively distribute navigation and hydrographic information. • Streamline notice to mariners and transmit information geospatially. • Correct errors on electronic nautical charts, and update the Coast Pilot, • Make better use of AIS data by transmitting critical information from shore to vessels. • Improve access to tide and current tables to include use of shore to vessel data technology. • Deploy ground-based augmentation systems such as DGPS to improve position fixing accuracy throughout the region.
Radio Communications	• Improve vessel bridge-to-bridge or ship-to-shore radiotelephone communications using new technology able to overcome radio frequency dead zones and interference. • Reduce voice radio channel congestion by taking advantage of digital messaging technology. • Deploy technology able to autonomously monitor and alert on critical spoken messages across VHF voice radio channels.
Active Traffic Management	• Improve Vessel Traffic Service anomaly detection, • Improve provision of VTS as per IMO Resolution A.1158(32) – providing timely and relevant traffic information, monitoring and managing traffic ship traffic and responding to developing unsafe situations • Identify and implement non-verbal methods for VTS to collect and distribute information.
Waterway Changes	• Review waterway and navigation channel alignments dimensions. • Review and reconsider locations of and types of aids to navigation.
Other Actions	• These would be risk mitigation measures needed that do NOT fall under any of the above strategy categories

Mitigation Effectiveness

Vessel Conditions	Traffic Conditions	Navigational Conditions	Waterway Conditions	Immediate Consequences	Subsequent Consequences
Deep Draft Vessel Quality	Volume of Commercial Traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
1.9 2.1	4.6 3.9	2.9 2.9	4.8 4.4	8.1 5.8	9.0 6.5
RISING	Balanced	Balanced	Balanced	Balanced	Balanced
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
2.2 2.1	5.5 4.3	4.4 3.8	5.8 5.5	8.8 5.0	6.8 5.9
Balanced	Maybe	Balanced	Maybe	Balanced	Balanced
Commercial Fishing Vessel Quality	Traffic Mix	Visibility Restrictions	Bottom Type	Hazardous Materials Release	Aquatic Resources
4.4 4.1	5.2 5.2	3.8 3.7	5.1 4.9	8.8 5.4	3.9 4.3
Balanced	RISING	Balanced	Balanced	Balanced	RISING
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic
3.3 4.2	4.1 4.3	3.9 4.1	8.2 5.6	6.3 5.6	6.9 6.6
RISING	RISING	RISING	Balanced	Balanced	Balanced

Additional Interventions

Vessel Conditions	Traffic Conditions	Navigational Conditions	Waterway Conditions	Immediate Consequences	Subsequent Consequences
Deep Draft Vessel Quality	Volume of Commercial Traffic	Winds	Visibility Impediments	Personnel Injuries	Health and Safety
Enforcement	Coordination / Planning	Balanced	Balanced	Balanced	Balanced
2.0 Caution	3.6 Caution				
Shallow Draft Vessel Quality	Volume of Small Craft Traffic	Water Movement	Dimensions	Petroleum Discharge	Environmental
Balanced	Voluntary Training	Balanced	Waterway Changes	Balanced	Balanced
	4.2 Caution		5.4 Caution		
Commercial Fishing Vessel Quality	Traffic Mix	Visibility Restrictions	Bottom Type	Hazardous Materials Release	Aquatic Resources
Rules & Procedures	Enforcement	Balanced	Balanced	Balanced	Voluntary Training
3.9	4.8 Caution				3.9 Caution
Small Craft Quality	Congestion	Obstructions	Configuration	Mobility	Economic
Voluntary Training	Radio Communications	Other Actions	Balanced	Balanced	Balanced
4.1	4.1 Caution	3.7 Caution			

Figure 10 – Side by side comparison of Books 4 and 5

3.5. Additional Mitigation Measures identified in Book 5

The additional mitigation measures were identified for each of the 'maybe' or 'rising' areas identified in book 4. Details of the additional measures identified in book 5 are included in the summary tables of the PAWSA process, provided in Annex A.

A summary of the results[3] from Book 5 are included in Table 7

Table 7 – Summary of Potential Mitigation Measures

Category	Potential Mitigation Measures
Deep Draft Vessel Quality	• Enhance ship crew training – but also take into consideration the need to provide training during workdays, rather than require during limited off-duty time • Identify options to share the Master-Pilot exchange with all navigation safety stakeholders. Consider electronic means to share the exchange with VTS such as the developing S100 data formats, including the use of S241 (route exchange) . • Pre-arrival review of terminal information including investigation options to do so through digital means • Increase targeted port state control inspections, based on a risk approach, with opportunity to make use of digital data exchange to support decision making. • Enhance / increase the use of digital data developments and modern communication means. • Deploy automated data exchange to reduce workload both onboard and ashore. • Enhance VTS equipment and training to reflect developments in the regulatory framework for VTS, digital data exchange and vessel tracking technologies.
Small Craft Quality	• Implement mandatory training and licensing, including focus on use of COLREGS • Require for small craft to use AIS, monitor and enforce this. • Build on existing public outreach, with increased outreach to small communities, providing free basic navigation training • Increase safety checks, with targeted activities throughout the year based on seasonal events. • Increase on-water safety/enforcement, with a dedicated on-water team. • Require proper radio use (training on radio procedures) • Implement digital data measures / monitoring • Implement measures to keep commercial waterways clear, including 'no-go' zones during specific transits (similar to aviation 'air exclusion zones' or 'no-fly zones') • Review and revise the (small) boater's handbook

[3] Note – Comments from participants have been expanded to provide clarity.

Category	Potential Mitigation Measures
Volume of small craft traffic	• Establish charted zones for recreational and small craft activities and restrict entry into these zones by commercial vessels. • Establish zones subject to small craft restrictions during periods with a high volume of commercial vessels. • Require/enforce event planning permits / use of legislation • Small craft certification, with licensing and periodic refresher for small craft quality and qualifications • Educate and require effective VHF 16 monitoring, enforce proper use of VHF radio
Traffic Mix	• Establish charted zones ('boxes' as described by workshop participants) for specific vessel use – including recreational and small craft activities and restrict entry into these zones by commercial vessels (i.e. Kite Surf Beach) and commercial traffic only zones. • Expand regulated navigation areas to restrict recreational vessels from congested narrow channels and fairways. • Deploy digital information to help recreational vessels spot deep draft vessels and better understand their movements. (For example, consider a smartphone app used by recreational vessels showing restricted and congested waterways and depicting deep draft vessel route intentions.) • Require and enforce event planning permits through the use of legislation • Review regulatory requirements and enforce manning for vessels and boats. • Promote interagency coordination through deployment of a hosted maritime domain picture sharable with all interested agencies. • Deploy a regional GSM network designed for maritime coverage—GSM antennas pointed over the waterways. Use this in conjunction with technology to combine AIS and other vessel tracking systems into a common maritime picture usable by those carrying standardized display equipment and those with internet access. • Investigate developments in digital radio and, as technology develops, establish a regional VOIP network to augment existing analogue VHF for consistent, reliable communications.
Congestion	• Use IWRAP data to give mariners historical reports on seasonal congestion. • Carry out a regular analysis (i.e. at least annually) of maritime traffic data using GIS and other technology to determine waterway usage trends and to help forecast areas of congestion. • Include autonomous decision-support technology in the VTS equipment suite. This includes, where appropriate, the automation of VTS tasks to provide VTS operators more time to focus on highest-risk and most congested areas.

Category	Potential Mitigation Measures
	• Upgrade VTS training to reflect current international best practice (IALA R0103, related model courses) and include realistic simulation training for all levels (VTS Operator, VTS Supervisor and VTS Revalidation training). • Review requirements for event planning, including advance notice, permit and promulgation process. • Increase public outreach, rules of the road (possible signage in boat ramp areas on key COLREGS aspects) • Implement a focus activity to enforce existing regulatory aspects, including alcohol use, boating safety requirements and enforcement of safety aspects for on water activities, • Establish zones reserved for large commercial vessels during periods of vessel congestion. • Review VHF radio use / congestion and identify additional VHF frequencies for use. This could include the investigation of developments in digital radio and, as technology develops, establish a regional VOIP network to augment existing analogue VHF for consistent, reliable communications. • Implement focused and frequent public information campaigns to educate on the criticality of our maritime transportation system, including the cost-benefits of investing in tools and systems to relieve congestion by better organizing vessel traffic.
Obstruction	• Increase on water support – debris patrols, inspections of waterways • Investigate and implement crowdsource waterway obstruction reporting. This include raising awareness for spotting and describing waterway obstructions and developing a simple electronic tool for reporting these obstructions. • Provide whale identification and evasion training to all mariners. Develop best practices for commercial maritime operations when whales are present in the waterways. Use technology for spotting and tracking whales. • Enact legislation with fines for failure to remove condemned and derelict vessels. Develop a geospatial database marking the locations and potential hazardous of derelict vessels or large debris. • Require electronic monitoring and alerting for all underwater infrastructure such as cables and pipelines. Enforce depth requirements for bay floor infrastructure with increased frequency for surveys of the most vulnerable bay floor infrastructure. • Provide funding for Army Corps of Engineers to increase debris parole missions and remove more dangerous debris.

Category	Potential Mitigation Measures
Waterway Dimensions	• Carry out dredging based on a risk approach to ensure charted drafts continue to be met, with updated hydrographic surveys • Ensure new construction, both above and below the water, is well outside the designated channels. • Streamline dredge permitting, reviewing the existing approach within a 'clearing house' for permits approach (one-stop shop) • Designate areas for commercial traffic flow and establish zones reserved for large commercial vessels during periods of vessel congestion • Recognize changing sizes and requirements for vessels which includes expanding turning basins widening channels and, where possible, increasing dredged depths. • Review AtoN, identify the options for potential use of digital AtoN and, where appropriate to address the mix of ship traffic, possible use of virtual AtoN.
Aquatic Resources	• Increase public awareness through focused campaigns, town hall meetings and training programs. • Require mandatory training and familiarity with aquatic resource areas • Use technology to monitor aquatic resource areas, including CCTV with FLIR capability. • Increase on-water presence to monitor and enforce requirements. • Increase signage on shorelines related to aquatic species and resources. • Review historic data and trends based on past knowledge of SAR incidents due to fishing seasons. This could result in the establishment of flexible fishing seasons around severe weather. • Monitor opening/closure times with increased on-water presence and enforcement of safety requirements.

4. IWRAP

The IALA Waterway and Risk Assessment Program (IWRAP) provides for a calculation of probabilities of ship collisions, allisions and groundings. The program is a part of the overall IALA Risk Management Toolbox as referenced in IALA Guideline G1018 Risk Management. IWRAP is a quantitative tool intended to work in conjunction with other tools in the Toolbox. The tool involves developing a model of the waterways to be analyzed, including the geometry of the relevant routes, the traffic volume and composition, as well as the bathymetry of the waterways in question.

Once the model has been defined, IWRAP calculates the expected average annual number of collisions and groundings likely to occur. This calculation is based on the above-mentioned model and a set of so-called Causation Factors which can be thought of as the probability that the vessel fails to make an evasive action to avoid the grounding or collision.

During the workshop participants viewed and provided input on the use of the IWRAP tool. This resulted in a number of focus area assessments, as provided in Figure 11, Figure 12, Figure 13, Figure 14.

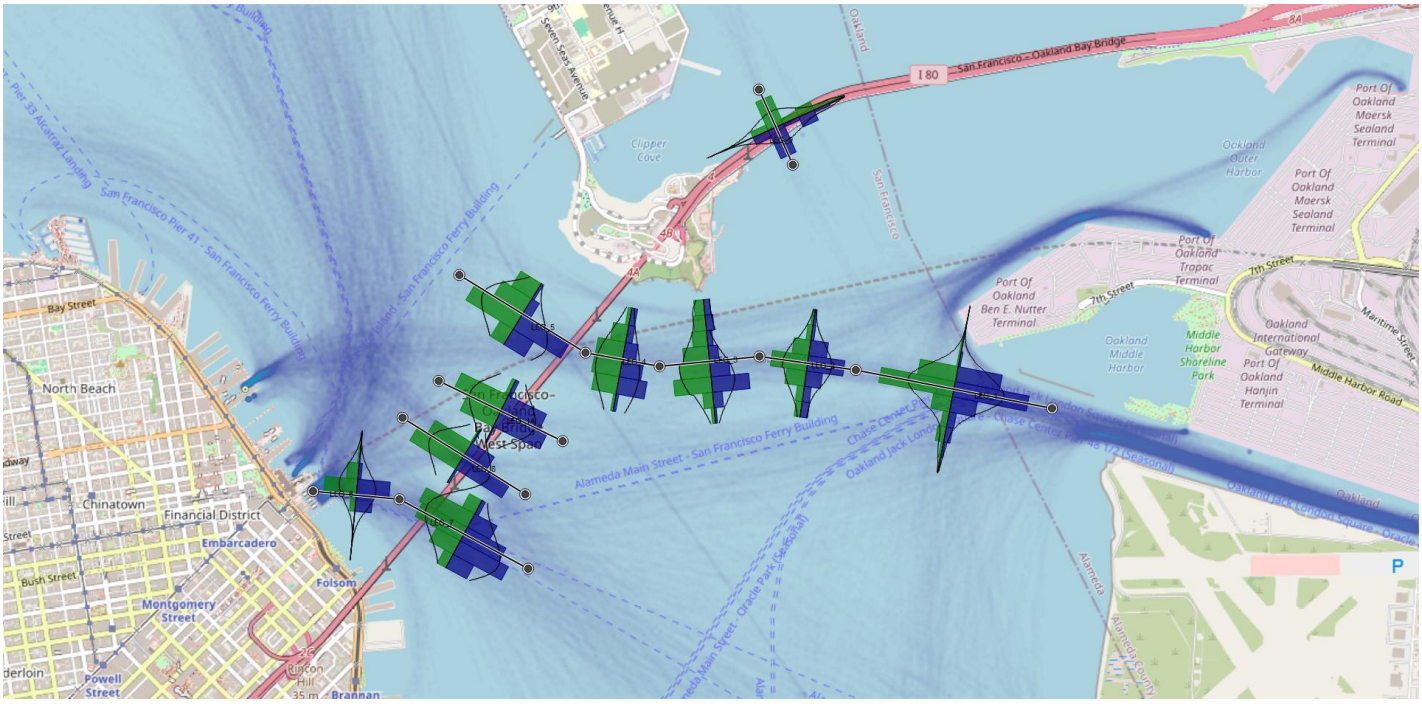


Figure 11 – IWRAP – General Overview

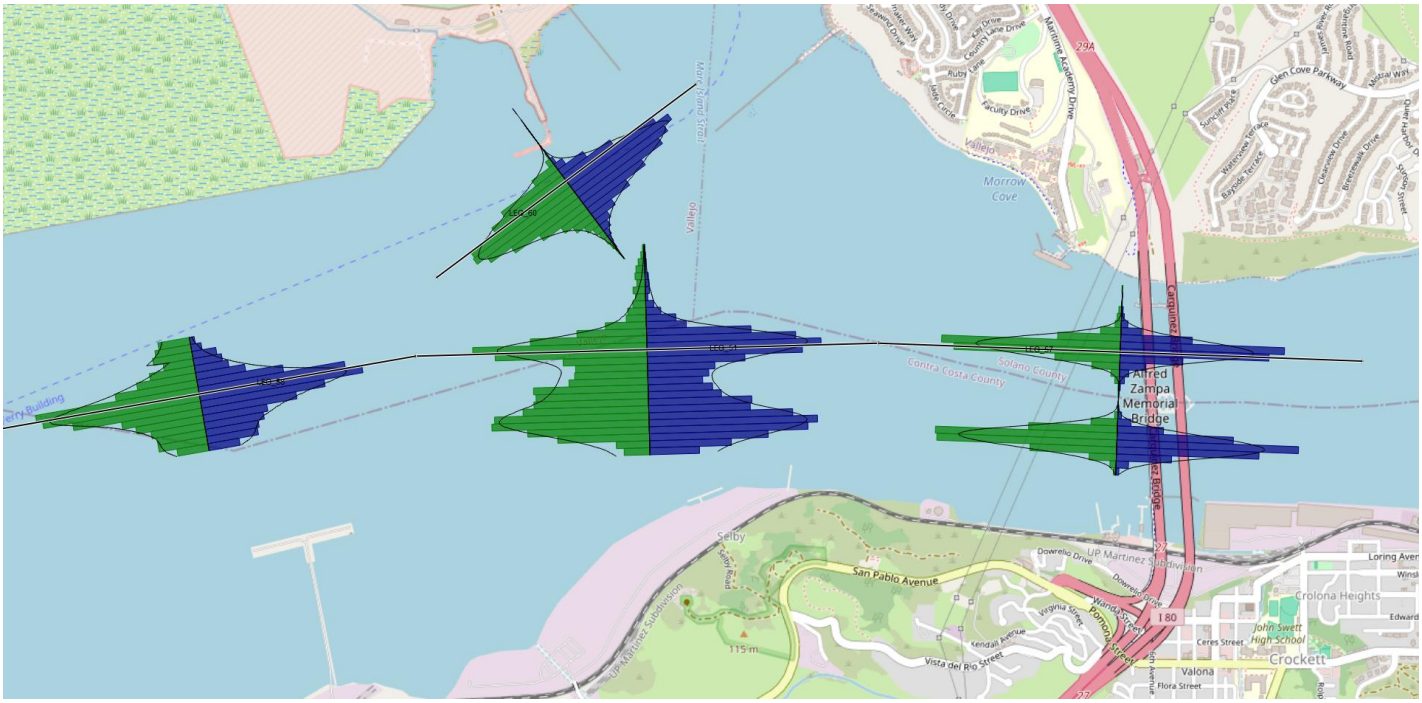


Figure 12 – IWRAP – Carquinez

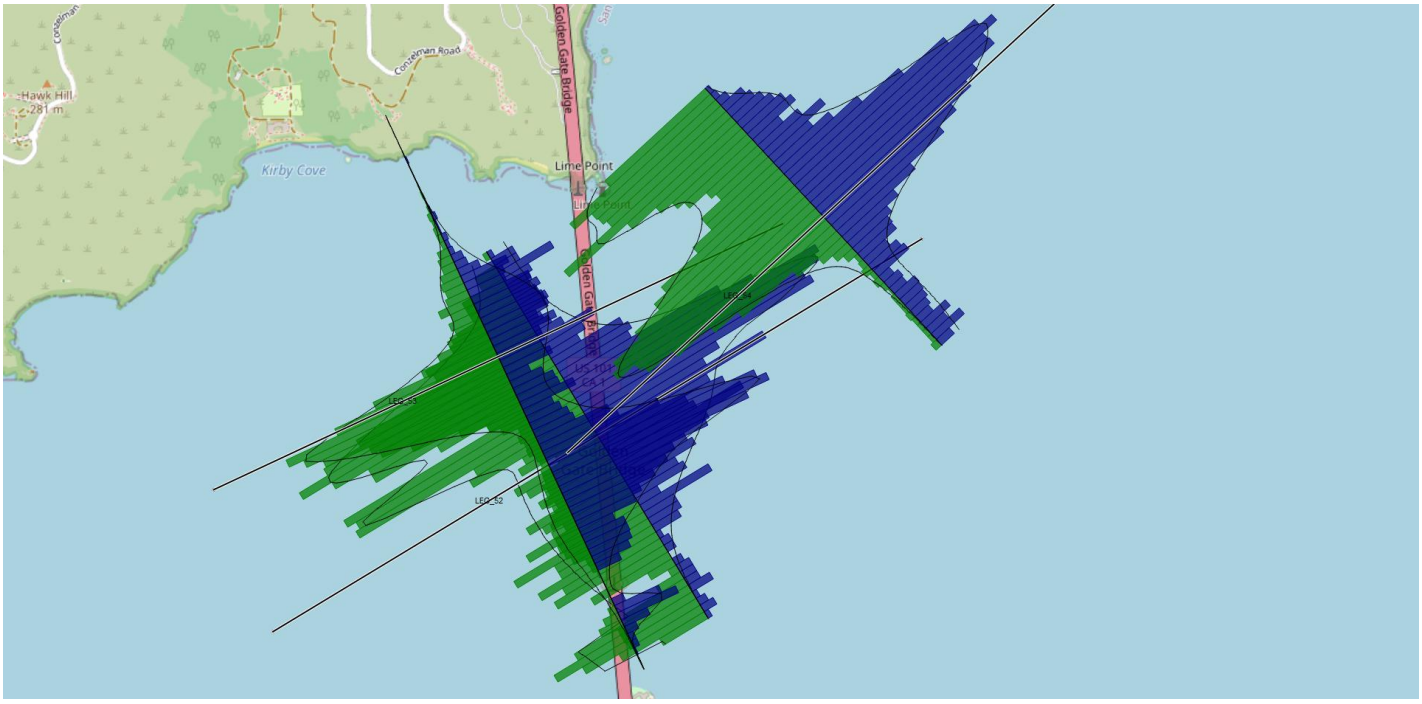


Figure 13 – IWRAP – Golden Gate Bridge

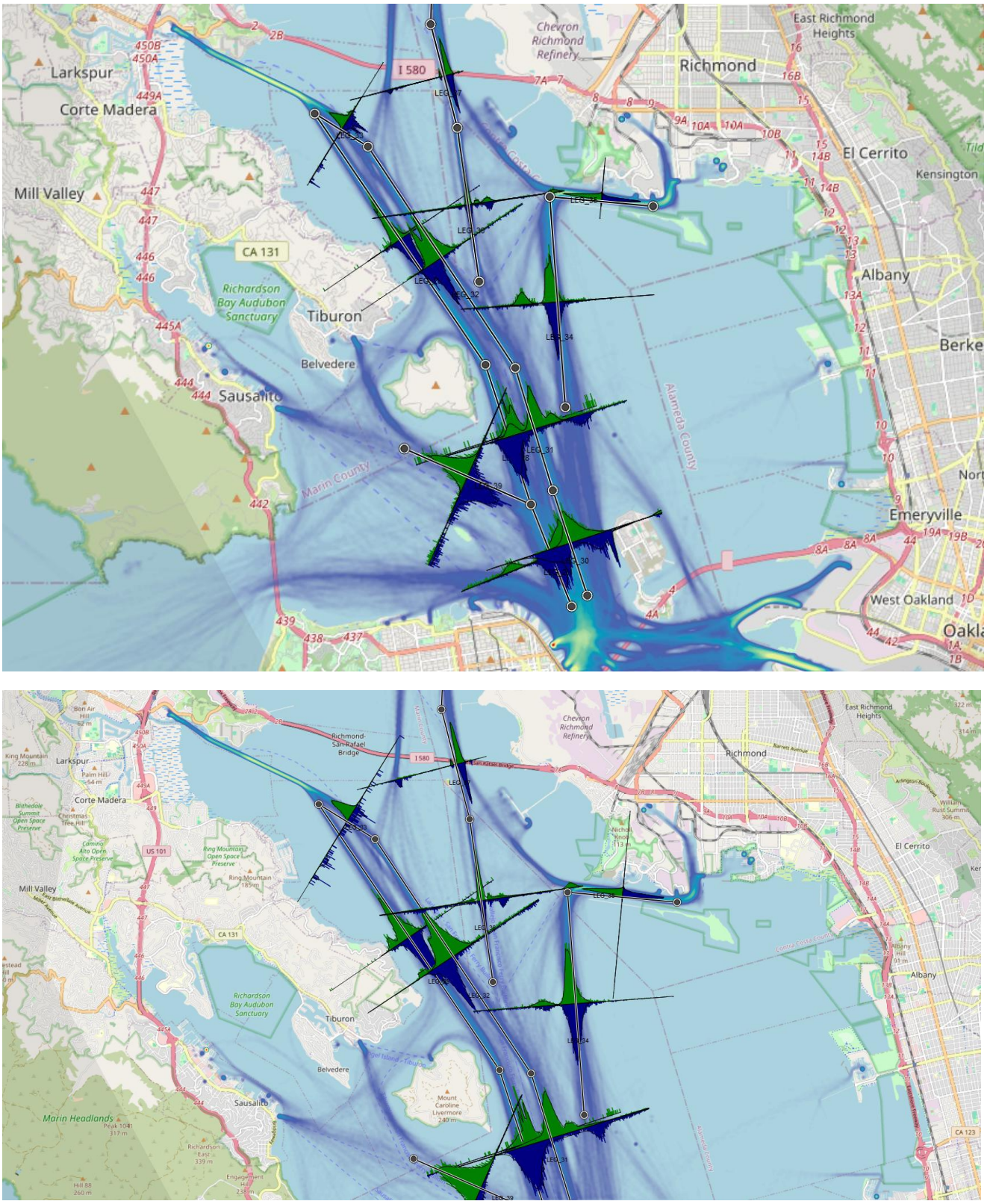


Figure 14 – IWRAP, Day/Night

5. Conclusions and Recommendations

The workshop resulted in robust and detailed discussions of the San Francisco Bay area. To facilitate the discussion the following waterway areas were identified:

- Pacific Ocean approaches to San Francisco Bay within a 38-mile radius of Mt. Tamalpais.
- San Francisco Bay including the South Bay down to Redwood City and the Central Bay north into San Pablo and Suisun Bays including Mare Island Straits and Carquinez Straits.
- The navigable portions of the Sacramento and San Joaquin Rivers in The Delta, including the Ports of Sacramento and Stockton.

The strong representation at the workshop reflects the strong commitment to safety of navigation, safe and efficient ship transits and protection of the environment and the adjacent shore infrastructure.

As the workshop made use of unique technology tools to facilitate access to the data and references, participants were able to have enhanced situational awareness which supported informed discussions throughout the interactive sessions.

Key conclusions from the workshop are identified within the body of this report and in the tables provided in Annex C. As a summary, these include:

- Significant work has already been undertaken in the San Francisco Bay Region to support safety of navigation in the San Francisco Bay area.
- The participation of so many highly knowledgeable professionals from diverse disciplines in a three-day workshop reflects a strong, shared commitment to enhancing regional maritime and transportation safety.
- The San Francisco Bar Pilots, Board of Pilot Commissioners, and California Department of Transportation demonstrated strong support and a commendable commitment to analyzing, discussing, and critically examining regional risks and past incidents. The San Francisco Harbor Safety Committee, along with its subcommittees and working groups, plays a major role in reducing risk by thoroughly examining hazards and developing non-regulatory maritime best practices.
- There is a need for additional mitigation measures to enhance the safety of navigation and protection of the environment to address specific concerns. These include:
    - Underwater structures like pipelines, tunnels, and cables pose risks of vessel contact, which can damage vessels, injure people, cause pollution, and disrupt regional transportation.
    - Vessel congestion near bridge navigation corridors, especially involving small craft, forces deep-draft mariners to make high-risk decisions with limited safe options and little room for error.
    - Aging maritime and waterway infrastructure, built for outdated vessel size and weight standards, increases the risk of damage and limits capacity and resilience.
    - Increasing vessel encounters with aquatic animals are causing harm to marine life and risking vessel damage and passenger injury.
    - Outdated VTS technology—data collection, reporting, tracking, and anomaly detection—hampers both operational performance and training effectiveness.
    - Legacy maritime communication methods—voice radio, email, phone calls, and texts—can no longer handle the growing volume, tighter timelines, and higher accuracy demands of modern maritime operations.
    - Failing to adopt advanced digital data exchange, communication, and vessel tracking technologies leaves VHF radio channels overloaded and both VTS operators and mariners overwhelmed by information saturation.

  - Failing to use geospatial tools like AIS application-specific messages to share waterway safety information with vessels underway increases reliance on overloaded VHF radio channels, creating bottlenecks that can delay or block the most urgent voice communications.
  - Unrealistic expectations for VTS operators and mariners to simultaneously manage communications on multiple radio channels lead to missed and misunderstood navigation.
  - Some regulations and maritime best practices aren't supported with necessary decision-support systems, tools, guidelines—visibility restrictions without means to determine visibility, requirement for VTS to listen to and error-check vessel bridge-to-bridge voice communications while simultaneously communicating on other channels, expectations that vessels adhere to security zones without a fool-proof method for communicating zone boundary lines.

- The workshop provided a valuable opportunity for a cross-agency approach to identifying hazards and risks, recognizing existing mitigation measures and proposing additional mitigation measures.
- Technology is advancing rapidly, offering new opportunities to adopt cutting-edge tools while still valuing traditional methods. Regional maritime and transportation stakeholders appear ready to embrace innovation and reexamine legacy operations, procedures, and policies to make the most of these advancements. Several agencies and organizations document maritime incidents, but few consistently share that information with all necessary stakeholders. During the workshop, infrastructure operators were often unaware of incidents that could have affected their assets. The absence of a standardized system—with consistent terms, data fields, and formats—for documenting maritime incidents prevents reliable analysis of incident frequency, density, and prevalence within the San Francisco Bay Region or across regions.
- Safety measures are risk mitigators—not proof that risk doesn't exist. Assuming there's no risk simply because mitigation is effective, it overlooks the fact that those measures, while costly or time-consuming, remain essential and justified.
- The San Francisco Bay Region is a highly complex system of delicate interdependencies, encompassing diverse waterway types, vessel classes, cargo categories, infrastructure, and economic drivers.
- As described by the workshop participants, Northern California's population relies heavily on the maritime system in the San Francisco Bay Region. A disruption, interference, or failure caused by a vessel incident could severely impact the California economy, the national economy, and daily life throughout the region.

The workshop process resulted in six (6) general recommendations related to the breakout group discussions:

Annex A - Attendees

Confirmed Title	Confirmed Name	Confirmed Affiliation	Confirmed Job
LT	Abby Hamann	USCG SSF Prevention	Officer
Captain	Alex Butler	American Maritime Officers	West Coast Rep.
	Allen Garfinkle	Board of Pilot Commissioners	Executive Director
	Andrew Fremier	MTC	Executive Director
	Angela Louie	Bay Area Transportation Authority	BATA Principal
Captain	Anne Mclntyre	SF Bar Pilots	SF Bar Pilot
	Ben Nguyen	Caltrans Emergency Services - CES	Homeland Security Liaison
CWO	Brian Dressler	USCG SSF Prevention	Officer
	Brian Snead	Kinder Morgan	Damage Prevention ROW Specialist
	Brian Spillane	Matson	Director Vessel and Chartering Operations
	Bryan Brandes	Port of Oakland	Maritime Director
	Carl Hausner	USCG District 11 Bridge Section	Division Chief
LCDR	Clark Sanford	USCG Sector SF Waterways	Division Chief
	Cody Aichele-Rothman	SF Bay Conservation and Development	BCDC Coastal Planner
	Darren Gewant	SF Bay Marine	Marine Surveyor
Captain	Dave Corbett	SF Bar Pilots	SF Bar Pilot
	David Man	Bay Area Transportation Authority	BATA Section Director
Captain	Dennis Plant	Chevron Shipping	Pilot Chevron Richmond
	Desmond DeMoss	Port of Oakland	Safety and Business Continuity Officer
Chief Mate	Doug Nagy	California Maritime Academy	Chief Mate - Golden Bear

Confirmed Title	Confirmed Name	Confirmed Affiliation	Confirmed Job
LCDR	Drew Stafford	USCGC Alder (WLB 216)	CO
	Emery Roe	UC Berkeley Center for Catastrophic Risk management	Research Professor
	Erik Anderson	Crowley -Tug Captain	Crowley Marine
	Erika Espinoza	Caltrans Emergency Services - CES	lead resiliency staff
	Erin Pierson	HSC Tug Operators	Crowley Marine Operations Manager
	Gary Reed	USCG Sector SF VTS	VTS Director
LT	Helen Oh	USCG SSF Prevention	VTS Operations Officer
	James Haussener	HSC Dredging Issues	Executive Director CMANC
Captain	Jarod Toczko	USCG Sector SF Command	Deputy Sector Commander
	Joey Kotfica	MTC	Public Information Officers
Captain	John Carlier	SF Bar Pilots	SF Bar Pilot
	John Fadeeff	Chevron Shipping Richmond Long Wharf	Marine Operations Manager
Captain	Jordan Balzueza	USCG Sector SF Command	Sector Commander
	Justin Taschek	Port of Oakland	Maritime Projects Administrator
	Kathy George	Marine Mammal Center	Director, Cetacean Conservation Biology
	Kevin Hartley	HSC Barge Operators	Marine Superintendent Fairwater
	Lawrence Wooster	Caltrans Emergency Services - CES	Recovery & Operation Engineer
	Lucas Joun	Marathon Petroleum	Port Captain Global Marine Martinez
LT	Madeline Chafin	USCGC Alder (WLB 216)	Executive Officer
	Mason Reed	Matson	Vessel Manager

Confirmed Title	Confirmed Name	Confirmed Affiliation	Confirmed Job
	Michael Hendley	Bay Area Rapid Transit	Director of Security Programs and Emergency Management
SCPO	Michael W. Gibb	USCG Sector SF ATON	ATON Officer
	Mike Jacob	Pacific Merchant Shipping Association	President
	N'guessan Affi	(CalSTA) California State Transportation Agency	Freight Policy Manager
	Paul Hendriks	Baydelta Maritime	Manager of Operations
	Paul Schulman	UC Berkeley Center for Catastrophic Risk Management	Research Professor
	Phoebe Cheng	San Francisco Bay Area Rapid Transit District	Group Manager of Civil/Structural/Track Engineering
Captain	Richard Ogg	Fishing Vessel Karen Jeanne	Commercial Fisherman
Captain	Robert Barley	Golden Gate Transportation Ferry	Supervising Vessel Master
	Rosalynn Chongchaikit	Bay Area Transportation Authority	BATA Principal
Captain	Samar Bannister	California Maritime Academy	Captain - Golden Bear School Ship
ENS	Saralyn Young	USCG SSF Prevention	Officer
	Shihua Nie	San Francisco Bay Area Rapid Transit District	
	Steve Song	Golden Gate BHTD	Civil Engineer
	Thomas Boone	USCG Sector SF VTS	VTS Training
LT	Will Harris	USCG SSF Prevention	Waterways Officer
Captain	Emanuel Tishler	Foss Maritime	Port Captain Northern California
Captain	Neil Billingsley	San Francisco Bar Pilots	Pilot
	Lenneal Gardner	Trans Bay Cable	Senior Manager Regulatory Affairs
LTjg	Jack Farrell	CG Sector San Francisco	Officer

Confirmed Title	Confirmed Name	Confirmed Affiliation	Confirmed Job
Captain	Chad Avellar	Chevron Shipping Richmond Long Wharf	Pilot
	Chris Long	California Department of Transportation	Structural
BM2	Benz Seaton	CG Sector San Francisco	Petty Officer

Annex B – Workshop Schedule

Dates: 15 to 17 April 2025
Location: Port of Oakland, 530 Water Street, Oakland, CA 94607

Time	Topic
15 April 2025	**Day 1**
8:30 – 9:00 am	Arrival – Welcome coffee
9:00 am	Opening Session: welcome, housekeeping and safety briefing
9:30 am	Keynote Presentation – Professor Emery Roe
9:50 am	Introduction and Process Overview
10:30 – 10:50 am	*Morning Break*
10:50 am	Waterways and Incidents Overview
11:30 am	Introduction to reference documents and tools used in breakout groups
11:45 am	Discussion on risk
12:30 – 1:30 pm	*Lunch*
1:30 pm	Breakout Groups Discussion Session 1
2:30 pm	Present results of Breakout Groups Discussion Session 1
3:00 – 3:20 pm	*Afternoon break*
3:20 pm	Introduction to IWRAP activity in the workshop
4:00 pm	PAWSA 'Next Gen' introduction
4:30 pm	Risk Scenario development
5:00 pm	Summary and wrap up for day 1
5:40 pm	*Meet and Greet event*

Time	Topic
16 April 2025	**Day 2**
8:30 – 9:00 am	Arrival – Welcome coffee
9:00 am	Opening, review of day 1
9:15 am	PAWSA Focus – MkII Book 1
9:45 am	PAWSA 'Next Gen' – Risk Characterization / survey
1015	Summary of morning activity
10:30 – 10:50 am	*Morning Break*
10:50 am	PAWSA Focus – Mk II – Book 2 (Risk Factor Rating)
11:40 am	Risk Scenario Creation – Take 2
1215	PAWSA Focus – 'Next Gen' – results
12:30 – 1:15 pm	*Lunch*
1:15 pm	PAWSA Focus – Mk II – Results of PAWSA Mk II Book 2; Agree reference scales
1:45 pm	PAWSA Focus – Mk II – Book 3 (Baseline Risk)
	(if time – Risk Scenario Creation – Take 3)
3:00 – 3:20 pm	*Afternoon break*
3:20 pm	IWRAP Update
3:40 pm	Prioritizing risk scenarios (for PAWSA 'Next Gen')
4:00 pm	Presentation results PAWSA Book 3 / discuss
5:00 pm	Summary of Day 2
5:30 pm	*End of day 2*

Time	Topic
17 April 2025	**Day 3**
8:30 – 9:00 am	Arrival – Welcome coffee
9:00 am	Opening review of Day 1 and 2
9:15 am	Discuss – Mitigation Measures
9:45 am	PAWSA Focus – Mk II - Book 4 (Mitigation Effectiveness)
10:30 – 10:50 am	*Morning Break*
10:50 am	PAWSA Next Gen – Quantitative Risk Assessment
12:00 am	PAWSA Focus – Mk II – Results of Book 4
12:30 – 1:30 pm	*Lunch*
1:30 pm	PAWSA Focus – Mk II Book 5 (5a, 5b and 5c) Each team provides sheets as they are completed for the PAWSA team to input into the templates.
2:30 pm	Breakout groups to review / revise outcomes from initial discussion session
3:00 – 3:20 pm	*Afternoon break*
3:20 pm	IWRAP Update – final overview
3:45 am	PAWSA Focus – Mk II – Results of Book 4
4:15 pm	Summarizing outcomes
4:30 pm	Closing comments / Complete Workshop Feedback Form
5:00 pm	*Workshop close*

Annex C – PAWSA Analysis Tables for Risk Rising Factors

Vessel Conditions: Deep Draft Vessel Quality	
Trend – risk is rising Top additional mitigation measure – Enforcement	
Baseline Risks: 1. Loss of steering and propulsion incidents continue to be prevalent and often happen around bridges and other critical infrastructure. 2. Variety of vessels transiting waterway: tank ships / container ships / bulk carriers / vehicle carriers / break bulk / chemical carriers / passenger vessels 3. Some bulk general cargo vessels operate closer to the safety margin than others depending on the type of cargo. 4. Due to the wide variety of vessel types, cargo types, and industries served by maritime, risks vary dramatically and often change rapidly based on the current situation (e.g, more inland bulk cargo during heavy fog season). 5. Ports with the greatest variety of cargoes and ship types often have higher risks. 6. Vessels with mixed language crews sometimes present greater risk especially during onboard crises such as loss of steering or propulsion. Communication between ship's crew and pilot and between ship's navigator and VTS are complicated by language challenges, especially during crisis situations. 7. Seafarer training standards and competence of crew can vary dramatically between different vessels, companies, and nationalities. 8. Continuing world-wide critical shortage of competent crew means vessels might operate in complex, congested SF Bay Region waterways with lesser-qualified personnel. 9. Increased use of electronics on vessels without consistent training leads to misuse or underuse of important tools. It also leads to information overload for vessel crew members. 10. Personal and professional use of mobile phones in the vessel wheelhouse is prevalent. Vessel bridge crews are further distracted when land-based officials often depend on mobile phones for ship to shore communications. professional use and personal use (phones on bridges) 11. Critical actions ashore and aboard vessels are sometimes delayed due to multiple layers in the decision-making chain. 12. Aging VTS monitoring equipment **Trends:** 1. Language issues are getting worse 2. A continued shortage of competent trainees / training programs	**Existing Mitigations:** 1. San Francisco Bar Pilots expertise has prevented damage due to a vessel steering or propulsion failure. 2. U.S. is holding crewmembers to a high standard including enforcement of Standards of Training, Certification, and Watchkeeping (STCW) requirements 3. Requirements for double-hulled tank ships 4. Vessel inspection requirements are stringent, but inspection officials are understaffed. 5. Use of Vessel Traffic Service (VTS) is vital, but ageing and underfunded VTS systems are sometimes operationally deficient. 6. Advanced arrival notification of deficiencies allowing USCG to take preliminary action before vessel arrives 7. Use of Port State Control (PSC) to determine vessel quality 8. Exposure liability / classification society process 9. Requirements and enforcement of International Safety Management (ISM) Code 10. Company participation in Safety Management Systems (SMS) 11. Company drug & alcohol policies in place 12. State of California tanker vessel tug escort requirements and multi-layer oversight of the execution of those requirements. 13. Well-trained and highly qualified pilots. 14. Continuously improving vessel electronics and technology (e.g., Electronic Chart Display Information Systems (ECDIS)) 15. Candid sharing of information through the Harbor Safety Committee, Maritime Security Committee, VTS-pilot committees, etc. promotes learning and prevention.

New Ideas

1. Novel uses of new technology for maritime coordination and planning such as digital information exchange coordinated by Marine Exchange.
2. Build mandatory shipboard training into crew workdays rather than requiring personnel work during days off to accommodate every-increasing training demands—prevent crew fatigue and burnout.
3. Blend shipboard training with other regional training to improve training quality and provide a more wholistic learning experience. Include stakeholders in training.
4. Establish a port handbook that provides all the details necessary to prepare an arriving vessel—regional rules and procedures, pre-arrival checklist, terminal guides, etc.
5. Address standards training related to electronic data in the wheelhouse—use of ECDIS, electronic data exchange, alerts and alarms and associated alarm fatigue and de-sensitizing, etc.
6. More and stricter enforcement by Port State inspection officers. Increase audit tempo.
7. Correct erroneous electronic chart information.
8. Establish a campaign to enforce AIS data accuracy. Inform vessels of erroneous AIS data and require them to correct it on the spot. Develop periodic reports highlighting vessels with accurate and erroneous AIS information.
9. Radio Communications. Implement and train on effective, efficient voice radio communications. Reduce radiotelephone clutter by streamlining communications to only essential information.
10. Radio Communications. Replace voice radiotelephone communications with electronic reporting wherever safe and efficient to do so.
11. Improve active traffic management through enhanced vessel tracking and surveillance such as transmitting digital information to and from VTS and vessels using, for example, Starlink, AIS, and other digital connectivity technology. – enhance surveillance (StarLink)/AIS/VTS equipment
12. Waterway changes. Increase frequency of dredging and streamline the dredge permitting process.
13. Other actions. Improve transparency in reporting, documenting, and training of vessel mechanical and electrical problems.

Vessel Conditions: Small Craft Quality

Trend – risk is rising

Top additional mitigation measure – Voluntary Training

Baseline Risks:

1. Small boat operator alcohol usage.
2. Maintenance and upkeep of small craft varies dramatically across the region. Small craft operating in the Central Bay and Golden Gate region tend to be of better quality than those operating in other area of the SF Bay Region.
3. Wind and human-powered recreational vessels such as wind surfers, kite surfers, sailboarders, and kayakers operate in waterways often congested with commercial vessels such as deep draft ships, tugs with tows, and high-speed passenger vessels. (see Traffic Mix)
4. Some small craft operators don't follow rules and regulations, (e.g., too-high speed for size of waterway).
5. Generally poor Rules of the Road knowledge.
6. Poor training and lack of qualifications for small boat operators.
7. Inadequate enforcement of existing requirements

Trends:

1. Recreational traffic is increasing.
2. Deteriorating reginal maritime knowledge base by small craft users
3. Increasing interaction of small craft with larger vessels

Existing Mitigations:

1. Outreach by pilots, VTS, Marine Exchange, Coast Guard Auxiliary, and Power Squadrons helped improve recreational boat operator competency over the years
2. HSC outreach by providing informational brochures and training videos for a variety of vessel operators from small to large craft.
3. Coast Guard and Pilot's outreach to marinas, yacht clubs, and racing associations before large marine events.
4. Increased use of Global Positioning System (GPS) and vessel position fixing applications by small vessels.
5. Increasing use of AIS aboard recreational vessels improves their visibility and enable them to spot approaching commercial vessels.
6. Increasing use of personal devices such as smart phones and tablets helps small vessels access weather and maritime safety information.
7. The more responsible recreational vessel rental companies provide safety instructions and, in some cases, formal training. This improves safety by educating inexperienced renters on unique risks in this region.

New Ideas:

1. Training and licensing for recreational vessels.
2. Programs for voluntary training. Provide more public outreach and training
3. Mandatory training requiring higher levels of certification focusing on COLREGS
4. Voluntary Training that includes awareness of manufacturer restrictions and limitations of equipment
5. Require training and certification for all boaters with a focus on COLREGS (specific reference to Rule 9)
6. On and off-water inspection and enforcement actions by USCG to include more USCG patrols.
7. Require AIS for small craft and enforce AIS carriage and use
8. Require training on radiotelephone regulations, the use of the radio, and necessity for a full-time radio watch
9. Take advantage of new, digital radio capabilities.
10. Keep commercial fairways clear of recreational vessels. Establish and chart 'areas' or 'boxes' designated for recreational vessel activities.
11. Update the boater's handbook and provide it digitally to improve its availability.
12. Deploy smartphone-like applications to be used by small-craft for waterway awareness. This includes real-time waterway alerts and other information a small-craft can use to keep out of the way of commercial vessels.

Traffic Conditions: Volume of Small Craft Traffic	
Trend – risk may be rising Top additional mitigation measure – Voluntary Training	
Baseline Risks: 1. As many as 1000 Marine Events per year including sailing regattas, powerboat races, mass swimming events); 2. Small craft activity is the heaviest on weekends and in summer, but trend is balancing out, with high activity year round 3. Sail boating most popular areas coincides with the highest density commercial traffic areas: San Francisco city front, Point Knox and Deep-Water Traffic Lane, Sausalito, Central Bay Traffic Lanes and Precautionary Area, Golden Gate Precautionary Area, Southampton Shoal Channel and Richmond Outer Harbor, South San Francisco Bay around the Oakland Inner and Outer Harbors. 4. During Crab season, fishing vessels often take up the entire waterway 5. During Salmon season the most popular fishing areas include the Offshore Northern and Southern Traffic Separation Schemes. 6. During Halibut season fishing vessel congestion is heavy in the Berkeley Pier area. This area is now more frequently trafficked by passenger ferries. 7. During Striper season the Mel's Reef area south of Alcatraz Island is congested with fishing vessels. This area is also heavily trafficked by dredges and deep draft ships. 8. Increasing marina development increases the concentration of recreational vessels. 9. Tourism activity in Bay Region waterways recently caused maritime incidents and near-miss encounters between deep draft vessels and recreational vessels. 10. Small craft without AIS transceivers are hard to see during good visibility and often impossible to see during restricted visibility. AIS use by recreational vessels is inconsistent and unregulated. 11. VTS equipment is aging and going without end-of-life replacement. 12. VTS equipment wasn't designed to spot and track small vessels. Specifications for VTS surveillance pre-dates modern recreational vessel traffic density. **Trends:** 1. Recreational boating population is increasing with significant growth in 'human powered' vessels. 2. Larger commercial vessels and an increase in fast ferryboats cases more interactions with recreational and other small vessels.	**Existing Mitigations:** 1. US Coast Guard Sector San Francisco Marine Event permitting process is thorough and transparent. USCG knows where and when events are taking place. Event planners collaborate with USCG to ensure harmony between marine events and commercial vessels. 2. In real time, VTS informs commercial vessels on details of Marine Events and informs on-the-water Marine Event coordinators of the locations and intentions of commercial vessels. 3. Marine Event coordinators communicate directly with VTS before and during events. 4. Event coordinators and USCG agree on seasonal restrictions and weather-related limitations for Marine Events 5. Outreach by USCG and Pilots continues to improve, and lessons learned are rapidly absorbed into operating guidelines. 6. Digital information available to small vessels is vast and continuously improving. There are training requirements for small craft users, but they're inadequate for such a densely maritime region with an ever-increasing population of recreational vessel operators.

New Ideas

1. Improve coordination and planning by establishing recreational boating zones, e.g., 'boxes' or 'areas.' For recreational activities.
2. Require mandatory training and periodic refresher training for recreational vessels
3. Require licensing for pleasure craft operators linked to the purchase of the recreational vessel. Emphasize navigation rules and regional maritime procedures.
4. Improve enforcement with more regular law enforcement presence on the waterways
5. Require and enforce radio communications training
6. Improve VHF 16 monitoring and reduce cross talk
7. More active traffic management connected to small craft and better monitoring of restricted areas. Close waterways to small craft high volume of commercial traffic or other special events

Traffic Conditions: Traffic Mix	
Trend – risk is rising Top additional mitigation measure – Enforcement	
Baseline Risks: 1. Mix of commercial and recreational vessels throughout waterways 2. Greatest mix of traffic is in Central San Francisco Bay where deep draft ships share narrow channels and fairways with tugboats, tugs and tows, passenger ferries, and dense concentrations of recreational and fishing boats. 3. Central San Francisco Bay around Alcatraz Island is the convergence point for all deep draft vessel traffic in the region. 4. Large volume and mix of vessels: a. Golden Gate Bridge: Precautionary Area with deep draft vessels converging on concentrations of fishing vessels, recreational vessels—human and wind powered—and tour boats. Tour boats make U-turns under the bridge for sightseeing and do so during ALL conditions of visibility. b. CB Eastbound Traffic Lane: Tour boats go counter to deep draft vessels in all conditions of visibility. A primary location for sailing regattas and mass swimming events. Adjacent to Fisherman's Wharf fishing fleet moorings with frequent fishing vessel mass arrival and departure events. Alcatraz ferries cross continuously. A primary dredge material placement area with dredges going counter to traffic flow. c. Point Simpton: Recreational vessels entering and exiting between Raccoon Strait and North Channel RNA. d. West end of the Oakland Estuary at Oakland Middle Harbor: Frequent convergence of deep draft vessels and sailing regattas. – e. Suisun Bay: Security zone for MOTCO complicates maritime traffic flow. Fishing and commercial vessels coincide in narrow channels with strong current. f. Carquinez Strait: Commercial vessels wind and human powered vessels frequently coverage with strong wind and current. g. Point Blunt: Blind bend at convergence of narrow channels and a Precautionary Area. Frequent encounters between deep draft, towing, and recreational vessels. h. CB Deep Water Traffic Lane: Convergence between recreational and ferry vessels exiting Raccoon Strait and the deepest deep draft ships. Dense fog during fog season. Yachting regattas.	**Existing Mitigations:** 1. Previous maritime incidents at bridges resulted in VTS and Harbor Safety Committee involvement resulting in new maritime best practices. 2. The Ferry Traffic Routing Protocol (FTRP) – means ferries follow proposed routes, allowing for others to predict their movements 3. The use of AIS increases awareness, but not all have AIS, and many fail to maintain accurate and up-to-date AIS data. but not all have AIS) 4. Permit process of marine events helps manage traffic issues 5. VTS routine broadcasts of information to mariners (e.g., location of fishing activities and regattas) 6. Use of RNAs with specific navigation guidelines, restrictions on vessel encounters, prohibition of certain vessels from entering, requirements for some vessels to use, vessel draft restrictions, and speed limits for vessels of 1600 gross tones or more. 7. Better USCG follow through with Rule 9 violation reports 8. Waterways designated as 'narrow channels and fairways' according to Rule 9. 9. Deep water routes are clearly marked 10. Due to shallow draft and maneuverability, high-speed ferries can get out of the way of slower vessels in the waterway

i. CB Westbound Traffic Lane: Tour boats go contrary to direction of traffic flow. Recreational vessels and yachting regattas. Tour boats passing close to Alcatraz Island encounter passenger ferries going in the opposite directly. **5.** Recreational vessels and high-speed ferries have no speed limits, except for slow-down requests from VTS for minimum wake zones. **6.** Aging and often out-of-service sensors and communications equipment and infrastructure critical for monitoring waterway. **Trends:** 1. Ships are getting larger, and density of small vessels is growing. 2. Volume of 'human powered' small craft is increasing.	
New Ideas 1. Establish charted 'areas' or 'boxes' for recreational vessel activities. 2. Rules / Procedures: - Implement more structured traffic patterns with enhanced vessel separation through dedicated traffic lanes and separation zones. 3. Establish no-go areas for recreational vessels and encourage interagency coordination of enforcement. 4. Expand VHF radio capabilities and establish VOIP channels. Require all operators, recreational and commercial, to use standardized (correct) radio procedures. 5. Expand active Traffic management to include AIS requirements for certain waterways and monitoring and enforcement for all vessels by a traffic management organization.	

Traffic Conditions: Congestion	
Trend – risk is rising Top additional mitigation measure – Radio Communications	
Baseline Risks: 1. Fishing seasons – a. Crab season: Vessels and crab pots in all Offshore TSSs b. Salmon season: Concentrations of fishing vessels in the Northern and Southern TSSs. c. Halibut season: Concentrations of fishing vessels north and south of Berkeley Pier. d. Striper season: Fishing vessels around Mel's Reef, CB Eastbound Traffic Lane, south of Alcatraz. 2. More than 40 fireworks shows are held annually. For example: a. Radio station organized fireworks shows. b. 4th of July throughout the region. c. New Years Eve at the San Francisco City front. d. Sports celebrations. 3. Increasing congestion with mix of vessels, shipping activity a. Ferries not following designated routes increase risk for recreational vessels that expect ferries on designated routes. b. Dredging in busy, narrow channels and fairways further restricts vessel movements and often requires complex advance communications and planning. c. RNA restrictions on vessel encounters and speed can cause crowding of vessels in areas outside the RNSs, an unintended consequence of the mitigation measure. Recreational vessel activity, both organized and spontaneous recreational events, often result in hundreds of recreational vessels or swimmers, and spectators, crowding narrow channels and fairways used by commercial vessels. d. Sand and Shell Mining near narrow channels and fairways. 4. AIS users often fail to keep data accurate and up-to-date. This can cause confusion with AIS data conflicts radiotelephone reported information. **Trends:** 1. None identified	**Existing Mitigations:** 1. The Ferry Traffic Routing Protocol (FTRP) – means, if ferries follow designated routes, others, including VTS, can predict their movements. 2. FTRP also enable forward planning for Marine Event permits to ensure recreational events take measures to avoid highest-risk passenger ferry operating areas. 3. The use of AIS increases awareness, but not all vessels have AIS and not all AIS users keep AIS data accurate and up-to-date. 4. US Coast Guard Marine Event Permit process enables forward planning for vessel operations to avoid conflicts with recreational events. 5. VTS often instructs vessels to update AIS information. 6. Offshore Vessel Traffic Advisory informs recreational and fishing vessels west of the Golden Gate Bridge of all commercial vessel operations. A need to focus especially on Rule 9 awareness broadcasts to remind small vessels to adhere to the rules of the road when deep draft vessels are in the area. 7. Candid, real-time and offline communications between maritime stakeholders, ports and terminals, and government agencies. 8. Use of the Marine Exchange data and 24/7 operation center for planning and real-time operations. 9. Use of two discrete VTS operating frequencies – Inshore and Offshore. 10. Rules of the Road (COLREGS) requirements for mariners and VTS. All VTS operators are required to pass a Rules of the Road certification exam. 11. Narrow channels and fairways are clearly marked and charted.
New Ideas 1. Coordination/Planning - Use IWRAP data to educate/provide mariners with historical reports on seasonal congestion 2. Decision support software – Use PAWSA and IWRAP data to help design event monitoring algorithms for alerting on anomalous vessel behavior	

3. Coordination/planning – electronically share permits and event planning activities with all stakeholders
4. Coordination/Planning – establish 'boxes' or 'areas' (charted) for recreational activities.
5. Limited access areas -- Restrict recreational vessels under certain circumstances from highest-risk / most congested narrow channels and fairways.
6. Rules / Procedures - Implement a more structured traffic separation system in areas outside RNAs and TSSs enhancing vessel traffic separation with dedicated lanes and routes.
7. Enforcement – More on-the-water enforcement during heavy maritime traffic time periods including increased boating-while-intoxicated enforcement for recreational vessels.
8. Nav/Hydro – More consistent and reliable dredging schedules keeping narrow channels and fairways dredged to their designated depths. Awareness that deeper waterways equals safer and more economically efficient vessel movements.
9. VHF radio – establish additional VHF / VOIP channels and require highly-structured radio syntax to reduce voice radio clutter.
10. Active Traffic management – require Class A AIS and other high-resolution electronic identification systems to enable enhanced vessel traffic management/organization and decision support systems
11. Active Traffic management – review existing approaches to VTS in comparison with international best practices. This could include an audit of existing processes against IMO Resolution A.1158(32) and related IALA Standards, Recommendations, Guidelines and Model Courses.
12. Review the process for communication ship-shore/shore-ship noting developments of decision support tools (DSTs); automated monitoring systems; the use of artificial intelligence and machine learning to identify issues and developments in digital data exchange and communications.
13. Other actions – More navigation safety outreach and education for recreational and fishing vessels. Better real-time reference material for mooring and anchoring locations capabilities, and limitations.

Navigational Conditions: Obstructions

Trend – risk is rising

Top additional mitigation measure – Other Actions

Baseline Risks:

1. Spring runoff and extreme weather events causing increased volume of and size of debris in all SF Bay Region waterways. –
2. Crab pots are often left in offshore traffic lanes requiring crab boats to navigate in the lanes to retrieve.
3. Wrecks and derelict vessels in and adjacent to narrow channels and fairways reducing the width of the waterways and increasing change of allision.
4. Old pylons, ruined docks and piers, and other dangerous debris obstructing the waterway around bridges and narrow openings
5. Underwater rocks and rocky outcrops adjacent to waterways trafficked by the largest, deepest vessels.
6. Extensive underwater infrastructure coincides with navigation channels throughout the region – metro rail tunnel, vehicle tunnels, petroleum and gas pipelines, critical high-voltage electric transmission lines

Trends:

1. Increased significant weather events lead to more debris
2. Obstructions continue to cause issues, even when they have been there for some time (situation is not getting better)

Existing Mitigations:

1. Provision of AtoN
2. US Army Corps of Engineers debris recovery program.
3. VTS alerts mariners regarding debris reports (but no method for tracking debris between voice reports).
4. Marine Exchange actively monitors submarine cable for PG&E.

New Ideas

1. Coordination/Planning – increase debris patrols / recovery.
2. Voluntary training – programs to raise awareness / prevention through people. Provide electronic tools to enable recreational and fishing vessels to report debris or other waterway risks.
3. Voluntary training – whale evasion / marine wildlife identification training.
4. Rules/Procedures – require utilities to be buried / minimum amount of cover (and follow through to very it remains).
5. Rules/Procedures – mandate removal of debris, old wrecks (and fines if not done).
6. Nav/Hydro – more, better, and more accessible hydrographic data, including real-time details on locations and risk associated with underwater structures/infrastructure.
7. Radio Communications (and Active Traffic Management) – alerts broadcast. Aggressive use of digital tools such as AIS messaging to alert with locations and risks associated with waterway obstructions.
8. Other – Increase funding to US Army Corps of Engineers for debris removal programs.

Waterway Conditions: Dimensions

Trend – risk may be rising

Top additional mitigation measure – Waterway Changes

Baseline Risks:

1. Width of channels (many quite narrow)
2. Benicia-Martinez Railroad Drawbridge lift span is 291 feet wide and 135 feet high; pilots limit maximum vessel width to 138 feet; vessels coming down river (westbound) are challenged because of current coupled with waterway dimensions.
3. Precise transit windows are necessary due to water depth and vertical waterway clearance. These limitations lead to multiple vessels transiting only at high water causing increased congestion. / the need for dredging
4. One-way at a time traffic areas require mariners and VTS maintain close watch on movement progress of multiple vessels simultaneously without any computerized decision support tools).
5. Narrow channels resulting in ship-to-ship interaction - moored vessels pulling away from dock when other vessels transit through area:
6. Anchorages with poor holding ground (i.e. Federal Anchorage 5 and 23 have limited holding areas - shoal to rocky bottom)

Trends:

1. Ships are getting larger making channel dimensions more critical than ever. Turning basins and existing infrastructure are pressed to their limits.
2. New fuels and green engine operating requirements affect vessel operating procedures and could affect vessel maneuverability.
3. Larger ships increase the risk of dangerous interaction when ships pass moored vessels.
4. Deeper ships with shallower water, often due to delinquent dredging, reduce under keel clearance and require vessels to operation closer to safety margins.

Existing Mitigations:

1. US Army Corps of Engineers provides real-time and monthly reports at Harbor Safety Committee meeting regarding completed dredging operations.
2. Ongoing dredging activities
3. Use of ATON to mark channels
4. Use of P.O.R.T.S sensors for real time reading of tidal and current levels
5. Berth to berth passage planning
6. Existing NOAA charting system
7. Use of GPS
8. Use of UKC (static approach)

New Ideas

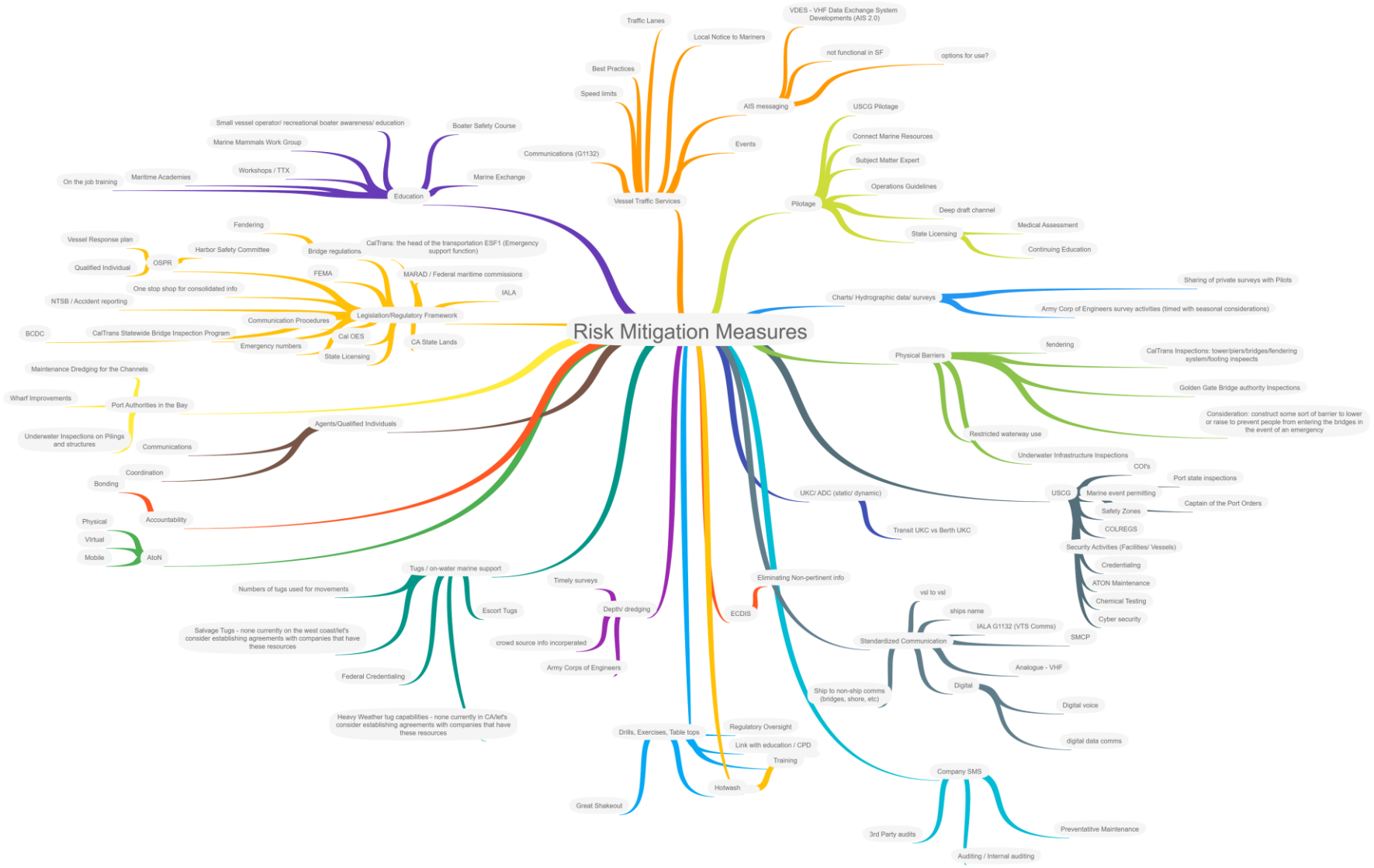
1. Coordination between dredging of federal channels and waterways adjacent to federal channels.
2. Voluntary training – provide outreach/training to raise awareness of issues.
3. Rules/Procedures – streamline dredge permit process, support for small project dredging.
4. Nav/Hydro : Conduct more frequent surveys and make survey data more easily accessed through apps or similar.
5. Traffic Management: Enhance vessel traffic monitoring and decision support for VTS operators to improve management of traffic around narrow channels, turning basins, RNA, and deep draft chokepoints.
6. Waterway Changes: increase channel widths and turning basin diameter with streamlined approach to dredging.
7. Dredging: Create dredging ‘windows’ to facilitate dredging while deconflicting dredging and shipping demands.
8. Infrastructure: Enhance infrastructure necessary to support increasing maritime activity.
9. Enhance Berth to berth passage planning and revise VTS procedures to support monitoring of transits.
10. Enhance surveys and effective promulgation through NOAA charting system.
11. Review GPS accuracy and provide tools to ensure effective and accurate position, navigation and timing is available throughout the waterway.
12. Implement a dynamic approach to UKC and develop procedures for use by ships, pilots and VTS.

<table>
<tr><th colspan="2">Subsequent Consequences: Aquatic Resources</th></tr>
<tr><td colspan="2">Trend – risk is rising

Top additional mitigation measure – Voluntary Training</td></tr>
<tr><td>Baseline Risks:
1. Multiple species in waterway (e.g., crab, smelt, halibut)
2. Year-round fishery with a seasonal component (e.g., halibut, salmon, striper)
3. Increased number of whales and other marine sea life in the waterway coinciding with maritime traffic.
4. Perceived lack of public knowledge regarding safety of aquatic resources.

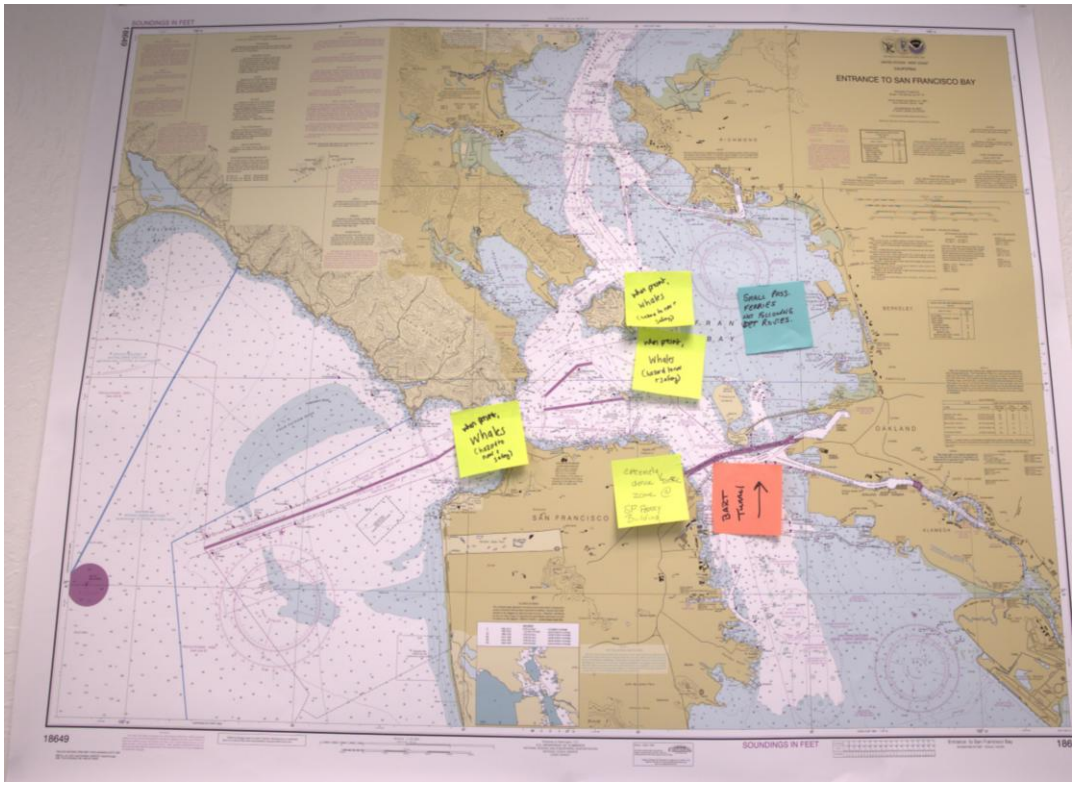
Trends:
1. Increased numbers of whales in the waterway</td><td>Existing Mitigations:
1. Area Contingency Plans have identified sensitive areas; agencies are required to respond within a particular timeframe in these areas
2. State agency (Fish & Game) monitors stock and orders closures / re-openings
3. Pending state legislation regarding impacted aquatic resources incidents
4. Good information network</td></tr>
<tr><td colspan="2">New Ideas
1. Coordination / Planning – interagency coordination, resources and emergency vessels.
2. Voluntary training – increased public awareness through outreach activities, training – a campaign with physical and online presence ‘where you transit impacts on resources’.
3. Rules / Procedures – interagency approach for reporting, voluntary shutdowns and restricted areas.
4. Enforcement – increased enforcement, funded, with penalty for illegal harvesting.
5. Surveillance and enforcement: Use technology such as low light or thermal cameras, high-resolution radar, acoustic monitors, etc. to spot and track marine wildlife and to enforce marine wildlife protection rules.
6. Use Technology to focus guidelines: Use technology and historic data to better focus marine protection guidelines and rules on areas of greatest concern.</td></tr>
</table>

Annex D – Rist Mitigation Measures Mindmap



Annex E – Images from the discussion session on incidents and near miss

Visualization of hazards, incidents and near misses were provided during the workshop.




KINDER
MORGAN
FULL PIPLINE
SAN FRANCISCO BAY
SOUTHERN PART
SOUNDINGS IN FEET
18651


SOUNDINGS IN FEET
18649
ENTRANCE TO SAN FRANCISCO BAY
RICHMOND
SAN FRANCISCO BAY
BERKELEY
OAKLAND
SAN FRANCISCO
ALAMEDA
Bay Bridge
OAK-SAN CHAN
18649
SOUNDINGS IN FEET
18649

Annex F – Incidents identified to support the PAWSA workshop

A number of incidents were identified to support the PAWSA Workshop.

Longitude	Latitude	Incident Description	Incident Date	Vessel	Incident
-122.4704	37.8276	Tanker evasive action to avoid CG Helo Operations	16/04/2024	POLARIS VOYAGER	Near Collision
-122.3962	37.8635	Ferry off route at 14 - 28 knots in fog reporting numerous recreational vessels.	30/10/2022	FERRY VELA	
-123.0691	37.9615	Yacht ROYAL POLARIS collision course with Passenger Ship QUEEN ELIZABETH off Pt. Reyes.	22/06/2022	QUEEN ELIZABETH	Hazardous Navigation
-123.1228	38.0043	WAN HAI NO 176 loses propulsion	09/04/2022	WAN HAI NO 176	Loss of Propulsion
-122.4102	37.8632	Close passing between CGC MUNRO and YM ENDEAVOUR at Alpha Buoy	05/03/2022	CGC MUNRO	Hazardous Navigation
-122.3454	37.7729	Highspeed ferry PERALTA runs over buoy in the South SF Bay	30/10/2017	PERALTA	Buoy Allision
-122.3549	37.8066	Crane Barge VENGEANCE sinks on the BART Tunnel	10/04/2017	DB VENGEANCE	Sinking
-122.4443	37.8354	Tanker TORM ASLAUG lost control in the Central Bay.	27/03/2017	TORM ASLAUG	Loss of Propulsion
-121.3346	37.9519	STAR LUSTER allision with power cables Port of Stockton.	19/01/2016	STAR LUSTER	Cable Allision
-122.1257	38.0384	Near bridge allision resulting in ship anchoring on Transbay Cable.	05/09/2014	OCEAN LIFE	Near Bridge Allision
-122.3858	37.7915	Tug DENISE LIND near allision with OBB A Tower	20/10/2013	TUG DENISE LIND	Near Allision
-122.6745	37.7410	TUG PETER M near collision with MV AFRODITI Offshore Precautionary Area	20/06/2013	TUG PETER M	Near Collision
-122.3701	37.8053	OVERSEAS REYMAR allision with OBB Echo Tower	07/01/2013	OVERSEAS REYMAR	Bridge Allision
-122.6538	37.7400	YM ZENITH and CHEMBULK HONGKONG near collision Offshore Precautionary Area	01/04/2009	YM ZENITH and CHEMBULK HONGKONG	Near Collision
-122.5033	37.8200	Tanker OVERSEAS CLELIAMAR lost power near Point Diablo. Came very close to grounding on the rocks.	27/01/2009	OVERSEAS CLELIAMAR	Loss of Propulsion
-122.4427	37.9354	Tug PACIFIC WOLF towing a barge allision RSRB W Span	10/01/2008	PACIFIC WOLF	Bridge Allision
-122.4235	37.8259	ROYAL PRINCE tour boat hard aground Alcatraz Islands	06/12/2007	ROYAL PRINCE	Grounding

Longitude	Latitude	Incident Description	Incident Date	Vessel	Incident
-122.3746	37.8008	COSCO BUSAN allision OBB Delta Tower	07/11/2007	COSCO BUSAN	Bridge Allision
-123.1791	38.0077	Collision FV EVA DANIELSON and CS BUONA MADRE with fatality	13/07/2007	EVA DANIELSON	Collision Fatality
-122.1207	38.0386	MUDCAT Tug and barge allide Benicia Martinez Railroad Bridge after failing to call for a lift. Operator screaming on VHF.	05/11/2005	Tug MUDCAT	Bridge Allision
-122.4455	37.9346	PACIFIC HIGHWAY avoids S/V and allides with RSRB W Span	11/07/2004	PACIFIC HIGHWAY	Bridge Allision
-122.4783	37.8133	Anhydrous Ammonia ship lost steering and propulsion.	12/03/1995	MUNDOGAS EUROPE	Near Allision
-122.4344	37.8414	CGC BOUTWELL and CS CALIFORNIA STAR near collision Harding Rock	25/08/1993	CGC BOUTWELL	Near Collision
-123.3297	37.9969	FV JACK JUNIOR TK GOLDEN GATE	26/05/1986	FV JACK JUNIOR	Collision Fatality
-122.6108	37.7714	Explosion of the chemical ship PUERTO RICAN	31/10/1984	PUERTO RICAN	Vessel Fire
-122.1203	38.0388	CSL TRAILBLAZER allision with Benicia-Martinez Railroad Bridge after power failure.	1995		Bridge Allision
-122.1233	38.0423	Crane Barge allides with and damages Benicia-Martinez Railroad Bridge.			Bridge Allision
-122.5058	38.1156	Damage to HWY 37 Bridge fender	2025	Unknown	Bridge Damage

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