Science Workshop Report: Spatial data contributions to Federal Initiatives in the Pacific Region

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Les numéros 1 à 456 de cette série ont été publiés à titre de Rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de Rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de Rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

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SCIENCE WORKSHOP REPORT: SPATIAL DATA CONTRIBUTIONS TO FEDERAL
INITIATIVES IN THE PACIFIC REGION

By

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This workshop report summarizes the presentations and discussions that resulted from a series of workshops held for DFO Science staff on Spatial Data Contributions to Federal Initiatives in the Pacific Region. The introductory workshop was held virtually on September 2nd, 2020 and was the first of a series of sessions focused on improving communication among initiatives and aligning spatial data efforts and deliverable development. Eight initiatives were introduced and discussed: Marine Spatial Planning (MSP), Marine Conservation Targets (MCT), Coastal Environmental Baseline Program (CEBP), Planning for Integrated Environmental Response (PIER), Salish Sea Initiative (SSI), Terrestrial Cumulative Effects Initiative (TCEI), Freshwater Habitat Science Initiative (FHIN) and the Whales Initiative. Participation at the introductory session included more than 90 DFO Science staff from the Ecosystem Science, Ocean Sciences, Stock Assessment and Research Divisions, as well as staff from National Headquarters and other sectors within the Pacific region (e.g. Ecosystem Management Branch, Fisheries Management Branch).

Seven subsequent taxa-specific workshops occurred throughout September and October, 2020: Oceanography, Groundfish & Rockfish, Invertebrates, Pelagic Fish, Mammals, Algae, Plants & Habitats and Salmon. The key objectives of the taxa-specific workshops were to build relationships among science staff, discuss how data sharing requests can be formulated to be streamlined and multi-user friendly, and identify opportunities to align spatial data efforts and outputs among science staff working on spatial data. Presentations, discussions and questions that occurred during each session are summarized in this report.

Résumé

Proudfoot, B., Robb, C., Rubidge, E., Murray, C & Sweazey, B. 2022. Science Workshop Report: Spatial Data Contributions to Federal Initiatives in the Pacific Region. Can. Tech. Rep. Fish. Aquat. Sci. 3458: viii + 73 p.

Le présent rapport sur l'atelier scientifique résume les présentations et les discussions découlant d'une série de séances offertes au personnel scientifique de Pêches et Océans Canada (MPO) sur les contributions aux initiatives fédérales en matière de données spatiales dans la région du Pacifique. La séance d'introduction, qui s'est tenue virtuellement le 2 septembre 2020, était la première d'une série de séances portant sur l'amélioration de la communication entre les initiatives et l'harmonisation des efforts en matière de données spatiales et d'élaboration des livrables. Huit initiatives ont été présentées et ont fait l'objet de discussions: planification spatiale marine, objectifs de conservation marine, programme sur les données environnementales côtières de référence, planification de l'intervention environnementale intégrée, initiative de la mer des Salish, initiative sur les effets cumulatifs terrestres, initiative scientifique sur l'habitat d'eau douce et initiative de protection des baleines. Plus de 90 membres du personnel scientifique de la Division des sciences des écosystèmes, de la Division des sciences des océans, ainsi que de la Division de l'évaluation des stocks et de la recherche du MPO y ont participé, ainsi que des membres de l'administration centrale et d'autres secteurs de la région du Pacifique (p. ex., la Direction générale de la gestion des écosystèmes, la Direction générale de la gestion des pêches).

Sept autres séances consacrées à des taxons ont eu lieu en septembre et octobre 2020 : océanographie, poissons de fond et sébastes, invertébrés, poissons pélagiques, mammifères, algues, plantes et habitats et saumons. Les séances consacrées à des taxons avaient principalement pour but d'établir des relations entre le personnel scientifique, de discuter de la façon dont les demandes de communication de données peuvent être formulées pour qu'elles soient plus simples et conviviales et de cerner les occasions d'harmoniser les efforts et les résultats relatifs aux données spatiales du personnel scientifique travaillant sur ces données. Les présentations et les discussions qui ont eu lieu et les questions qui ont été posées pendant chaque séance sont résumées dans le présent rapport.

Acronyms

ADCP	Acoustic Doppler current profiler
CCG	Canadian Coast Guard
CEBP	Coastal Environmental Baseline Program
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch per unit effort
CTD	Conductivity, temperature and depth
DFO	Fisheries and Oceans Canada
EEZ	Exclusive Economic Zone
FFHPP	Fish and Fish Habitat Protection Program
FGP	Federal Geospatial Platform
FHIN	Freshwater Habitat Science Initiative
MCT	Marine Conservation Targets
MEQ	Marine Environmental Quality
MPA	Marine Protected Area
MSDI	Marine Spatial Data Infrastructure
MSP	Marine Spatial Planning
NGO	Non-Governmental Organization
NRKW	Northern Resident Killer Whale
OPP	Oceans Protection Plan
PIER	Planning for Integrated Environmental Response
RCP	Representative Concentration Pathway
ROMS	Regional Ocean Modelling System
SDM	Species Distribution Model
SRKW	Southern Resident Killer Whale
SSI	Salish Sea Initiative
TCEI	Terrestrial Cumulative Effects Initiative
TMX	Trans Mountain Expansion
WCVI	West Coast Vancouver Island

Workshop Overview

Context

In the Pacific Region, DFO Science is participating in a variety of new directed initiatives, relatively short-term programs with sunset funding. These initiatives overlap in geographic space, include similar partners and have complementary scientific deliverables. This workshop was intended to develop shared understanding among DFO Science staff of the initiatives that are underway, improve communication among initiatives, and align spatial data efforts and deliverable development. The workshop focused on the Science Branch components of the initiatives, in particular on deliverables related to spatial data products and tools.

The objectives of the workshop were to:
1. Identify overarching vision, linkages, and complementarities between initiatives in Pacific Science Branch
2. Develop an understanding of complementary initiatives and deliverables within Science Branch
3. Build relationships and improve communication among Science staff working on complementary initiatives
4. Identify opportunities to align spatial data efforts and outputs

By convening this workshop, a number of benefits were anticipated: shared knowledge and increased understanding of the directed initiatives underway; increased coordination and integration among initiatives; and more efficient compilation and creation of spatial data products and tools, with the potential for utility across multiple initiatives.

Eight initiatives in particular were identified:
- Freshwater Habitat Science Initiative (FHIN)
- Marine Spatial Planning (MSP)
- Marine Conservation Targets (MCT)
- Ocean Protection Plan
  - Coastal Environmental Baseline Program (CEBP)
  - Planning for Integrated Environmental Response (PIER)
- Trans-Mountain Expansion (TMX)
  - Salish Sea Initiative (SSI)
  - Terrestrial Cumulative Effects Initiative (TCEI)
- Whales Initiative (including additional measures for Southern Resident Killer Whale)

The workshop began with an introductory session that introduced the eight initiatives, provided the national and regional context, and shared initiative-specific information on geographic scope, spatial data and tool development, and data sharing/accessibility. Seven subsequent taxa-specific workshops focused on: Oceanography, Groundfish & Rockfish, Invertebrates, Pelagic Fish, Mammals, Algae, Plants & Habitats and Salmon. At each taxa-specific workshop, participants discussed the development of spatial data products and tools and how to align efforts across initiatives to improve the efficiency and quality of deliverables.

Introductory Session

Format

The 3-hour long introductory session was held via Microsoft (MS) Teams on September 2nd, 2020. A total of 91 staff ([Appendix 1](#)) attended the session, including 9 presenters and 2 facilitators from Stratos. The workshop began with a brief welcome and introduction provided by Carrie Robb (Science). Barb Sweazey (Stratos facilitator) introduced the intention and objectives of the introductory session and provided an overview of the agenda. Liisa Peramaki (Director, Environment and Biodiversity Science Branch) and Eddy Kennedy (Division Manager, Ecosystem Sciences Division) then presented an overview of the National and Regional Contexts of the initiatives that are the focus of the workshop. A series of initiative-specific speed talks followed that presented more detailed activities and deliverables related to spatial data. The presentations are summarized below.

Overview Presentation

National and Regional Context of National Initiatives with Spatial Data Components
Presenters: Liisa Peramaki (Director, Environment and Biodiversity Science Branch) and Eddy Kennedy (Division Manager, Ecosystem Sciences Division)

A high level overview of National initiatives/programs with spatial data contributions (Figure 1) provided national and regional context for aligning complementary temporal, spatial and thematic components of the initiatives.
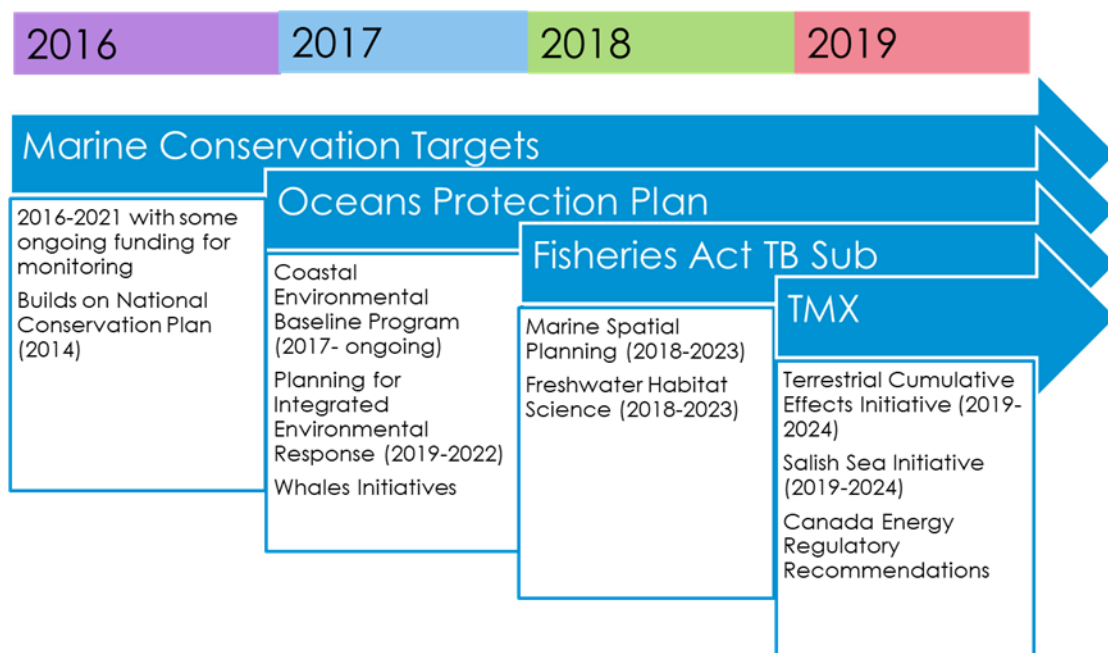

Figure 1: Timeline for initiation of programs discussed in this workshop. TB = Treasury Board, TMX = Trans-Mountain Pipeline Expansion

For each program, National and Regional specific deliverables were outlined, along with details of program leads (at National and Regional levels), science contributions to deliverables, geographic scope

(Figure 1) and timeline of each initiative. The importance of collaboration and integration across teams to improve efficiency and the quality of deliverables was emphasized. The value of bringing freshwater and marine researchers together in this workshop was also highlighted.

Table 1: National and regional geographic scope of initiatives.

Initiative	National Geographic Scope	Pacific Geographic Scope
Marine Conservation Targets (MCT)	National	All Pacific bioregions
Coastal Environmental Baseline Program (CEBP)	Six 'pilot' areas across Canada	Port of Vancouver & Port of Prince Rupert
Planning for Integrated Environmental Response (PIER)	Four 'pilot' areas across Canada	BC Coast divided into 8 Canadian Coast Guard sub-areas and an Oil Fate and Behaviour Study in Prince Rupert
Whales Initiative	Salish Sea/ SRKW Critical Habitat	Salish Sea/ SRKW Critical Habitat
Marine Spatial Planning (MSP)	Four Planning areas across Canada	MSP North – Northern Shelf Bioregion MSP South – Strait of Georgia and Southern Shelf bioregions
Freshwater Habitat Science Initiative (FHIN)	National	Freshwater habitat
Terrestrial Cumulative Effects Initiative (TCEI)	Watersheds along the proposed TMX expansion route	Fraser River Basin
Salish Sea Initiative (SSI)	Salish Sea	Salish Sea/SRKW critical habitat

Participant Questions/Discussions
A discussion (both verbal and via MS Teams Chat) followed about whether there are plans to make connections with scientific programs that are being carried out independently from the initiatives discussed in the workshop. References were made to the North Pacific Anadromous Fish Commission (NPAFC) surveys as an example of data that could be incorporated into the initiatives discussed in the workshop (e.g. TCEI). From a regional perspective, there are plans to connect with other initiatives not discussed during the workshop, with the goal being to coordinate and utilize existing data as opposed to collecting new data. Questions about utilizing project management and tracking applications (such as DMApps & Knowledge Graph Technology) to facilitate data and progress sharing across initiatives was also discussed in the MS Teams Chat. DMApps is currently being piloted to track projects in the Pacific Region.

Speed Talks on Initiatives in the Pacific Region
A series of speed talks provided more detail on the region-specific objectives, activities, contacts and existing/anticipated spatial data products for each initiative. The speed talks are summarized below.

Marine Spatial Planning (MSP)

Presenter: Miriam O (Section Head, Ecosystems Sciences Division, Marine Spatial Ecology and Analysis Section)

The overarching goal of the Marine Spatial Planning (MSP) initiative in the Pacific Region is to produce marine spatial plans, spatial data products and science advice that can inform the management of marine spaces to balance ecological, economic, cultural and social objectives. The development of MSP-related spatial data products in the Pacific Region is a highly collaborative process, which ensures that the spatial data products are as useful and complementary as possible in order to support the broader MSP objectives and other initiatives underway in the same geographic space.

Geographic scope: MSP has been initiated in two planning areas in the Pacific: MSP North (Northern Shelf Bioregion) and MSP South (Strait of Georgia and Southern Shelf Bioregions). Spatial data are being developed and analyzed coast-wide.

Deliverables: DFO Science is responsible for four key deliverables

1. Spatial data products for inclusion in the MSP Atlas that is being developed by the MSP Program lead (DFO Oceans Management). This work is guided by the development of the following key outputs:
   a. An inventory of available spatial data – in progress
   b. A prioritization framework for MSP Data (Figure 2)
   c. Identification of ecological conservation priorities (MSP North; SAR 2017/19)
   d. Development of conceptual models of major habitat types – in progress; tech report anticipated
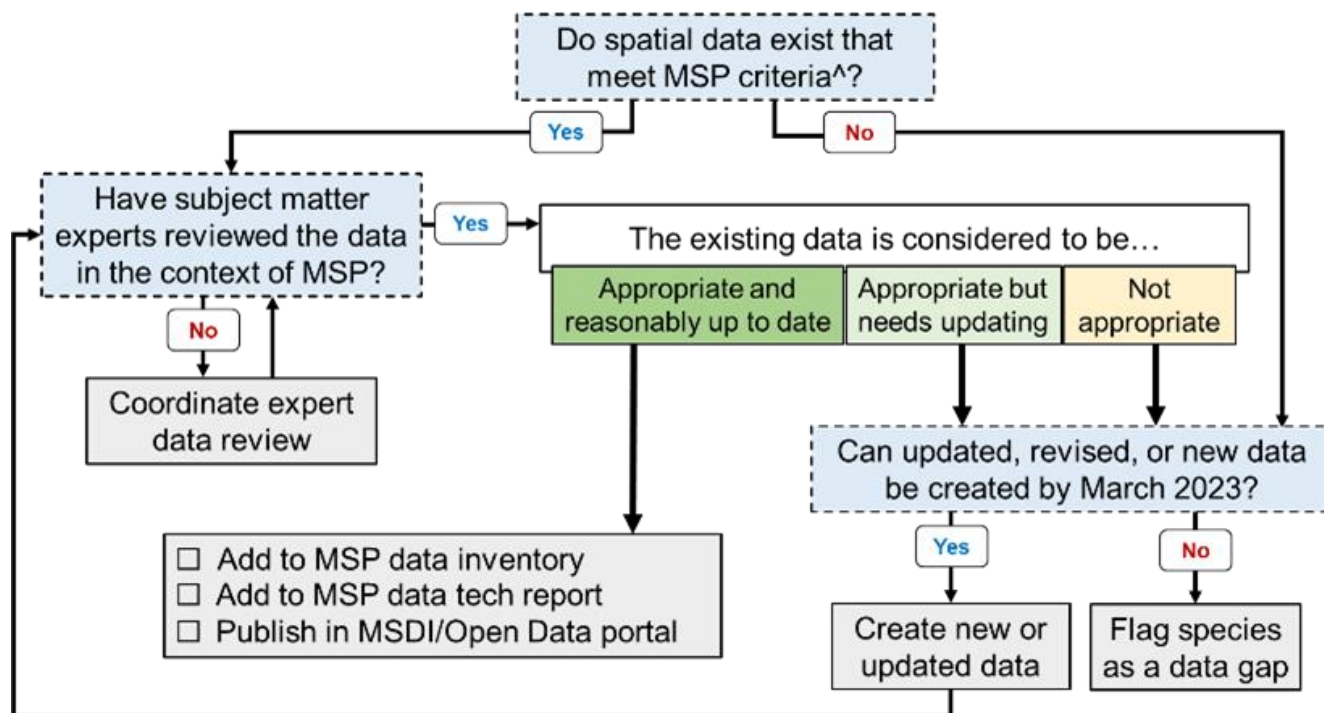

Figure 2: Prioritization framework for Marine Spatial Planning (MSP) data. MSDI: Marine spatial data infrastructure.

2. Spatial data and methods to fill key data gaps, examples of which include:
   a. Species distribution models for 20 species and the associated environmental layers used to build the models. A species distribution modelling framework[1] was developed that presents a range of modelling approaches for a variety of data availability scenarios. The framework also includes purpose-built R scripts developed to implement the SDM framework. The R scripts are available on the MSEA GitLab.
   b. Multispecies groundfish community models for MSP North and MSP South. Spatial outputs include species-specific distributions, spatial patterns of community structure and species richness maps for 48 groundfish species.
   c. Spatial data representing areas of importance, such as forage fish hotspots, significant benthic areas and updates to data developed to support MPA network planning.
3. Cumulative impact mapping and the production of human activity maps, habitat classes and a vulnerability matrix. An ArcGIS python toolbox has been developed to standardize and replicate the cumulative impact maps.
4. The development of trade-off analyses to support decision making and the development of MSP zones. The analyses incorporate ecologically significant species, conceptual models for major habitat types, sample zoning frameworks, spatial data for ecological features and spatial data for human activities.

Spatial data availability: MSP spatial data products are provided through two primary portals:
- MSP North (MPA network data): SeaSketch
- MSP South: GIS Hub and MSDI/FGP/OpenData. The GIS Hub is the central place to find key spatial datasets for MSEA staff and other users in DFO Pacific Science. It is designed to allow users to search, preview, download, and find detailed information (metadata) about the datasets.

Marine Conservation Targets (MCT)
Presenter: Miriam O (Section Head, Ecosystems Sciences Division, Marine Spatial Ecology and Analysis (MSEA))

The overarching goal of the Marine Conservation Targets (MCT) initiative in the Pacific Region is to provide science advice to support the identification and monitoring of Marine Protected Areas (MPAs) and OECMs (Other Effective Area-Based Conservation Measures) to meet Canada's commitments to conserving 25% of our oceans by 2025 and 30% by 2030. A consistent approach to providing advice across multiple MPAs and conservation areas and building upon previous work guides the work being done as part of the MCT initiative in the Pacific Region.
Geographic scope: Pacific Region Exclusive Economic Zone (EEZ)
Deliverables: The main deliverables for the MCT initiative in the Pacific Region are:

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[1] Nephin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. 2020. Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.

1. The identification of important habitats and areas, including sensitive benthic areas (SBAs), Ecologically and Biologically Significant Areas (EBSAs) and OECMs that may contribute to MCT targets[2,3]
2. Science advice for the offshore AOI process and SGaan Kinghlas-Bowie Seamount MPA[4,5,6,7]
3. Science advice for the development of MPA/conservation networks in Pacific bioregions[8,9]
4. Science advice on monitoring MPAs/OECMs/conservation networks[10,11]
5. Field programs and research to improve understanding of important ecosystems and areas of high conservation value

Spatial data availability: MCT spatial data products are available on [SeaSketch], GIS Hub and OpenData. Spatial data includes 238 spatial datasets for the Northern Shelf Bioregion representing 123 species and 15 areas/habitats. Visual survey videos are available on [Ocean Network Canada's SeaTube].

Coastal Environmental Baseline Program (CEBP)
Presenter: Paul Covert (Physical Scientist, Ecosystem Sciences Division, Aquatic Ecosystems and Marine Mammals (AEMM))

The overarching goal of the Coastal Environmental Baseline Program (CEBP) is to collect comprehensive data to establish the current state of the ecosystem in two BC ports that have existing or potential high vessel traffic. Baseline data are being collected by scientists with DFO, First Nations, NGOs and local governments.
Geographic scope: Port of Prince Rupert and the Port of Vancouver
Deliverables: The main deliverables for the CEBP are comprehensive and open-source baseline datasets for the Port of Prince Rupert and the Port of Vancouver that can be used to characterize these coastal ecosystems. CEBP abiotic and biotic data (Figure 3**Error! Reference source not found.**) are collected using a variety of sampling and analytical techniques, including oceanographic sensors, discrete

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[2] Rubidge, E., Jeffery, S., Gregr, E.J., Gale, K.S.P., and Frid, A. 2020. Assessment of nearshore features in the Northern Shelf Bioregion against criteria for determining Ecologically and Biologically Significant Areas (EBSAs). DFO Can. Sci. Advis. Sec. Res. Doc. 2020/023. vii + 63 p.

[3] Rubidge, Emily, Nephin, J, Gale, K.S.P., & Curtis, J. 2018. Reassessment of the Ecologically and Biologically Significant Areas (EBSAs) in the Pacific Northern Shelf Bioregion. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/053. xii + 97 p.

[4] DFO. 2018. Assessment of Canadian Pacific Cold Seeps against Criteria for Determining Ecologically and Biologically Significant Areas. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/002.

[5] DFO. 2015. Application of an ecological risk assessment framework to inform ecosystem-based management for SGaan Kinghlas-Bowie Seamount and Endeavour Hydrothermal Vents Marine Protected Areas. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/037.

[6] DFO. 2015. Development of risk-based indicators for Endeavour Hydrothermal Vents Marine Protected Area using the ecological risk assessment framework. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/053.

[7] https://www.dfo-mpo.gc.ca/csas-sccs/Schedule-Horraire/2020/11_25-26-eng.html

[8] DFO. 2017. Framework for Identification of Ecological Conservation Priorities for Marine Protected Area Network Design and its Application in the Northern Shelf Bioregion. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2017/019.(Errata : October 2018)

[9] DFO. 2019. Design Strategies for the Northern Shelf Bioregional Marine Protected Area Network. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2019/026.

[10] DFO. 2018. Reassessment of the Ecologically and Biologically Significant Areas (EBSAs) in the Pacific Northern Shelf Bioregion. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/040.

[11] DFO. 2020. Science Guidance on Approaches for Marine Bioregional Network Monitoring and Evaluation. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2020/035.

oceanographic samples, plankton trawls, aerial imagery (ShoreZone), habitat mapping, intertidal and dive surveys, trawls, seines, ROV surveys and acoustic tracking.
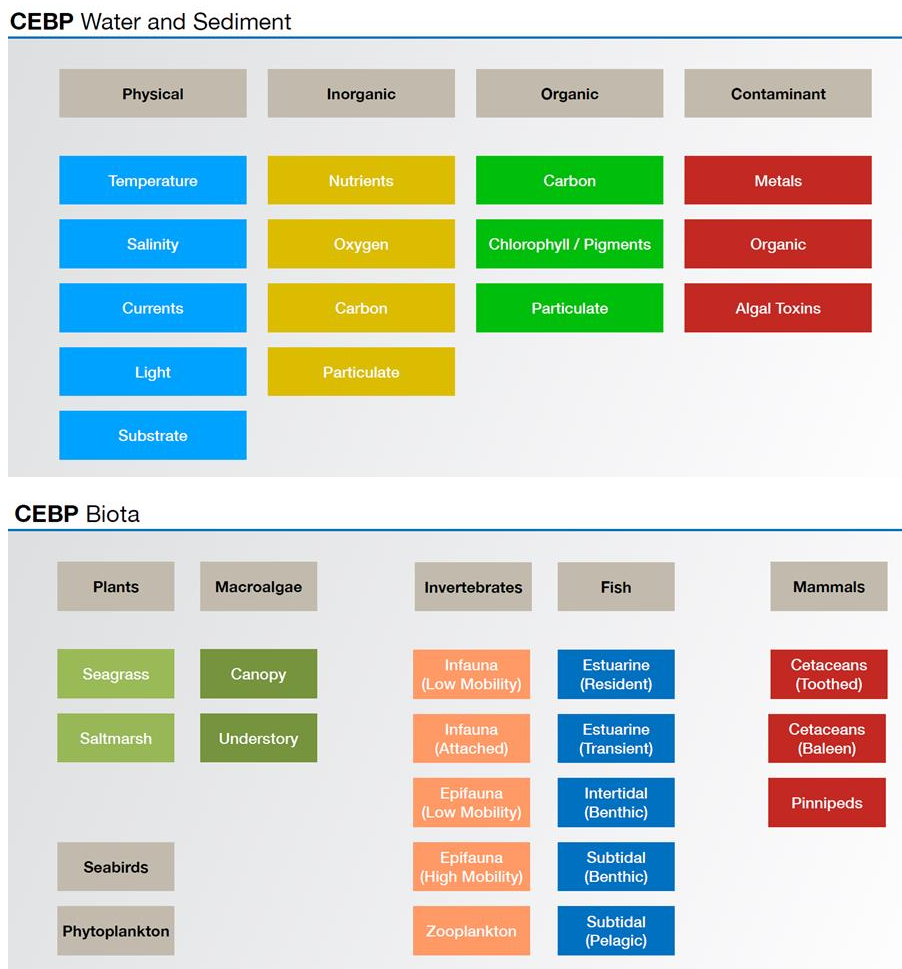
Figure 3: Abiotic and biotic data collected at the Port of Vancouver and the Port of Prince Rupert as part of the Coastal Environmental Baseline Program (CEBP)

Spatial data availability: The main portal for all CEBP data is the St. Lawrence Global Observatory (SLGO). Metadata for all CEBP data follows the ISO 19115 standard and will be housed in the SLGO and links to other repositories will be included.

Planning for Integrated Environmental Response (PIER)
Presenter: Jessica Finney (Aquatic Research Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis (MSEA))

The overarching goal of the Planning for Integrated Environmental Response (PIER) initiative in the Pacific Region is to support the development of up to eight new Canadian Coast Guard (CCG) environmental response area plans. The initiative involves collaborations with First Nations to describe

sensitive and vulnerable marine and aquatic species and sensitive areas for use in development of various response plans and other tools and products.

Geographic scope: BC Coast, divided into eight CCG Environmental Response Areas (Figure 4).
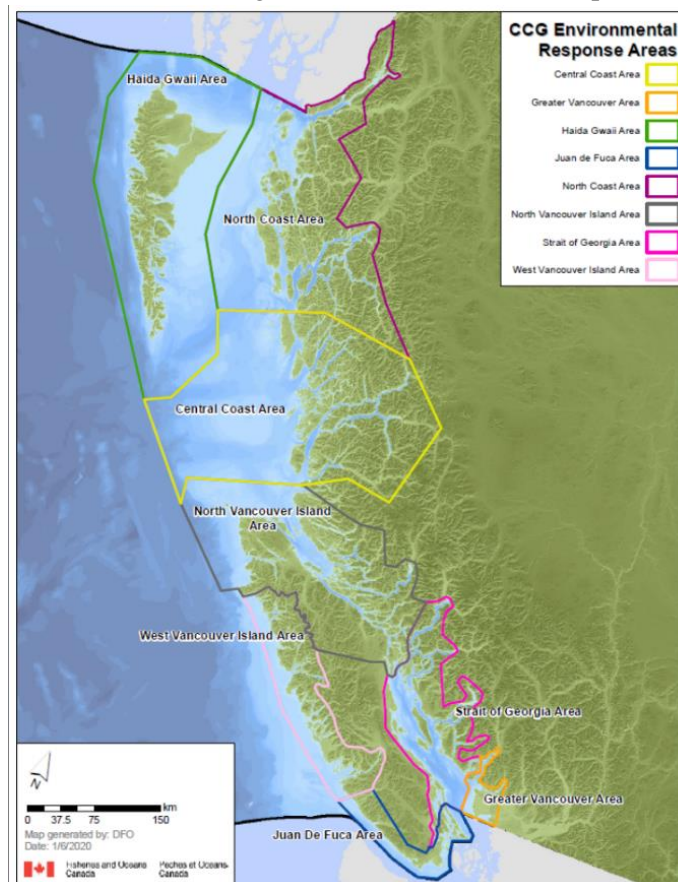
Figure 4: Canadian Coast Guard (CCG) Environmental Response Areas that define the spatial scope of the Planning for Integrated Environmental Response (PIER) initiative

Deliverables: The main PIER deliverables are products, tools and ecological data layers to support response and planning activities. An overview of the tools and spatial layers that have been developed/are currently in development was provided.

1. PIER Tools:
    a. Vulnerability to Oil
        i. CSAS Vulnerability to Oil Assessments[12,13]
        ii. Expansion of vulnerability assessments underway to differentiate between types of oil (gas and diesel, Bunker C, diluted bitumen)
        iii. Development of factsheets on sensitive species that are highly vulnerable to oil

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[12] Thornborough, K., Hannah, L., St. Germain, C., and O, M. 2017. A framework to assess vulnerability of biological components to ship-source oil spills in the marine environment. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/038. vi + 24 p.

[13] Hannah, L., St. Germain, C., Jeffery, S., Patton, S., and O, M. 2017. Application of a framework to assess vulnerability of biological components to ship-source oil spills in the marine environment in the Pacific Region. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/057. ix + 145 p.

b. Species Distribution Models for 12 species that are highly vulnerable to oil (an additional 8-10 are in progress)
        i. CSAS Species Distribution Model (SDM) framework[14] (https://gitlab.com/dfo-msea/sdm)
    c. Data Accessibility and Management:
        i. GIS Hub
        ii. Species database (in development) that will allow Environmental Incident Coordinators to easily search for and obtain data by species and area
2. PIER Spatial Layers that have been developed through collaborations with various groups and data holders to obtain and share new spatial data for use in response and planning. PIER spatial layers are available on the GIS Hub and include:
    a. Eleven spatial data layers containing information on 27 highly vulnerable species sub-groups
    b. Ongoing refinements to shallow benthic habitat maps using dive surveys
    c. Environmental data representing bathymetric, ocean circulation and remote sensing derivatives
    d. Species distribution models
    e. Shoreline imaging and mapping to support shoreline classification

Spatial data availability: Data are available and accessible on GIS Hub. Code and tools are available on the MSEA GitLab page.

Salish Sea Initiative (SSI)

Presenter: Kathryn Berry (Aquatic Science Biologist, Ocean Sciences Division, Ocean Ecology and Biogeochemistry (OEB))

The overarching goal of the Salish Sea Initiative (SSI) is to support administrative, technical and scientific capacity building for First Nations to conduct stewardship and environmental monitoring activities in the Salish Sea to better understand how human actions are affecting valued ecosystem components (VECs). Thirty-three First Nations whose territories are within the geographic scope of the SSI are eligible to participate in the SSI.

Geographic scope: The SSI geographic scope includes the marine shipping corridor from the mouth of Juan de Fuca Strait and through the southern Strait of Georgia to Vancouver and extends to the high tide line and to the limit of brackish water.

Deliverables: The main deliverable for the SSI Science Team is a toolkit of resources to support stewardship and environmental monitoring activities. The toolkit includes:
1. An interactive map illustrating SSI First Nations participants and their territories, SSI stewardship and monitoring programs, DFO generated information and data layers representing publicly available data and data collected by SSI First Nations.
2. A data catalogue containing:
    - Sociocultural components and Indigenous Knowledge
    - VECs

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[14]Nephin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. 2020. Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.

- Marine traffic (e.g. tanker vessels)
- Critical habitat (e.g. for Southern Resident Killer Whale, SRKW)
- Contaminants
- ShoreZone geology
- Commercial and recreational fishing areas
3. Common SSI Information Portal (including a mobile application) to support Indigenous knowledge data acquisition, mapping and monitoring. Specifically, the software will support data collection, organization and mapping and allow for streamlined data sharing between and amongst SSI First Nations and the Government of Canada. The platform being used is Trailmark.

Spatial data availability: A key component of the SSI is to help facilitate the collection, storage and analysis of data collected by SSI First Nations. The SSI will abide by the First Nations Principals of OCAP (Ownership, Control, Access and Possession) with user defined privacy settings that allow SSI First Nations to option to share data between other SSI participants and the Government of Canada if they choose. The data products will also help inform Cumulative Effects Management Framework (under Recommendation 1, TMX). The SSI will also provide data via OpenData and Federal Geospatial Platforms.

Terrestrial Cumulative Effects Initiative (TCEI)/Freshwater Habitat Investment
Presenter: Jeffrey Lemieux (Section Head, Ecosystem Sciences Division, Freshwater Ecosystems)

The overarching goal of the Terrestrial Cumulative Effects Initiative (TCEI) is an improved understanding of concerns related to historic and potential land-based cumulative effects on freshwater fish habitat. The TCEI is a TMX accommodation measure, which was developed to address concerns of potentially impacted Indigenous groups. Meaningful two-way dialogue with Indigenous groups is a key component of the TCEI. The TCEI goals, deliverables and resources overlap with the Fisheries Act Renewal (Bill C-68) in terms of improving the ability to predict species and habitat distribution for all salmon and freshwater species at risk in the Pacific Region.
Geographic scope: 13 watersheds, from the Lower Fraser River to Edmonton, via the North Thompson River.
Deliverables: The main deliverables of the TCEI in the Pacific Region are:
1. Spatial tools to quantify cumulative effects that can be utilized in the context of concerns identified by Indigenous groups
2. Identification of terrestrial stressors and how human activities impact fish productivity and habitat along the TMX corridor

Freshwater Habitat Science Initiative (FHIN)
Presenter: Emma Hodgson (Research Scientist, Ecosystem Sciences Division, Freshwater Ecosystems).

The overarching goal of the Freshwater Habitat Science Initiative (FHIN) is to ensure that scientific information on freshwater fish, fish habitat and effectiveness of relevant management measures is available to inform management decisions. There are eight priority research areas as a focus for the first five years of the program (2018-2023) that were identified in consultation with the Fish and Fish Habitat Protection Program. The eight include: cumulative stressors, ecosystem indicators, effectiveness science, pathways of effects, codes of practice, risk assessment tools, tool development, and science question prioritization. Within the Pacific region, the initial stages of this initiative are focused on the themes of cumulative effects and ecosystem indicators. The specific goals are to identify important juvenile salmon habitat areas, how they contribute to fish productivity, and to better understand how human activities impact salmon and their habitats. The current regional focus is on the case study region of the North Thompson watershed, a tributary to the Fraser River. Conversations with local Fish and Fish Habitat Protection Program (FFHPP) biologists, the Secwépemc Fisheries Commission and the Simpcw First Nation have all contributed to directing the FHIN research in Pacific region and to developing science priorities.

Geographic scope: Freshwater salmon habitat, with a focus on the North Thompson coho salmon population (threatened under COSEWIC)

Deliverables: The initial spatially-explicit deliverables of the FHIN in the Pacific Region are listed below, all focused on our case study region of the North Thompson watershed; though there are multiple projects with outputs that will not be as spatially focused not listed here:
1. Map of juvenile coho salmon watershed use
2. Map of wetland coho presence during low and high flow years
3. Develop indicators connecting land use to habitat and fish metrics (non-spatial) using landscape metrics, habitat sampling and fish sampling (e.g. density, physiology, life history)

Whales Initiative
Presenter: Sean MacConnachie (Section Head, Ecosystem Sciences Division, Aquatic Ecosystems and Marine Mammal Science (AEMM))

An overview of marine mammal research activities undertaken by the Aquatic Ecosystems and Marine Mammal Science section was provided:
1. Tracking Chinook salmon through killer whale critical habitat (Basin and Coastal Scale Interactions Program)
     - Objective: Track Chinook salmon movement patterns in SRKW habitat
     - Activities: Acoustic tagging used to detect patterns and estimate movement rates, habitat use and survival of Chinook salmon has shown evidence of differential distribution of California, Columbia and Fraser River stocks within the SRKW critical habitat. Individuals within stocks also show differing speed, milling behavior and routes as they migrate through the SRKW critical habitat.
     - Geographic Scope: SRKW critical habitat (red polygon in Figure 5)
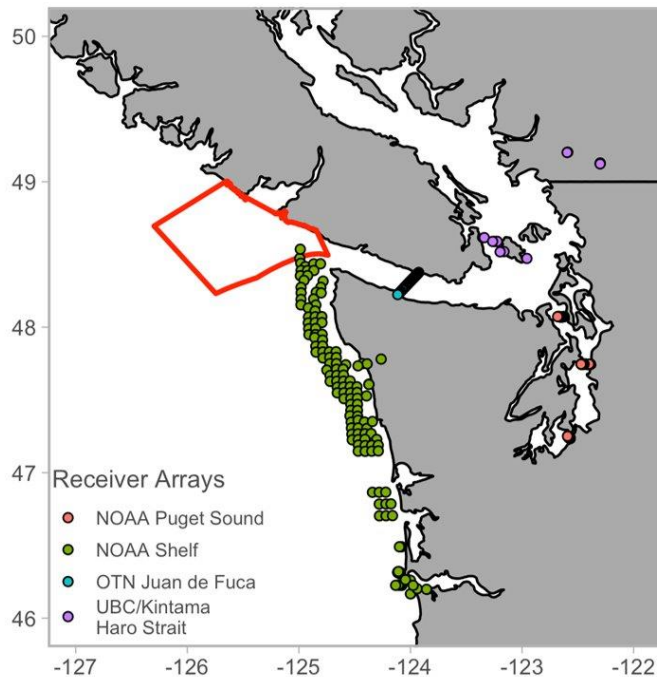
Figure 5: Southern Resident Killer Whale (SRKW) critical habitat on the west coast of Vancouver Island (red polygon) and the network of receiver arrays used to estimate SRKW movement rates, habitat use and survival

- - Spatial data products: Chinook salmon distribution, migration and behaviour patterns in SRKW critical habitat on the west coast of Vancouver Island (WCVI)
  - Key contacts: Cameron Freshwater and Jackie King
2. Marine Environmental Quality Behavioral and Acoustic Baseline
   - Objective: Quantify habitat use and activity state of southern and northern resident killer whales (SRKW, NRKW)
   - Activities: Surveys in the southern and northern Salish Sea using a combination of techniques, including boat surveys and DTAGs (digital acoustic recording tags).
   - Geographic Scope: Salish Sea and SRKW critical habitat
   - Spatial data products: Maps showing habitat use and movement of SRKW and NRKW. Focal follow data.
   - Key contact: Sheila Thornton
3. Ocean Protection Plan-Marine Environmental Quality (MEQ) Acoustics (Noise Baseline)
   - Objective: Reduce the impact of day-to-day vessel traffic on the acoustic environment of marine mammals
   - Activities: Supported the development of 2019 SRKW measures to address acoustic and physical disturbance threats and prey availability. Produced a monitoring and assessment framework to assess these measures
   - Geographic Scope: SRKW critical habitat
   - Spatial data products: Whale presence, whale behavior, vessel noise and ambient acoustics metrics, vessel analysis (AIS, small non-AIS, recreational fishing etc.).
   - Key contact: Sheila Thornton

4. Cetaceans Research Program (CRP)
    - Objective: Long term research program focused primarily on at-risk cetacean species and sea otters.
    - Activities: Visual surveys and acoustic detections
    - Geographic Scope: BC Coast
    - Spatial data products: Ship survey data (visual surveys)
    - Key contact: Thomas Doniol-Valcroze
5. Pacific Region International Survey of Marine Megafauna (PRISMM) - 2018
    - Objective: Systematic surveys of marine megafauna were undertaken on the BC Coast
    - Activities: 17,000 km of systematic transects in both inshore and offshore regions were used to produce estimates of cetacean density (e.g. Figure 6)
    - Geographic Scope: BC Coast
    - Spatial data products: Cetacean density estimates for BC coast (e.g. Figure 6).
    - Key contact: Thomas Doniol-Valcroze
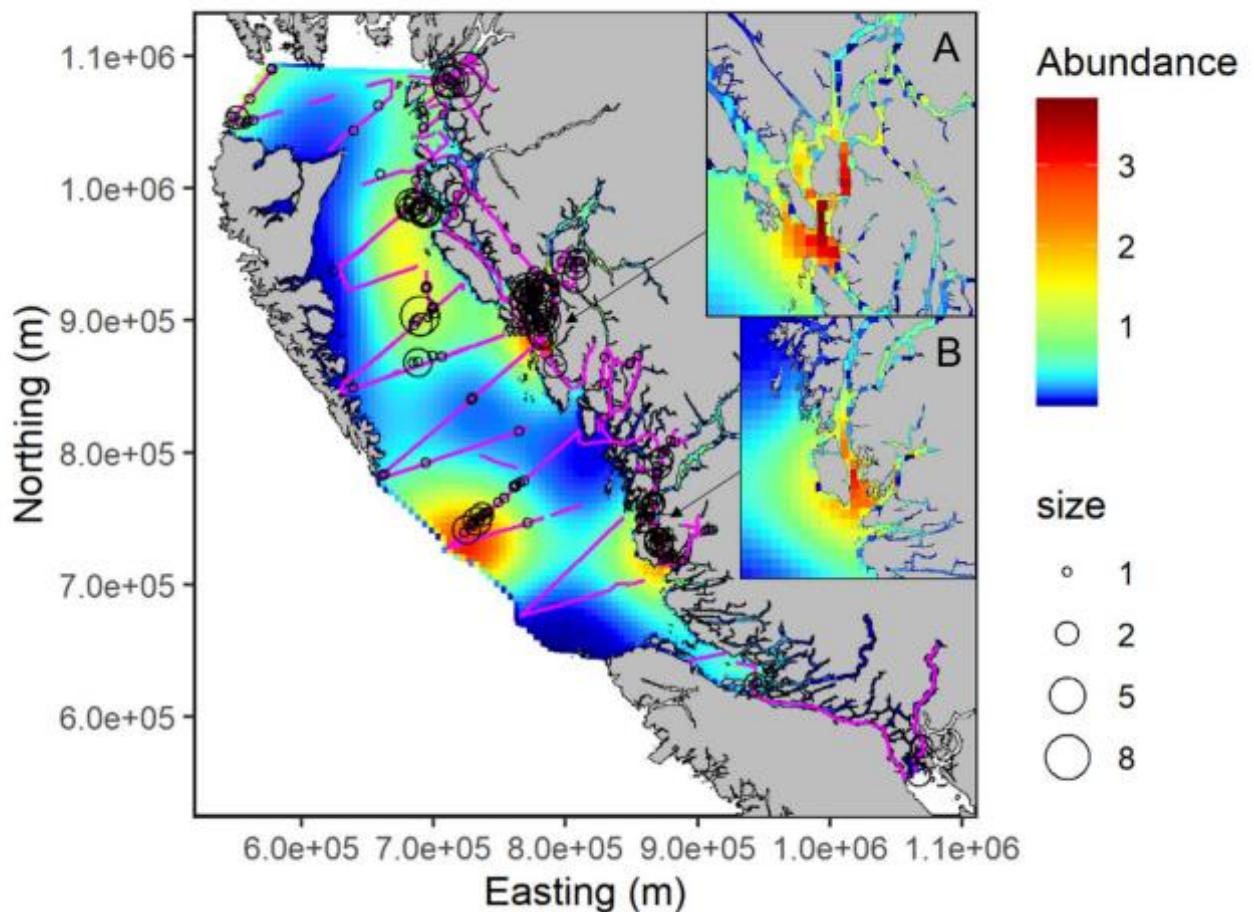
Figure 6: Estimated humpback whale density derived from PRISMM survey data. Refer to CSAS 2021/049 for details.

6. Pinniped Research Program
   - Objectives: Research program primarily focused on harbour seals, California and Steller sea lions.
   - Activities: Abundance estimates via aerial surveys and counts and diet composition studies through scat analysis
   - Geographic Scope: BC Coast
   - Spatial data products: Species count data
   - Key contact: Strahan Tucker
7. Programs not discussed in depth but with potential spatial data:
   - Commercial and recreational CPUE (Key contact: Wilf Luedke)
   - Contaminants (Key contact: Tanya Brown)
   - Acoustic modelling (Key contact: Svein Vagle)
   - Whale detection and collision avoidance (Key contact: Harald Yurk)

Summary of MS Teams Chat and Workshop Feedback

Summary of MS Teams Chat Content

Generally, conversations in the MS Teams Chat were brief and focused on specific details of presentations, such as project management and tracking applications (refer to Participant Questions/Discussion for National and Regional Context presentation), metadata standards and whether spatial data storage/sharing platforms mentioned during initiative-specific presentations are linked to databases/platforms used by other initiatives (e.g. MSDI or FGP). The following metadata standards were confirmed in the MS Teams chat:

- MSDI: ISO 19115:2003
- FGP: Harmonized North American Profile of ISO 19115
- St Lawrence Global Observatory (SLGO): ISO 19115

The metadata standards for the portals used by the MSP (MSDI/FGP) and CEBP (SLGO) initiatives are compatible, meaning that CEBP baseline data can be linked to the atlases and interactive maps that are being produced for the MSP initiative.

Towards the end of the workshop, the MS Teams Chat content focused on connections and synergies between participants working on complementary initiatives. There was a comment about work that is currently underway that involves collaborating with a First Nation to develop a method to use Traditional Ecological Knowledge to inform species distribution modelling and that the information may be useful and applicable to staff working on similar work in other initiatives. Information was shared about the Regional Spatial Data Coordination Group (ReSDaC) that has been meeting regularly for the past few months and is co-chaired by Steve Schut (Science Branch) and Corinna Favaro (Ecosystem Management Branch). There was also comment in the MS Teams Chat about the several programs underway in the Regional Ecosystem Effects on Fish and Fisheries (REEFF) section that carry out spatial work on a variety of species (e.g. salmon, herring, pelagics and forage fish).

Feedback from Post-Workshop Survey

Results from the workshop survey following the introductory session were used to plan for and improve the taxa-specific sessions that followed. Survey respondents' (n=32) answers are summarized below:

Please indicate how helpful you found the workshop in terms of learning about the initiatives and identifying possible linkages

Answered: 29   Skipped: 3
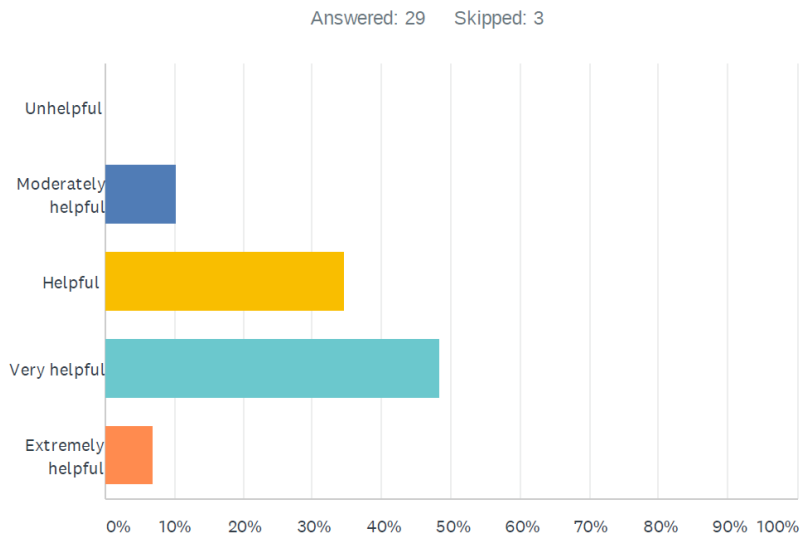
Please describe what was best about this workshop

Several respondents indicated that they appreciated learning about the broader goals and timelines of the initiatives (from both regional and national perspectives) and benefited from learning about who is leading/working on the initiatives. Several respondents indicated they would have liked more details of the spatial data products mentioned during the initiative-specific presentations.

Please describe what improvements could be made for future workshops

-More time for a longer facilitated discussion at the end of the presentations to synthesize potential synergies and shared challenges.

-More details on the types of spatial data products that exist/are currently being developed

-Expand the breadth of the audience to include non-Science sectors.

Of the initiatives presented in this Introductory Session, please indicate those that you feel could benefit/connect with the work you are doing (Yes, my work connects)
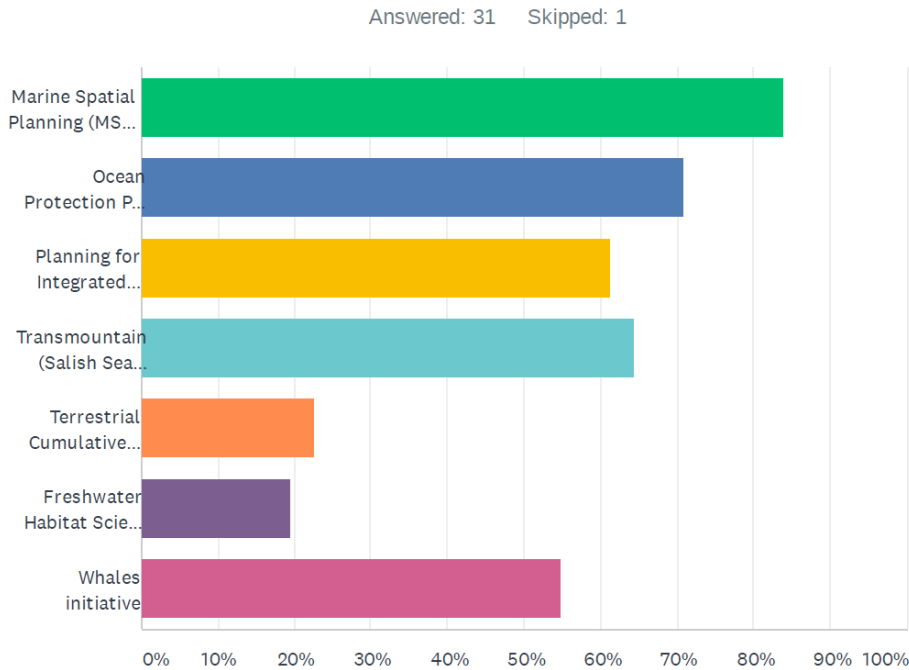
Please indicate which of the following data-specific workshops you would be interested in attending

	YES	NO	MAYBE	TOTAL
Marine mammal data	52.17% 12	17.39% 4	30.43% 7	23
Groundfish data	55.56% 10	5.56% 1	38.89% 7	18
Forage fish and salmon data	63.64% 14	9.09% 2	27.27% 6	22
Invertebrate data	68.18% 15	9.09% 2	22.73% 5	22
Habitats and physical features	71.43% 20	3.57% 1	25.00% 7	28
Oceanographic data	62.50% 15	12.50% 3	25.00% 6	24

Please use the space provided to offer any other comments or questions

General positive feedback. The need for a central inventory of data products and spatial data resources for new hires was highlighted by several respondents.

Introductory Session Agenda

Table 2: Agenda for the Introductory Session of the DFO Science Workshop: Spatial Data Contributions to Federal Initiatives in the Pacific Region

Time	Agenda Item	Lead
10:00 am	**Welcome and Introductions** • Opening Remarks • Workshop Overview • Objectives & Agenda	Stratos, Carrie Robb
10:10 am	**Overview of initiatives** • National and Pacific context on the origins, objectives, and key deliverables of the initiatives	Liisa Peramaki, Eddy Kennedy
10:40 am	**Questions**	All participants, facilitated by Stratos
10:55 am	**Break** – *5 minutes*	
11:00 am	**Speed talks on initiatives** • Marine Spatial Planning (MSP) & Marine Conservation Targets (MCT) • Ocean Protection Plan (Coastal Environmental Baseline (CEBP) & Planning for Integrated Environmental Response (PIER))	Miriam O (MSP, MCT), Paul Covert (CEBP), Jessica Finney (PIER)
11:30 am	**Break** – *5 minutes*	
11:35 am	**Speed talks on initiatives (continued)** • Salish Sea Initiative (SSI) & Terrestrial Cumulative Effects Initiative (TCEI) • Freshwater Habitat Science Initiative (FHIN) • Whales Initiative	Kathryn Berry (SSI), Jeffrey Lemieux (TCEI), Emma Hodgson (FHIN), Sean MacConnachie (Whales)
12:35 pm	**Break** – *5 minutes*	
12:40 pm	**Questions and discussion** • Synergies • Commonalities	All participants, facilitated by Stratos
1:00 pm	**Adjourn**	

Oceanography Data Session

Date: September 18th, 2020 (9 – 11am)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Cathryn Murray
Rapporteur: Beatrice Proudfoot

Objectives

- Build relationships among science staff and discuss how data sharing requests can be formulated to be streamlined and multi-user friendly
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary

This section summarizes the presentations and discussions that occurred during the Oceanography Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Cathryn Murray. Di Wan, Angelica Peña and Lu Guan presented overviews of the oceanographic data holdings and previous/ongoing work. A group discussion followed where participants discussed challenges, potential synergies and priorities for future work. Participants reviewed a draft MSP spreadsheet listing existing oceanographic datasets and discussed the importance of communication between data producers and data users. Key messages from this data session were:

- The importance of communication and collaboration between data generator and data user, especially when adapting oceanographic datasets for their use in species distribution modelling.
- The challenges of communicating the limitations of the data while balancing the need for OpenData and quick turnarounds on initiatives – including having metadata that is appropriate and useful for scientists that clearly outlines limitations of the data
- The need for a central inventory or master list of oceanographic data that is regularly updated and includes contact information for data producers
- Datasets that are needed (e.g., high resolution nearshore oceanographic data layers to support species distribution modelling) should be identified and prioritized for future work

Data Overview Presentations

Presentation Title: Oceanographic Data and Numerical models
Presenter: Di Wan (Physical Oceanographer, Ocean Science Division, Ocean Modelling and Prediction)

An overview of the geographic scope and temporal coverage of OSD oceanographic surveys and data holdings was provided. Oceanographic data are collected during the ~100 research cruises that occur each year. Approximately 1300 CTD profiles are collected each year. Converting CTD sample points to produce raster layers is not a trivial task and is not done by simple interpolations. Additional data sources (NOAA, Argo IOS data) are used in addition to the CTD data to produce continuous raster layers and climatologies. Little oceanographic data has been collected in MPAs in the past 10 years. CTD, ADCP, current velocity, weather station and surface drifter data can be accessed through

www.waterproperties.ca/data. Lighthouse temperature data and zooplankton data can be accessed through the OpenData Portal. Phytoplankton data is currently being prepared for publication on OpenData.

<u>Numerical Models</u>

- NEMO[15] Model for northeast Pacific Ocean
  - o Project Lead: Amber Holdsworth
  - o 1.5 – 2.25 km resolution, 50 vertical levels
  - o Forecast to 2065
  - o Temperature, salinity, circulation and biogeochemistry
- ROMS[16]
  - o ~3km resolution, 31 vertical levels
  - o Hindcast 1995-2008
  - o Temperature, salinity, circulation
- ROMS-BC[17] – discussed in detail in next presentation
  - o Project Lead: Angelca Peña
  - o ~3km resolution, 42 vertical levels
  - o Hindcast 1979-2010 & 1981-2018
  - o Temperature, salinity, circulation and biogeochemistry

Presentation Title: ROMS British Columbia Coastal Model (ROMS-BC)
Presenter: Angelica Peña (Research Scientist, Ocean Science Division, Ocean Modelling and Predictions)

ROMS-BC is a coupled circulation/biogeochemical model of the BC coast that simulates main physical and biogeochemical conditions of the region. This implementation of the Regional Ocean Modelling System (ROMS) has been used to examine seasonal and inter-annual variability of ocean conditions and primary production. It has also been used to forecast the potential responses to climate change. ROMS-BC has three main simulations:

- o Hindcast-1: 1979 – 2010 (wind and daily atmospheric forcing from North America Regional Reanalysis (NARR))
- o Climate change projections for the 2041- 2070 (based on RCP4.5 and RCP8.5 emissions scenarios)
- o Hindcast-2: 1981-2018 (wind and daily atmospheric forcing from ERA5)

Model outputs include: temperature, salinity, currents, nutrients (nitrate, ammonia and silicate), phytoplankton biomass and primary production, pH and omega saturation state and oxygen. The model grid resolution and forcing fields (in particular winds) are too coarse to reproduce conditions in narrow inlets, near shore and the Strait of Georgia so a mask is applied over these areas.

<u>Questions/discussion:</u>

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[15] Holdsworth, A. M., Zhai, L., Lu, Y., & Christian, J. R. (2021). Future Changes in Oceanography and Biogeochemistry Along the Canadian Pacific Continental Margin. *Frontiers in Marine Science*, *8*, 190.

[16] Masson, D., & Fine, I. (2012). Modeling seasonal to interannual ocean variability of coastal British Columbia. *Journal of Geophysical Research: Oceans*, *117*(C10).

[17] Peña, M. A., Fine, I., & Callendar, W. (2019). Interannual variability in primary production and shelf-offshore transport of nutrients along the northeast Pacific Ocean margin. *Deep Sea Research Part II: Topical Studies in Oceanography*, *169*, 104637.

Question about what model (ROMS or NEMO) is best for building species distribution models that predict into the future, and if it is advisable to use a consistent model in model building and model forecasting stages.

Answer: NEMO and ROMS each perform better in certain areas/situations, so it is best to use as many model outputs (i.e. use ROMS and NEMO) as you can and compare results and uncertainties.

Question about whether model outputs are published and available.

Answer from Angelica Peña: Not currently. The ROMS-BC model needs to be peer reviewed before putting it on OpenData and data users need to be aware of model uncertainties and limitations.

Answer: NEMO publication was just submitted, and in the process of putting monthly averages on OpenData and OceanNavigator (a tool developed under the OPP).

The questions about data access led to a discussion about the importance of communicating model uncertainty and limitations to end users. It was agreed that this should be done in the form of a peer-reviewed publication, detailed metadata and when possible, direct correspondence between data producers/custodians and data users. Communication between data producers/custodians and data users can help ensure that the data is used appropriately (e.g. mask areas with high uncertainty). Data producers expressed concerns about downscaling oceanographic data to finer resolutions for use in species distribution modelling, particularly in areas where the models are less certain and in areas with high topographic complexity. This poses a challenge for participants working on species distribution models because they require fine resolution data (particularly for nearshore areas). The discussion reinforced the need for communication among data producers and users.

Presentation Title: MSP Oceanographic Spatial Data Products
Presenter: Lu Guan (Aquatic Technician, Ocean Sciences Division, Ocean Ecology and Biogeochemistry)

An overview of oceanographic spatial data products that have been/are currently being developed for MSP was provided.
- Seasonal climatologies of the Canadian Pacific EEZ developed from Mike Foreman's seasonal climatologies for the northeast Pacific, include the following variables:
    - Temperature
    - Salinity
    - Sigma-t

    The spatial resolution of these data is ~0.333 km, and there are 50 depth levels. Fifty rasters (.tif) are available by season and will be available for download from FGP/OpenData.
- Seasonal sea level height climatology (in progress)
- Seasonal oxygen climatology (in progress – data gathering)
- Update observational climatology from 1980-2010 to 1990-2020 (in progress – data gathering)

Proposed oceanographic spatial data products for MSP:
- Water current velocities from ROMS-BC model
    - Seasonally averaged from 1981-2018
    - 3km resolution
- Zooplankton
    - Seasonal averages in biomass of copepod-by-size-groups (1990-2019) for outer BC coast
- Satellite derived SST and chlorophyll-a

- o Monthly SST climatology (4km & 1km in resolution) of Canadian Pacific Exclusive Economic Zone (1981-2010)
- o Monthly SST climatology (4km & 1km in resolution) of Canadian Pacific Exclusive Economic Zone (1990-2020)
- o Monthly chlorophyll-a climatology (4km & 1km in resolution) of Canadian Pacific Exclusive Economic Zone (2003-2020)

General Discussion and MS Teams Chat

A brief discussion followed about whether there are any other data products not discussed so far that participants should be aware of. There was a discussion about a predicted substrate layer that was produced at 20m and 100m resolution using a Random Forest modelling approach[18]. The substrate layer is useful while fine scale and high resolution multibeam bathymetry and backscatter data continues to be collected. The model domain covers the full BC Coast and is available on the GIS Hub.

There was a question about what kinds of data products (oceanographic and other) are most useful for managers in terms of planning. From an MSP perspective, long term trend analyses are important. The data product requirements also depend on the goals and objectives of each initiative (e.g. the PIER initiative may require more real-time data products while MSP requires oceanographic data at fine enough scales to support nearshore species distribution modelling). It's also important to note that the oceanographic data products are used for a variety of purposes, and having the tools (such as a Shiny App) that allows users to extract the data necessary would be a useful endeavor.

The theme of data access was also revisited by participants. Participants who are working on SSI and CEBP discussed the desire of First Nations colleagues to have easier access to datasets through non-government channels/databases.

Participants then reviewed the draft MSP data inventory and discussed gaps, concerns and potential synergies. The need for a central inventory of all regional science spatial data was discussed. The MSP Science team have been working to develop a standard list of region-specific data for MSP for display in the MSP atlas. This is a large task that may be informed by the taxa-specific sessions that are part of this workshop series. Data with limited spatial coverage may not be included in the MSP list/MSP Atlas. Work is underway to include both Science and non-Science data (e.g., economic data) in the inventory. Several participants expressed a desire for an internally accessible master inventory that helps monitor progress and make a prioritization plan.

Participants then revisited the conversation about the importance of communication between data producers/custodians and data users, particularly when adapting oceanographic model outputs to fine resolutions for nearshore species distribution modelling. Robust simple interpolation methods may not be appropriate for the downscaling that is required, so identifying and recording missing datasets, such as fine resolution oceanographic data is important and can help guide future research directions for data producers. Flagging datasets that may not be appropriate/useful is important for staff working on initiatives with short timelines for the production of deliverables (e.g. SDMs).

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[18] Gregr, E. J., Haggarty, D. R., Davies, S. C., Fields, C., & Lessard, J. (2021). Comprehensive marine substrate classification applied to Canada's Pacific shelf. *PloS one*, *16*(10), e0259156.

Table 3: Oceanography Data Session Agenda

Time	Agenda Item	Lead
9:00 am	**Welcome and Introductions** • Workshop overview • Roundtable introductions	Cathryn Murray
9:15 am	**Data overview and review of previous work** • Overview of OSD data holdings – Di Wan • ROMS model – Angelica Pĕna • New MSP spatial data products – Lu Guan • Other data sources and products	Data experts
9:45 am	**Discussion** • Review of spreadsheet of existing data • Other data product efforts currently underway	All participants
10:45 am	**Future Directions** • Priorities for new datasets or products • Possibilities for collaboration, future work	Roundtable
11:00 am	**Adjourn**	

Groundfish and Rockfish Data Session

Date: September 22nd, 2020 (1-3 pm)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Barb Sweazey
Rapporteur: Beatrice Proudfoot

Objectives
- Build relationships among science staff and discuss how data sharing requests can be formulated to be streamlined and multi-user friendly
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary
This section summarizes the presentations and discussions that occurred during the Groundfish/Rockfish Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Emily Rubidge and Barb Sweazey. Dana Haggarty, Sean Anderson, Philina English, Patrick Thompson, Robyn Forrest and Lisa Lacko provided overview talks on the surveys, analyses and current/ongoing projects that they are involved in. A group discussion followed where participants discussed gaps, data sharing/availability and potential synergies. Key messages from this data session were:

- The need to address the gap in groundfish spatial data and spatial data products for the Strait of Georgia
- The need for a central inventory of groundfish spatial data and spatial data products
- The value of and need for working collaboratively across sectors to meet complementary objectives

Data Overview Presentations
Presentation Title: DFO Groundfish Surveys
Presenter: Dana Haggarty (Inshore Rockfish and Lingcod Program Head, Stock Assessment and Research Division, Groundfish Section)

Groundfish Survey Program:
- Random depth-stratified surveys
  - Synoptic bottom trawl
    - Hecate Strait/West Coast Vancouver Island (WCVI) alternates with Queen Charlotte Sound/West Coast Haida Gwaii (WCHG) each year
  - Hard bottom longline hook
    - Outside North/Inside South alternates with Outside South/Inside North each year
  - Sablefish

The groundfish survey program also includes Pacific hake hydroacoustic surveys, small mesh multi-species bottom trawl surveys and surveys in partnership with the International Pacific Halibut Commission. CTD data is collected at or near the survey sites. All catch is identified, sorted by species and weighed and biological samples are collected based on sampling protocols. The survey data is used for groundfish stock assessment, protected area planning, species distribution modelling and ecosystem models. The Synoptic Trawl and the Hard Bottom Longline data are accessible through OpenData.

The data is also used in [the BC Groundfish Synopsis Reports](), which are reproducible reports based on groundfish data holdings. Less frequent/discontinued surveys that may have data relevant to workshop participants include Strait of Georgia (SoG) synoptic trawl surveys, spiny dogfish longline surveys, SoG juvenile lingcod trawl surveys, hook and line surveys and various visual surveys using towed cameras and remotely operated vehicles (ROVs). ROV surveys occurred in rockfish conservation areas (RCAs) in 2009-2011 & 2018.

Presentation Title: Ongoing BC Groundfish Spatial Data Projects with sdmTMB
Presenter: Sean Anderson (Stock Assessment Biologist, Stock Assessment and Research Division, Groundfish Section)

This presentation provided an overview of [sdmTMB]() and its applications for analyzing groundfish spatial data. sdmTMB is an R package that implements spatial or spatiotemporal predictive-process GLMMs (Generalized Linear Mixed Effects Models). Among other functionalities, sdmTMB can use a Tweedie distribution to represent data with zeros and continuous positive values (e.g., fish biomass density), allow for time-varying covariates (e.g., letting fish move deeper over time), estimate threshold/breakpoint effects (e.g. a threshold of warmer water temperature above which fish abundance is expected to change), and can estimate spatially varying trends (e.g., fine scale spatial trends in biomass with fishing or climate change). A number of projects are ongoing with the package including estimating model-based indices of abundance, "stitching" multiple surveys together, accounting for changes to survey protocols, evaluating spatiotemporal changes to fish condition, estimating metabolic breakpoints (thresholds of required oxygen for a given water temperature), and evaluating how groundfish distributions are changing in response to local climate velocities (discussed in detail in next presentation).

Questions/discussion

Question about whether temperature and oxygen predictions have been compared with ROMS.
Answer: Yes, the predictions match quite well, including in extrapolated regions.
Answer: ROMS-BC model is validated using groundfish data.

Presentation Title: Are Pacific Groundfish Shifting their Distribution in Response to Local Climate Velocities?
Presenter: Philina English (Research Scientist, Stock Assessment and Research Division, Groundfish Section)

The sdmTMB framework was used to test the association between changes in groundfish biomass density and local climate velocities[19]. The analysis uses climate variables (dissolved oxygen and bottom temperature) derived from CTD data collected during research trawl surveys. Spatial outputs are trimmed to species distributions. These variables are converted to climate velocities—the speed and direction an organism would have to move to maintain consistent conditions. Across species, warming was associated with declines in biomass, while increases in dissolved oxygen were positively related to biomass; however, the strength of effects differed depending on local conditions. In the warmest locations, warming velocities were associated with negative biotic velocities (estimated distance to nearest location with same biomass when local biomass is declining) for one quarter of species-maturity combinations. In the coolest locations, nearly all species exhibited stable or increasing biotic velocities.

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[19] English, P.A., Ward, E.J., Rooper, C.N., Forrest, R.E., Rogers, L.A., Hunter, K.L., Edwards, A.M., Connors, B.M. and Anderson, S.C., 2021. Contrasting climate velocity impacts in warm and cool locations show that effects of marine warming are worse in already warmer temperate waters. *Fish and Fisheries*.

Presentation Title: Multispecies Groundfish Model
Presenter: Patrick Thompson (Research Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

Synoptic trawl data (2003-2018) is used to model multiple groundfish species using a hierarchical modelling of species communities (HMSC) approach. The HMSC approach leverages information about the co-occurrence of species to make predictions, and produces models for individual species, species richness (biodiversity hotspots) regions of distinct compositions (bioregions) and temporal changes in species richness through time. The 57 most common groundfish species were modelled for the BC coast (excluding the Strait of Georgia) at a 3km resolution using the following environmental variables: depth, broad bathymetric position index (BPI), substrate muddiness, substrate rockiness, temperature, productivity, tidal speed, current speed, dissolved oxygen and commercial fishing effort. A publication is currently in preparation.

Presentation Title: Evidence for rapid avoidance of rockfish habitat under reduced quota and comprehensive at-sea monitoring in the British Columbia Pacific halibut fishery
Presenter: Robyn Forrest (Research Scientist, Stock Assessment and Research Division, Quantitative Assessments Methods)

An overview of a study[20] to determine whether the Pacific halibut fleet changed where it fishes since large reductions in yelloweye rockfish quota were implemented in 2016 was provided. Pacific halibut and yelloweye rockfish have overlapping habitat (particularly in the summer), and the study aimed to determine whether the fleet could maintain their halibut catch by avoiding yelloweye hotspots. The approach involved using a cluster method developed by Trevor Branch at the University of Washington to identify and calculate attributes of the fishing grounds (e.g. species composition, depth, effort) before and after the change in yelloweye quota. A utilization ratio was used to identify abandoned and newly utilized fishing grounds. Utilization ratio values vary between -1 (indicating a fishing ground was abandoned, and 1 (indicating a newly utilized fishing ground since the quota change). Utilization ratios can be mapped to visualize areas that were used more or less after the quota change. Results indicate that the fleet was able to rapidly respond to the reduction in yelloweye quota and control species composition of catch by moving to other areas.

Questions/discussion:

Question about whether the delineated fishing grounds would be a useful data input for marine spatial plans to identify areas that are revisited by the fleet.
Answer: Because the fishing grounds are not static and can change depending on quotas, it would depend on how the data would be used and the timeframe used to delineate the fishing grounds. The abandoned and negatively utilized fishing grounds have been entered into SeaSketch and could be useful for planning.

Question about whether the defined fishing grounds have associated effort data.
Answer: They are defined by location of sets and number of sets. Effort metrics such as hours fished or number of hooks can be associated with fishing grounds.

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[20] Forrest, R.E., Stewart, I.J., Monnahan, C.C., Bannar-Martin, K.H. and Lacko, L.C., 2020. Evidence for rapid avoidance of rockfish habitat under reduced quota and comprehensive at-sea monitoring in the British Columbia Pacific halibut fishery. *Canadian Journal of Fisheries and Aquatic Sciences*, *77*(8), pp.1409-1420.

Presentation Title: BC Sablefish Survey
Presenter: Lisa Lacko (Groundfish Biologist, Stock Assessment and Research Division, Quantitative Assessment Methods)

The BC Sablefish survey involves DFO Science and the Canadian Sablefish Association. Random depth-stratified surveys occur annually, and trapping methods are consistent with the fishery. The surveys occur coast wide in 5 spatial strata and 3 depth strata (ranging from 100 to 1400 m). Four main inlets are also surveyed each year. The surveys occur in October and November. The data are used to generate stock abundance indices, which are coupled with tagging and biological data to form key inputs into the operating models used in Management Strategy Evaluation to guide the BC sablefish fishery. The latest technical report indicates a notable increase in catch per unit effort (CPUE) in recent years, with the average weight of sablefish in 2018 and 2019 reaching record mean lows due to large numbers of small fish. The surveys also collect information on non-target species (age, sex, DNA, weight) and oceanographic data (temperature, depth, salinity).

Questions/discussion
Question about whether information about the spatial distribution of juveniles is investigated.
Answer: The spatial distribution of juveniles is not currently being analyzed, but the data are available to do so.

Presentation Title: Spatial Data Overview – Groundfish & Rockfish
Presenter: Katie Gale (Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An inventory of spatial data products that support MSP is currently underway. Four broad categories of spatial data were highlighted as useful for MSP and MPA network planning in the Northern Shelf Bioregion:
- Distribution Data
  - Observations/catch records measuring abundance, presence, presence-absence
  - Can be point data, aggregated into grids or spatially interpolated
  - Do not involve predictions and are limited to the spatial extent of input data
  - Examples of groundfish distribution data used in current and previous planning exercises:
    - Kernel densities of normalized CPUE for 37 groundfish species
    - Pacific hake biomass index
    - Gridded normalized CPUE for 10 groundfish species
- Species distribution/habitat suitability models
  - Single or multi-species observations are correlated with environmental variables to predict presence our abundance outside the sampled area
  - Examples of groundfish distribution data used in current and previous planning exercises includes:
    - SDMs for quillback and yelloweye rockfish using SDM Framework
    - Community/joint SDMs for 57 groundfish species (Thompson et al. *in prep*).
- Significant Areas
  - Ecologically and Biologically Significant Areas (EBSAs)[21]
  - Areas important for spawning/breeding, rearing/nursery, feeding, migrating, aggregations
  - Hotspots of diversity/productivity
  - Areas important for vulnerable or threatened species (e.g. Critical Habitat)

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[21] Clarke, C.L., and Jamieson, G.S. 2006. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase II – final report. Canadian Technical Report of Fisheries and Aquatic Sciences 2686.

- o Sensitive Benthic Areas
- o Areas with rare features or unique genetic populations
- o Examples of groundfish distribution data used in current and previous planning exercises:
  - ▪ Important Areas for groundfish species[22]
  - ▪ Fish richness and biodiversity hotspots[23]
- Habitat Proxies

General Discussion and MS Teams Chat
Four questions guided the group discussion about gaps, potential synergies and priorities for future work.

1. *Can you think of any spatial data products that have not been identified that would help inform ongoing efforts?*

The spatial data products produced by the groundfish group are well aligned with the needs of the MSP, however one of the biggest gaps highlighted in this session is the lack of spatial data products for the Strait of Georgia (SoG). The following surveys were highlighted as potential data sources that could help fill this gap: longline surveys (occur every second year in the SoG), two bottom trawl surveys that occurred in the SoG, acoustic surveys led by Stephane Gauthier, historical surveys (although their utility may be questionable), juvenile lingcod surveys (1991 & 2003-2006) and hook and line surveys (1984-85 & 2003-2006). Another gap that was highlighted is the limited seasonal component of the groundfish data. The following sources may help address this gap: spiny dogfish surveys occur in the fall (~triennial, 1989, 2005, 2008, 2011, 2014, 2019) and ROVs and towed video work that has taken place in winter months. However, the ROV and towed video survey dataset may not be large enough to investigate temporal patterns and trends.

It was noted that there is interest in rockfish data for the Salish Sea Initiative (e.g., halibut in the Swiftsure Bank region). DFO's groundfish surveys do not cover the Swiftsure Bank region and the best source for data in that area is the IPHC (https://www.iphc.int/data/time-series-datasets).

2. *Are there other spatial data products that would be useful for other initiatives that participants are involved in?*

A discussion followed about the need for data access (both internally and externally). It was noted that the groundfish data unit is working towards the Government mandate to make survey data available through OpenData platforms. Trawl surveys are available through OpenData, and new surveys will be added once they are completed and uploaded to GFbio. Longline surveys will soon be available through OpenData. It was also noted that external/internal clients can request data through the Regional Data Unit (specifically the Pacific Catch Statistics page). The benefit of requesting data through the Regional Data Unit is that requests for data for multiple species can be coordinated and streamlined. The longline surveys are also available on OpenMaps and will be available externally once a metadata formatting issue is addressed (in progress).

- Link to groundfish synoptic bottom trawl surveys: https://open.canada.ca/data/en/dataset/a278d1af-d567-4964-a109-ae1e84cbd24a
- Link to groundfish hard bottom longline surveys: https://open.canada.ca/data/en/dataset/945e0f13-119b-451b-9038-50c6eb641aef

A discussion followed about whether spatial data products (e.g. maps, SDM outputs) will be made publicly available. This is particularly relevant for MSP, which requires spatial data products that can be

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[22] Clarke, C.L., and Jamieson, G.S. 2006a. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase I - Identification of Important Areas. Can. Tech. Rep. Fish. Aquat. Sci. 2678

[23] Rubidge, E., Nephin, J., Gale, K.S.P., and Curtis, J. 2018. Reassessment of the Ecologically and Biologically Significant Areas (EBSAs) in the Pacific Northern Shelf Bioregion. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/053: xii + 97 p.

interpreted by planners and the public (e.g. maps and results of analyses as opposed to the data itself). it was also noted that, from a SSI perspective, publicly available data is required for all analyses as the overall objective is to support First Nations in their territorial marine stewardship and future cumulative effects management.

Participants were open to ideas about the most effective ways to share and house the spatial data products discussed during this session, however many analyses are still in progress and outputs are not currently shareable. The data and code used to produce the some of the model outputs and maps is publicly available. It was also noted that it would be useful if the GFSynopsis outputs could be published as an open map service. Data held by the International Pacific Halibut Commission (IPHC) has privacy considerations.

3. *Are there particular spatial data products (either existing data or those discussed in the presentations earlier today) that would help your initiative? If so, are there any steps that would be needed to make the data more useful for your initiative?*

Spatial economics data (e.g. landings, catches) was discussed as being beneficial for several initiatives. Corinna Favaro noted that the DFO Ecosystems Management Branch GIS unit is mapping catches and landed values over space.

Emily Rubidge noted that Danielle Perron (DFO Policy and Economics) is working on ecosystem services analyses with the Province of BC. This work is primarily focused on incorporating socioeconomic data into the MPA network using Marxan, which has involved identifying areas of particular economic importance.

Spatial data that could support quantitative work to identify important areas (and timing) for spawning, breeding, rearing, etc. would be beneficial for MPA network planning, MCT and MSP. Currently this is done through expert based processes, however a more analytical approach is needed.

4. *How can we work together to create spatial data products that would be more broadly useful to the multiple federal initiatives?*

The Regional Spatial Data Working Group (ReSDaC) is a multi-sectorial group focused on spatial data products and building connections and linkages across sectors and groups.

The community mapping work that Patrick Thompson is leading is an example of working across sections and initiatives to collaborate to meet complementary objectives.

Table 4: Groundfish/Rockfish Session Agenda

Time	Agenda Item	Lead
1:00 pm	**Welcome and Introductions** • Workshop Overview • Roundtable	Stratos; Emily Rubidge
1:10 pm	**Overview of current projects** • Dana Haggarty • Sean Anderson • Philina English • Patrick Thompson • Robyn Forrest • Lisa Lacko / Brendan Connors • Katie Gale **Questions (following each presentation)**	Data experts
2:00 pm	**Discussion** • Review of existing data • Other data sources or data efforts currently underway	All participants
2:45 pm	**Future Directions** • Priorities for new spatial data products for the different initiatives • Possibilities for collaboration, future work	All participants
3:00 pm	**Adjourn**	

Invertebrates Data Session

Date: September 29th, 2020 (9-11 am)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Barb Sweazey
Rapporteur: Beatrice Proudfoot

Objectives

- Build relationships among science staff, highlight ongoing work and discuss data needs and priorities
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary

This section summarizes the presentations and discussions that occurred during the Invertebrates Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Cathryn Murray and Barb Sweazey. Rob Flemming, Janet Lochead, Jessica Finney, Natasha Salter and Brett Howard provided speed talks on the surveys, analyses and current/ongoing projects that they are involved in. A group discussion followed where participants discussed gaps, data sharing/availability and potential synergies. Key messages from this data session were:

- The broad spatial extent and complex coastline in BC means that substantial resources are required to produce spatial data products for invertebrates in the nearshore/intertidal zone
- Collaborations and discussions can be continued through the internal DFO intertidal working group. The goal of the group is to initiate discussions on ways to link intertidal data from different groups.

Data Overview Presentations
Presentation Title: Shellfish Data Unit
Presenter: Rob Flemming (Acting Program Head, Stock Assessment and Research Division, Shellfish Data Unit)

An overview of activities undertaken by the shellfish data unit was provided. One of the main objectives that the shellfish data unit is working towards is making shellfish data more user-friendly and easily accessible. Shellfish data is collected from commercial harvest logs (trap, dive, trawl and past fisheries). Biological samples from fishery-dependent and research surveys are collected for commercial species to support stock assessment. Data was originally compiled in several MS Access databases and since 2003 has been moved onto SQL server. There are seven SQL databases for shellfish data with MS Access front-end interfaces. Staff can access the databases directly and it's recommended that users study the "A2Tables" and "A3Fields" for descriptions, read supporting publications, talk to subject matter experts and read Integrated Fisheries Management Plans for commercial species to understand how management regimes and market conditions may have affected the fisheries. The structure of the new SFBioSQL database was developed to mimic the GFBio (Groundfish) database. The TRIP table is a new feature that allows users to extract data based on the sampling protocol used (similar to the GFBio database). The shellfish data unit also collects and stores beach polygon data from clam surveys. Beaches were delineated by hand on nautical charts and later digitized. Work is ongoing to clean and remove

redundancies in the beach polygon data, and the shellfish data unit is open to working with other groups/individuals to make the data as useful and accessible as possible.

Questions/discussion:
Several workshop participants expressed interest in accessing the beach polygon data. Another intertidal dataset, the "Murfitt Data", was also discussed. This dataset also represents beaches digitized from nautical charts. Several participants expressed interest in this data.

Presentation Title: DFO Science Dive Surveys – Benthic Invertebrates and Nearshore Habitats
Presenter: Janet Lochead (Marine Invertebrate Biologist, Stock Assessment and Research Division, Marine Invertebrates Section)

An overview of data collected in DFO Science dive surveys was provided. There are two main categories of dive surveys:
1. Single species surveys used primarily to develop quota calculations for fisheries. The following species are surveyed during single species surveys (note that abalone surveys are to monitor the recovery of the species):
    o Giant red sea cucumber density surveys:
        ▪ Date range: 1997 to present
        ▪ Goal: estimate density and mean weight to inform area re-openings and quota calculations
        ▪ Methods: Transect surveys randomly placed every 2km along shoreline
        ▪ Data: Single species enumeration and size with some habitat data
    o Geoduck density surveys:
        ▪ Date range: 1995 to present
        ▪ Goal: estimate density and mean weight for quota calculations. Collect biological data to estimate age and growth to develop age-structured population models.
        ▪ Methods: Transect surveys in geoduck beds (>5000 beds)
        ▪ Data: single species enumeration and size with some habitat data
    o Green sea urchin index site surveys:
        ▪ Date range: 1995 to present
        ▪ Goals: estimate density and size to inform harvest recommendations and assess stock status against reference points
        ▪ Methods: Transect surveys at fixed locations
        ▪ Data: single species enumeration and size with detailed habitat data (substrate type/percent cover, algal species/percent cover canopy, understory, turf and encrusting)
    o Red sea urchin density surveys:
        ▪ Date range: 1995 to present
        ▪ Goals: estimate density and size for quota calculations and harvest recommendations.
        ▪ Methods: transect surveys randomly placed every 1-2 km along shoreline
        ▪ Data: single species enumeration and size with detailed habitat data
    o Northern abalone index site surveys:
        ▪ Date range: 1978 to present; 5 year rotation
        ▪ Goals: estimate density and size to monitor stock status and recovery (prior to 1990 – for quota calculations).
        ▪ Methods: Breen (grid) surveys. 4 transects with 4 quadrats per transect, most sites selected in 1970's.
        ▪ Data: single species enumeration and size with detailed habitat data

2. Multispecies surveys used to assess stock status against reference points.
   - Date range: 2016 to present
   - Goals: Develop coast wide, long-term time series to assess stock status of several benthic invertebrates against reference points
   - Methods: Transect surveys; design in development
   - Data: Multispecies enumeration and size with detailed habitat data.

Questions/discussion:

Question: About whether the dive surveys include a harvest component.
Answer: Harvest experiments are conducted as part of some surveys (e.g. sea cucumber and red urchin)

Presentation Title: Species Distribution Modelling – Invertebrate Data Layers
Presenter: Jessica Finney (Aquatic Research Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis Section)

An overview of how the Species Distribution Modelling Framework[24] has been applied to predict the distribution of invertebrate species in the nearshore and shelf regions of the BC Coast was provided. Species distribution modelling is a rapid and cost-effective approach for estimating suitable habitat for a species of interest. The framework provides a standardized approach to model development and facilitates the model building process by providing guidance on all stages of the model building process (including providing R code available on the MSEA Gitlab). The MSEA Gitlab also has code that automatically pulls data from the shellfish database and code for spatializing dive survey data to give quadrats geographic coordinates. Species distribution models (SDMs) are currently being refined for the following species: Dungeness crab, red sea urchin, Pacific geoduck and northern abalone. Future SDMs will be produced for green sea urchin, purple sea urchin, sea cucumber, Olympia oyster, intertidal bivalves (using a joint SDM approach), horse clam and Dungeness crab (using electronic monitoring data). A knowledge-based habitat suitability modelling approach is taken for data deficient species. Outputs of the invertebrate SDMs are expected to be posted on the GIS Hub in early 2021. The environmental data layers used in the models are available by on GIS Hub.

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[24] Nephin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. 2020. Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.

Presentation Title: Coastal Environmental Baseline Program (CEBP) Invertebrate Data
Presenter: Natasha Salter (Physical Scientist, Ecosystem Sciences Division, Aquatic Ecosystems and Marine Mammals)

A recap of the CEBP was provided (refer to the [CEBP section of the introductory session section](#) for details). The CEBP collects abundance, presence/absence, distribution and contaminant concentration data for a variety of epifaunal and infaunal invertebrates, including aquatic invasive species. Invertebrate-specific data collected by DFO researchers through the program are outlined below. Invertebrate-specific data are also being collected by First Nations. All metadata and select datasets will be publicly available through the St. Lawrence Global Observatory or OpenData Canada.

1. Intertidal epifauna and infauna surveys:
   - o Date range: Annually since 2018 (anticipated to 2021)
   - o Location: CEBP study areas (Port of Prince Rupert surveys are anticipated for summer 2021).
   - o Goals: Provide data on intertidal biota at sites, quantify seasonal and annual trends in abundance and diversity, and identify factors influencing biota that could inform oil spill response planning and remediation recommendations
   - o Methods: Survey quadrats (epifauna), take sediment cores (infauna), and collect additional data on influencing factors (intertidal height, beach gradient, substrate, wave exposure, oceanographic context) at each site

2. Subtidal epifauna and infauna surveys
   - o Date range: Anticipated
   - o Location: CEBP study areas
   - o Goals: Characterize macrofaunal communities associated with the shallow benthic subtidal and shoreline installations
   - o Methods: Collect benthic grab samples (infauna and substrate) along a transect that extends the intertidal sites into the subtidal zone, and collect and analyze imagery for epifaunal density and substrate composition at shoreline installations

3. Monitoring contaminants of concern in shellfish tissues using [PollutionTracker](#) – a marine pollution monitoring program run by [Ocean Wise](#).
   - o Date range: 2019
   - o Locations: CEBP study areas (5 sites in Prince Rupert area and 3 sites in Vancouver area)
   - o Goals: Examine levels of contaminants of concern in marine sediments and invertebrate tissue
   - o Methods: Collect nearshore subtidal sediment, crab, clam and mussel tissue samples to examine levels of contaminants

4. Aquatic Invasive Species (AIS)
   - o Date range: ongoing
   - o Locations: CEBP study areas
   - o Goals: Monitoring and early detection of AIS (primarily tunicates)
   - o Methods: Deploy AIS settlement plates

Questions/discussions:

A brief discussion in the MS Teams chat occurred about potentially combining/comparing CEBP invertebrate data and other surveys discussed during this session (e.g. dive surveys, shellfish data unit surveys).

Presentation Title: Aquatic Invasive Species (AIS) Science
Presenter: Brett Howard (Aquatic Biologist, Ecosystem Sciences Division, Nearshore Ecosystems)

An overview of AIS data collection programs was provided. The programs have been ongoing since 2006 and use a combination of annual site-specific surveys and opportunistic sampling. Settlement plates are deployed to detect invasive tunicates. Green crabs are sampled using traps. Two approaches are being taken to provide guidance to managers about where to trap green crabs, with an overall objective to find a balance between analytical complexity and site specificity to model and manage invasions.

1. 'Simple' site characterization process
    - Approach: Characterize sites using Google Earth imagery to determine potential green crab habitat
    - Benefits: Simple approach, site specific
    - Drawbacks: Low spatial coverage, qualitative
2. Green crab niche model for BC Coast
    - Approach: Identifying hotspots using stacked species distribution models[25]
    - Benefits: Broad spatial extent (BC Coast), quantitative
    - Drawbacks: Complex and not site-specific enough to support management needs.

Current efforts are focused on developing a rapid site selection tool that quantifies beach size/shape, freshwater presence, sediment type and temperature/salinity and identifies areas with a high likelihood of green crab presence. A stochastic boosted regression modelling approach is being used to predict sites in the Salish Sea that are most likely to support hyper-abundant green crab as part of a CSAS request. A publication on this work is pending. A suite of environmental variables, including minimum fetch, high water edge habitat and isolation are being used in the models.

Questions/discussion: A brief discussion on MS Teams focused on some specifics of the green crab modelling work.

Question about how the beach size and shape metrics are calculated.
Answer: The approach involves clipping the study area to the high and low water line, measuring the width of the beach and then filtering out areas based on beach width and shape.

A green crab environmental niche model[26] might be useful for comparing with the models discussed in this presentation.

It was also noted that BC ShoreZone has started to map intertidal zones as polygons, which could be useful for green crab modelling. This work has so far only been done for the Vancouver Harbour (webmap with ShoreZone polygon data).

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[25] Lyons, Devin A., J. Ben Lowen, Thomas W. Therriault, David Brickman, Lanli Guo, Andrea M. Moore, M. Angelica Peña, Zeliang Wang, and Claudio DiBacco. "Identifying marine invasion hotspots using stacked species distribution models." *Biological Invasions* 22, no. 11 (2020): 3403-3423.

[26] Therriault, T.W., Herborg, L.M., Locke, A., McKindsey, C.W. and Department of Fisheries and Oceans, Ottawa, ON(Canada); Canadian Science Advisory Secretariat, Ottawa, ON(Canada), 2008. Risk assessment for European green crab (Carcinus maenas) in Canadian waters. Fisheries and Oceans Canada, Science.

Presentation Title: Nearshore Community Assemblages
Presenter: Sarah Davies (Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis) and Joanne Lessard (Research Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

The objective of this research program is to describe and map the nearshore community assemblages along the BC Coast. The work involves two components: benthic habitat mapping SCUBA surveys and Hierarchical Bayesian joint species distribution modelling. The SCUBA dive transects are randomly distributed along the coastline and extend from the shoreline to depths of 60ft. The presence/absence of invertebrate and algal species and the substrate type is recorded in 1 x 5 m quadrats from deep to shallow. There are 11 substrate classes and the percentage of cover is recorded for the top three substrate classes observed within each quadrat. Details and methodology can be found in a 2018 Technical Report. Community ecological data is analyzed using a Hierarchical Bayesian joint species distribution modelling approach, which allows for predictions for rare species using co-occurrence data from other species. Observed variation in species occurrences can be partitioned into measured environmental variation and random processes. This approach is currently being considered by the Habitat Mapping Program (Jessica Finney) to analyze community structure and distribution of infaunal clam communities using intertidal survey data.

Questions/discussion

Question about whether temperature data used in the modelling is from measurements taken during the dive surveys or from modelled temperature data.
Answer: Modeled temperature data (the same data used in the individual SDMs presented by Jessica Finney).

Presentation Title: Spatial Data Overview – Invertebrates
Presenter: Katie Gale (Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An inventory of spatial data products that support MSP is currently underway. Four broad categories of spatial data were highlighted as useful for MSP and MPA network planning in the Northern Shelf Bioregion
- Distribution Data
  - Observations/catch records measuring abundance, presence, presence-absence
  - Can be point data, aggregated into grids or spatially interpolated
  - Do not involve predictions and are limited to the spatial extent of input data
  - Examples of invertebrate distribution data used in previous planning exercises:
    - Kernel densities of normalized CPUE for sponge, coral, sea pen, tanner crab and scallops
    - Gridded average sponge cover, gridded presence of 22 invertebrate species
- Species distribution/habitat suitability models
  - Single or multi-species observations are correlated with environmental variables to predict presence our abundance outside the sampled area
  - Examples of species distribution/habitat suitability models used in previous planning exercises:

- SDMs for abalone, geoduck, red urchin, Dungeness crab, orange sea pen, littleneck clam, ochre sea star and blue mussel complex using SDM Framework[27]
- Habitat suitability models for six groups of cold-water coral and sponges in the Northeast Pacific[28]
- Significant Areas
  - EBSAs
  - Areas important for spawning/breeding, rearing/nursery, feeding, migrating, aggregations[5]
  - Hotspots of diversity/productivity
  - Areas important for vulnerable or threatened species (e.g. Critical Habitat)
  - Sensitive Benthic Areas
  - Areas with rare features or unique genetic populations
  - Examples of Significant Areas used in previous planning exercises:
    - Identification of Important Areas in the Pacific North Coast Integrated Management Area[29,30]
    - Invertebrate richness and biodiversity hotspot analysis[31]
- Habitat Proxies

General Discussion and MS Teams Chat

Four questions guided the group discussion about gaps, potential synergies and priorities for future work.

1. *Can you think of any spatial data products that have not been identified that would help inform ongoing efforts?*

A discussion about ongoing challenges and progress in terms spatial data and spatial data products in the nearshore/intertidal zone highlighted the following:

- The existence of an internal DFO intertidal working group that is focused on sharing information on work in the intertidal zone. There is substantial data on certain species, but not necessarily on biodiversity. The group is working to fill that gap.
- The broad spatial extent and complex coastline in BC means that substantial resources are required to produce spatial data products for the nearshore/intertidal zone.
- There are challenges associated with the need for site-level decision making when analyses are often done on a coast-wide scale.
- There is a Bottom Patch data layer for the full BC coast that contains substrate data for the intertidal zone. Refer to the Algae/Plant/Habitat data session report for more information about the Bottom Patch data.

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[27] Nephin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. 2020. Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.

[28] Chu, J. W., Nephin, J., Georgian, S., Knudby, A., Rooper, C., & Gale, K. S. (2019). Modelling the environmental niche space and distributions of cold-water corals and sponges in the Canadian northeast Pacific Ocean. *Deep Sea Research Part I: Oceanographic Research Papers*, *151*, 103063.

[29] [5]Clarke, C.L., and Jamieson, G.S. 2006. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase II – final report. Canadian Technical Report of Fisheries and Aquatic Sciences 2686.

[30] Clarke, C.L., and Jamieson, G.S. 2006a. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase I - Identification of Important Areas. Can. Tech. Rep. Fish. Aquat. Sci. 2678.

[31] Rubidge, Emily, Nephin, J, Gale, K.S.P., & Curtis, J. 2018. Reassessment of the Ecologically and Biologically Significant Areas (EBSAs) in the Pacific Northern Shelf Bioregion. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/053. xii + 97 p

2. *Are there other spatial data products that would be useful for other initiatives that participants are involved in?*

Several participants expressed interest in a coast-wide eelgrass spatial layer. Ashley Park is working on an eelgrass SDM. It's anticipated that the eelgrass SDM will be available on the GIS Hub in the new year. Work is currently underway to compile eelgrass presence data to update a spatial dataset for the full coast. There is also a National Eelgrass Task Force (NET Force) working to produce a National dynamic map of eelgrass distribution in Canada.

An additional coral and sponge dataset that consists of presence/absence observations derived from ROV, groundfish trawl, shellfish dive and external surveys is available for download from the GIS Hub. The code used to derive the data is also accessible.

Participants working on the SSI expressed interest in spatial data products for the Salish Sea and that there may be opportunities for connections between First Nations and DFO staff who are all conducting shellfish surveys. Participants noted that there is good survey coverage for some invertebrate species in the Salish Sea. There are also annual prawn and ROV survey data available for the Salish Sea. The AIS fouling survey has decent coverage in the Vancouver and east coast of Vancouver Island region, however green crab trap data is limited. The recent summary report of DFO Pacific Science field operations may also help identify research programs with complementary/useful data to support the various initiatives.

Key notes from a brief discussion on MS Teams Chat about data specific to Howe Sound are:
- Limited diver survey data has been collected in Howe Sound aside from a sea cucumber survey that occurred in 2012.
- ROV surveys were done in Howe Sound at least twice in recent years

3. *Are there particular spatial data products (either existing data or those discussed in the presentations earlier today) that would help your initiative? If so, are there any steps that would be needed to make the data more useful for your initiative?*

A brief discussion on MS Teams Chat highlighted the need for a simple map or layer that represents invertebrate research data coverage for the coast. There is a new collaborative project to develop an ROV database that can be spatially queried to identify species data from groundfish, invertebrate and MSEA data holdings while also providing information on species status (e.g. SARA listed, oil vulnerability). It is anticipated that the ROV database will be available in the next 1-2 years.

From an MSP perspective, there is a general preference for broader spatial products. Invertebrate data is generally collected in smaller areas with high resolution. SDMs are a useful tool that can balance the needs of MSP with the availability of appropriate invertebrate data.

In contrast, other initiatives have different spatial needs, such as fine scale data for oil spill response planning. Work is underway to use substrate and fetch data to produce vulnerability categories for oil spill response planning.

4. *How can we work together to create spatial data products that would be more broadly useful to the multiple federal initiatives?*
- Continue collaborations in the intertidal working group
- Continue to share data and updates with workshop participants as data and spatial data products are developed.
- Data holders and stewards continue to provide information on where/how data is stored and database access

Table 5: Invertebrates Session Agenda

Time	Agenda Item	Lead
9:00 am	**Welcome and Introductions** • Workshop Overview • Roundtable	Stratos; Cathryn Murray
9:10 am	**Overview of current projects** • Shellfish databases - Rob Flemming • Dive surveys – Janet Lochead • Species distribution models – Jessica Finney • Coastal environmental baseline data – Natasha Salter • Green crab – Brett Howard • Nearshore community assemblages – Sarah Davies and Joanne Lessard • Katie Gale **Questions (following each presentation)**	Data experts
10:00 am	**Discussion** • Review of existing data • Other data sources or data efforts currently underway	All participants
10:45 am	**Future Directions** • Priorities for new spatial data products for the different initiatives • Possibilities for collaboration, future work	All participants
11:00 am	**Adjourn**	

Pelagic Fish Data Session

Date: September 29th, 2020 (1-3 pm)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Barb Sweazey
Rapporteur: Beatrice Proudfoot

Objectives
- Build relationships among science staff, highlight ongoing work and discuss data needs and priorities
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary
This section summarizes the presentations and discussions that occurred during the Pelagic Fish Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Patrick Thompson and Barb Sweazey. Jennifer Boldt, Stephane Gauthier, Matt Grinnell and Cliff Robinson provided speed talks on the surveys, analyses and current/ongoing projects that they are involved in. A group discussion followed where participants discussed gaps, data sharing/availability and potential synergies. Key messages from this data session were:

- Acoustic surveys have the potential to provide information on non-target species and seasonality, however current capacity and resources to extract non-target species data are limited
- The need to coordinate efforts so that the same spatial data products can be used for the needs/objectives of multiple federal initiatives
- Analytical tools and modelling approaches can allow for multiple data sets collected across different sampling programs to be used in analyses.
- Interest in developing a dataset showing the extents of DFO research surveys

Data Overview Presentations
Presentation Title: Pelagic Surveys
Presenter: Jennifer Boldt (Research Scientist, Ecosystem Sciences Division, Regional Ecosystem Effects on Fish and Fisheries)

An overview of two survey programs was provided:
1. Pelagic Integrated Ecosystem Science Survey (co-led by Jennifer Boldt and Jackie King)
   - Goal: Understand factors affecting abundance, distribution, food web linkages of pelagic fish species (e.g. Pacific herring, juvenile salmon)
   - Objectives: Examine species distribution, composition and abundance; collect morphometric data, diet data and biological samples; examine the prey environment by sampling zooplankton and conducting oceanographic monitoring using various instruments (primarily CTD). The surveys focus on juvenile Pacific salmon, Pacific herring, Pacific sardine and other forage fish.
   - Survey Area: WCVI to Queen Charlotte Sound
   - Methods: Trawl surveys occur in June/July. Eight strata are determined by depth and biological communities. Twenty-minute trawl hauls occur in a random selection of 4 x 4

km blocks, allocated by strata size. All species are enumerated and biological data is collected. CTD, chlorophyll, zooplankton and acoustic data are also collected.
- Data availability:
    - Data published in annual reports[32, 33]
    - CTD data in IOS database (online)
    - Zooplankton data in IOS Zooplankton Database
    - Fish data is housed in an MS Access database and is available upon request
    - Data is summarized in various reports (e.g. State of the Pacific Ocean)

2. Strait of Georgia Age-0 Pacific Herring Survey
- Objectives: Estimate the relative abundance of age-0 herring, measure lengths, weights and condition of age-0 herring, and understand factors affecting age-0 herring abundance and condition. The relative abundance of age-0 herring is a potential indicator of recruitment to the adult herring population, and the relative abundance, size and condition of age-0 herring are potential indicators of prey availability and quality to predators, such as Coho and Chinook Salmon.
- Survey Area: Strait of Georgia
- Methods: Annual surveys occur in Sept-Oct. Ten core transects are sampled during the night using a small purse seine. CTD and zooplankton data are also collected. Surveys provide relative abundance and relative condition indices.
- Data availability:
    - Data is published in annual reports[34]
    - Data is available through the Salish Sea Marine Survival Project Strait of Georgia Data Center
    - Fish data is housed in MS Access database and is available upon request
    - Data is summarized in various reports (e.g. State of the Pacific Ocean reports)

Questions/discussion

Question about how many additional species data are collected in the Pelagic Integrated Ecosystem Science Survey and if any analyses of community diversity have been done.
Answer: The focal species are herring, juvenile salmon, juvenile rockfish, and other pelagic fish species. The number of species are published in the reports mentioned during the presentation. Community analyses are planned, and species composition analyses have been done for the nighttime pelagic surveys.

Question about whether surveys are done in other regions of the coast.
Answer: Juvenile herring surveys were done in the North Coast in the past. Current surveys only cover the north and west coasts of Vancouver Island. There may be an additional survey that extends further. Other surveys that extend further north are the hake and herring spawn surveys (discussed in later presentations in this session).

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[32] King, J., J.L. Boldt, H. Dennis-Bohm, T. Zubkowski, E. Anderson, L. Flostrand and S. Tucker. 2019. Integrated Pelagic Ecosystem Surveys on the Vancouver Island Continental Shelf, July 7 - August 2, 2017 and July 5 - July 29, 2018. Can. Tech. Rep. Fish. Aquat. Sci. 3318: xi + 115 p.

[33] Boldt, J., Anderson, E., King, J., Dennis-Bohm, H., Zubkowski, T., and Flostrand, L. 2020. Integrated Pelagic Ecosystem Survey on the Vancouver Island Continental Shelf, June 15 - July 15, 2019. Can. Tech. Rep. Fish. Aquat. Sci. 3339: vii + 85 p.

[34] Thompson, M., Boldt, J.L., Dennis-Bohm, H., and Grinnell, M. H. 2020. Strait of Georgia juvenile herring survey, September 2018. Can. Manuscr. Rep. Fish. Aquat. Sci. 3201: vi + 53 p.

Presentation Title: Acoustic Surveys
Presenter: Stephane Gauthier (Acoustic Research Scientist, Ocean Sciences Division, Ocean Ecology and Biogeochemistry)

An overview of the acoustic survey program in BC was provided. Acoustic surveys provide a high resolution 3-dimensional view of the distribution of animals in the water column. Acoustic surveys are combined with pelagic trawls and optical tools help interpret the acoustic backscatter and determine the species detected across different frequencies. Spatially explicit GPS data is collected along acoustic survey tracks. The joint NOAA/DFO Pacific Hake Survey covers the entire Pacific Coast from south of California to the Alaska border. The survey is targeted for hake, and data on other species, including herring, krill, juvenile rockfish and other mesopelagic species are also collected. Transects extend from 50 -1500 m depth, and transects are typically spaced 10-20 nm apart. Work is currently underway to automate the extraction of krill data from the acoustic surveys. Acoustic data are also opportunistically collected as part of Line-P and La Perouse oceanographic surveys (2005-present), during seamount surveys, and in the Strait of Georgia during salmon surveys. Acoustic surveys were completed in the Strait of Georgia in 2011, 2012, 2014 and 2016. A substantial amount of raw acoustic data has been collected, however the processing required to extract information on the presence of other species is currently a barrier. More capacity is needed in order to extract data that could be used to identify diversity and productivity hotspots and information on additional species.

Questions/discussion

Question about whether the raw data is useful to others given how much work is required to extract species information.
Answer: Data products are useful, but is unlikely that the raw data is useful given how much effort is required to extract information such as biomass and density distributions.

Question about whether there is any uncertainty or error estimates associated with different frequencies for the species groups.
Answer: Without ground-truthed data, it can be difficult to differentiate species such as herring and pollock. However there is a high confidence when differentiating species with and without swim bladders. Quantifying uncertainty is one of the challenges.

Question about whether CHS multibeam backscatter could be used to detect species in the water column.
Answer: Most CHS surveys do not collect water column data because it is a large volume of data that is considered "noise" for CHS mapping purposes. Additionally, the multibeam echosounders used by the CHS are different than the water column echosounders, which makes quantitative interpretations difficult. CHS has offered to collect water column data if DFO Science can store and interpret it.

Presentation Title: Herring Assessment Program (no PowerPoint)
Presenter: Matt Grinnell (Aquatic Science Biologist, Stock Assessment and Research Division, Quantitative Assessment Methods))

The key research objective of the herring stock assessment program is to use simulation models to test the performance of different harvest rules and examine population drivers of stock collapse and recovery. The surveys and analyses are geared toward stock assessment (which is currently underway). The surveys and analyses also contribute to management strategy evaluation (MSE) – a multi-year iterative process. Surveys include annual surveys of herring spawn (egg deposition) and collection of biological samples from commercial and test fisheries (length, sex, age at maturity). There are two main categories of spawn surveys: surface spawn surveys (1951-1987) and dive surveys (1988-present). Key outputs are biomass trends and stock projections that are reported as CSAS Research Documents or Science Advisory Reports and harvest levels. Data requests are handled through the program (as opposed to the data section) in order to provide data users thorough explanations of the caveats of the data.
Data is available through annual data summary reports[35]. Additional information on the spawning index can be found at: http://github.com/grinnellm/SpawnIndex. A draft technical report can be found at: https://github.com/grinnellm/SpawnIndex/blob/master/tr/Draft.pdf.

Questions/discussion

Question about the herring spawn index and how reliable, available and shareable to dataset is.
Answer: Spawn data is available, and spawn and biomass indices at specific point locations along the coast. Length and width of spawn is also available for these locations (however all data is associated with a point location). In terms of reliability, the more recent data (dive data) cover a smaller spatial extent and are more precise than the older data (surface spawn surveys) which are less reliable.

Question about the whether the point locations (for spawn and biomass indices) are analogous to the cumulative herring spawn index. A description of the Shiny App was also requested.
Answer: The cumulative herring spawn index is a dataset that is no longer maintained (discontinued around 2016) and the spawn data described above can be used instead. The FIND Shiny App was created to answer questions and requests that the team frequently receive. The idea with the FIND Shiny App is that the user enters coordinates and a range of years to get a map and data for herring spawn in the area/time frame requested.

Question about whether the surveys include a harvest component.
Answer: Yes, whole fish are collected and assessed for length, weight at age, sex, maturity.

Presentation Title: Forage Fish Research Program – September 2020
Presenter: Cliff Robinson (Research Scientist, Ecosystem Sciences Division, Regional Ecosystem Effects on Fish and Fisheries)

The overarching research objective is to assemble the best available information on key forage species in nearshore food webs and model the spatial extent/condition of their habitat(s) to assess/understand effects of ocean climate variability and/or anthropogenic activities. Focal species for this research are Pacific sand lance, surf smelt, euphausiids, shiner perch (TBD: juvenile rockfish, northern anchovy, eulachon). The study area extends from the high tide line to 30 m depth (within the kelp zone). A sand lance burying

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[35] https://github.com/grinnellm/Reports

habitat distribution model is complete[36]. Work with Amber Holdsworth is currently underway to understand how ocean climate influences burying habitat on the WCVI. A sand lance and surf smelt intertidal spawning habitat model is currently being developed with preliminary results anticipated prior to field season (December – January). Pelagic foraging hotspot modelling is also underway for Barkley Sound, Baynes Sound and Haro Strait. Rhian Evans (post-doc) is leading a project to use spatiotemporal modelling approaches to understand factors affecting the distribution and biomass of euphausiids along the Pacific Coast. Most species (except euphausiids) are considered data deficient, so data are obtained from multiple sources (e.g. eDNA, citizen scientist monitoring programs).

Questions/discussion

Question about access to model outputs as they become available.
Answer: The goal is to make the model outputs available. At this point it is not decided where the data will be stored (internally or on OpenData). It is expected that the models will be updated and refined as more data becomes available, so communicating with end users (e.g. data users, Oceans Managers, Fisheries Managers) that the maps and model outputs are not static is important.

Presentation Title: Spatial Data Overview – Pelagics
Presenter: Katie Gale (Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An inventory of spatial data products that support MSP is currently underway. Four broad categories of spatial data were highlighted as useful for MPA network planning in the Northern Shelf Bioregion
- Distribution Data
    - Observations/catch records measuring abundance, presence, presence-absence
    - Can be point data, aggregated into grids or spatially interpolated
    - Do not involve predictions and are limited to the spatial extent of input data
    - Examples of pelagics distribution data used in MPA Network planning in the NSB:
        - Kernel densities of normalized CPUE for Pacific sand lance
        - Pacific hake biomass index from joint NOAA/DFO acoustic surveys
        - Pacific herring spawn habitat index
- Species distribution/habitat suitability models
    - Single or multi-species observations are correlated with environmental variables to predict presence our abundance outside the sampled area
    - No SDMs were available at the time of MPA Network planning in the NSB
- Significant Areas
    - EBSAs
    - Areas important for spawning/breeding, rearing/nursery, feeding, migrating, aggregations[37]
    - Hotspots of diversity/productivity
    - Areas important for vulnerable or threatened species (e.g. Critical Habitat)
    - Sensitive Benthic Areas
    - Areas with rare features or unique genetic populations
    - Examples of Significant Areas used MPA Network planning in the NSB:

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[36] Robinson, C. L., Proudfoot, B., Rooper, C. N., & Bertram, D. F. (2021). Comparison of spatial distribution models to predict subtidal burying habitat of the forage fish Ammodytes personatus in the Strait of Georgia, British Columbia, Canada. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *31*(10), 2855-2869.

[37] Clarke, C.L., and Jamieson, G.S. 2006. Identification of ecologically and biologically significant areas in the Pacific North Coast Integrated Management Area: Phase I – Identification of important areas. Can. Tech. Rep. Fish. Aquat. Sci. 2678: vi + 89 p.

- Identification of Important Areas in the Pacific North Coast Integrated Management Area[38, 39]
- Identification of important areas for eulachon spawning by consulting with experts and using available data to rank estuaries.
- Habitat Proxies

General Discussion and MS Teams Chat

Four questions guided the group discussion about gaps, potential synergies and priorities for future work.

1. *Can you think of any spatial data products that have not been identified that would help inform ongoing efforts?*

A discussion about whether data that could help delineate important spawning and rearing habitat and seasonal variation in habitat use is available through any of the surveys highlighted in the session. It was noted that there is sometimes the capacity to explore seasonality in the acoustic data because the surveys happen in May and September, however processing and extracting the data is the challenge and more capacity is required to work at automating the process. In terms of spatial planning, it can be challenging to delineate important areas for mobile/migratory species that occupy different habitats/regions during different life history stages.

2. *Are there other spatial data products that would be useful for other initiatives that participants are involved in?*

It was noted that an important layer needed for oil spill response planning (and likely other initiatives) is an eulachon spawning layer. Currently there are 21 fixed transect surveys in three areas in the New Westminster and Massey Tunnel regions. The surveys measure the relative abundance of eulachon spawn by deploying a bongo net over the side of the boat. The survey locations do not change and have been ongoing since the early 2000s. Data is currently stored in an MS Access database. Eulachon data is also available from the multispecies surveys. This data is stored in the GFBio database and the Groundfish section is the data custodian. First Nations fisheries may also be collecting eulachon data, but it is not held by DFO. DFO Fisheries Managers have access for Food Social & Ceremonial programs, however the data is in a diversity of formats and collected using a variety of methods.

3. *Are there particular spatial data products (either existing data or those discussed in the presentations earlier today) that would help your initiative? If so, are there any steps that would be needed to make the data more useful for your initiative?*

A discussion about the overlap among species that are caught across the different surveys highlighted the need to ensure that multiple different species-specific models and spatial data products aren't being produced in the same way for different initiatives. This is complicated where federal initiatives have slightly different requirements and deliverables. However, coordinating efforts so that the same spatial data products can be used for multiple needs/objectives would be strategic. Combining the results of different survey methods can and has been done (e.g. Vector Autoregressive Spatio-

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[38] Clarke, C.L., and Jamieson, G.S. 2006. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase II – final report. Canadian Technical Report of Fisheries and Aquatic Sciences 2686.

[39] 5Clarke, C.L., and Jamieson, G.S. 2006. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase II – final report. Canadian Technical Report of Fisheries and Aquatic Sciences 2686

Temporal modelling), however the approach for combining multiple surveys depends on the end goal of the analyses.

Several participants expressed interest in a reference map showing where all pelagic research is happening (e.g. acoustic surveys, multispecies trawls, herring surveys). Work is underway to produce a visual representation of where and when acoustic data has been collected. Non-spatial information on DFO surveys and external groups monitoring in BC waters has recently been compiled. The 'trips' table in the SFbio database may contain survey polygons. It was also added that one of the requirements for MSP is a map showing survey footprints/extents. It is anticipated that the map would be available by the end of the next fiscal year.

4. *How can we work together to create spatial data products that would be more broadly useful to the multiple federal initiatives?*

Salish Sea Initiative (SSI) is only going to use publicly available data. Knowing what data is intended to be uploaded to OpenData or public data sources would be useful for the SSI. A brief discussion also highlighted the importance of detailed and metadata and spatial data products that are interpretable by a wide audience, including data users, managers and the public. Kayleigh Gillespie noted that she is able to assist anyone in documenting their metadata and sharing data internally on GIS Hub, which would benefit multiple initiatives.

Table 6: Pelagic Fish Data Session Agenda

Time	Agenda Item	Lead
1:00 pm	**Welcome and Introductions** • Workshop Overview • Roundtable	Stratos; Patrick Thompson
1:10 pm	**Overview of current projects** • Integrated pelagic ecosystem survey – Jennifer Boldt • Acoustic surveys – Stephane Gauthier • Herring – Matt Grinnell • Forage fish – Cliff Robinson • Spatial data overview - Katie Gale **Questions (following each presentation)**	Data experts
2:00 pm	**Discussion** • Review of existing data • Other data sources or data efforts currently underway	All participants
2:45 pm	**Future Directions** • Priorities for new spatial data products for the different initiatives • Possibilities for collaboration, future work	All participants
3:00 pm	**Adjourn**	

Mammals Data Session

Date: September 30th, 2020 (1-3 pm)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Barb Sweazey
Rapporteur: Beatrice Proudfoot

Objectives
- Build relationships among science staff, highlight ongoing work and discuss data needs and priorities
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary

This section summarizes the presentations and discussions that occurred during the Mammals Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Carrie Robb and Barb Sweazey. Thomas Doniol-Valcroze, Linda Nichol, Strahan Tucker and Sheila Thornton provided speed talks on the surveys, analyses and current/ongoing projects that they are involved in. A group discussion followed where participants discussed gaps, data sharing/availability and potential synergies. Key messages from this data session were:

- The importance of being aware of and understanding the limitations and caveats of marine mammal data, particularly in terms of effort and the non-systematic nature of many of the marine mammal survey programs.
- The need for a coordinated and streamlined approach for data sharing and accessibility and a notification system so data users can track progress and changes to the spatial data products they are using.

An overview of spatial datasets collected by the Cetacean Research Program (CRP) was provided. Caveats, limitations and potential uses of the data and spatial data products was also discussed. The program objectives are to assess the status of SARA-listed cetaceans, identify potential critical habitat, conduct Recovery Potential Assessments and assist with Recovery Strategies and Action Plans. The US Marine Mammal Protection Act Bycatch rule also requires population estimates for all species (not just SARA-listed species). The following spatial datasets were discussed:

1. Photo-identification data
    - Non-systematic surveys – focused on areas that maximize the likelihood of encounters
    - No effort information
    - Cannot be used for density or absence modelling
    - Date range: 2005 - 2008
2. CRP dedicated ship-based surveys
    - Mostly non-systematic surveys (systematic after 2017)
    - Effort information available
    - Distance sampling protocols could allow correction for visibility and detectability
    - Use caution when used for density or habitat modelling
    - Date grange: 2002-2017
3. CRP sightings collected during pelagic fish surveys (CCGS Ricker)

- Systematic surveys – but designed for fish, not whales
- Effort information available
- No distance sampling protocols (cannot be corrected for detectability)
- Can be used to model density with caveats, however the spatial coverage is limited (WCVI) and the dataset does not represent the majority of the work done in the CRP
- Date range: summer 2012 and 2013

4. CRP Aerial Surveys
   - Systematic surveys
   - Effort information available
   - Used to model habitat and distribution of whales on the continental shelf (WCVI) and assess risk of ship strikes
   - Date range: 2012-2015 (predominantly fall and winter)

5. Pacific Region International Survey of Marine Megafauna (PRISMM 2018)
   - Systematic surveys for BC coast
   - Effort information available and corrected for visibility and detectability
   - Used to calculate abundance estimates and distribution of all cetacean species in BC waters. Surveys designed to collect data for density/habitat modelling.
   - Date range: summer 2018

6. BC Cetacean Sightings Network
   - Non-systematic – data collected opportunistically by citizen scientists, researchers, whale watching operations
   - Requires effort corrections
   - Data can be requested

It was emphasized that while the CRP collects data that may be useful for various federal initiatives, many of the data sets have effort issues, so caution must be used when to inferring density or absence.

Questions/discussion

Question about whether there has been any interest in using the whale density maps for modelling marine mammal predation effects.
Answer: The density maps would certainly be useful for understanding where cetaceans may be having predation effects. Not aware of anything that has been done concretely yet.

Question about whether there are plans to publish the density maps on FGP or OpenData.
Answer: They are included in a CSAS publication[40]. The spatial data products (e.g. density layers) are ideal for sharing/distribution on OpenData (or other portals) because they can be easily interpreted and caveats/effort issues have been dealt with. The density maps can also be adapted to specific projects (e.g. cropped and zoomed to specific analysis areas or MPAs). However, it is important to note that the PRISMM density maps represent a snapshot in time, and are not derived from repeat surveys. A new project focused on the southern Salish Sea involves a series of monthly surveys from Vancouver to Swiftsure Bank that will be used to calculate abundance and distribution of cetacean species over time.

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[40] Wright, B.M., Nichol, L.M., Doniol-Valcroze, T. 2021. Spatial density models of cetaceans in the Canadian Pacific estimated from 2018 ship-based surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/049. viii + 46 p.

Question about whether there are plans to repeat the PRISMM surveys in future years.
Answer: We have a legal obligation to provide updated estimates at least every 8 years. Next time, the survey will likely be broken up into smaller areas as opposed to undertaking a single, resource intensive survey.

Several workshop participants from the MSP, CEBP, SSI and PIER initiatives expressed interest in the cetacean density maps. The cetacean density maps could be useful for oil spill response planning, and included in the MSP Atlas (a key deliverable of the MSP initiative) but the caveat mentioned above that PRISMM represents a one-time snapshot that does not capture the variability in cetacean distribution patterns. The MSP initiative could help with the OpenData publication process.

Presentation Title: British Columbia's sea otter (*Enhydra lutris*) population in 1977-2017
Presenter: Linda Nichol (Research Biologist, Ecosystem Sciences Division, Aquatic Ecosystems and Marine Mammal Section)

An overview was provided of surveys done to assess the sea otter population size, trends in population growth and range expansion. Sea otters were extirpated from British Columbia by 1929 and were absent thereafter until re-introduction of animals from Alaska (1969-1972), where they had also been severely depleted by the maritime fur trade but not extirpated. BC's sea otter population is recovering to reoccupy the species historical habitat in BC. To monitor the population and organize survey effort and results, the occupied range is divided into survey segments. The first survey segment encompasses the area where the reintroduced animals were released and first colonized. New segments are added as the population range has increased with population growth and recovery. There are now twenty-four survey segments from Clayoquot Sound, Vancouver Island to the central British Columbia coast. A coast-wide survey of these segments is completed every 5 -years using boat-based counts along consistent survey routes within each segment. Segments near the area of re-introduction are surveyed annually and during the intervening years areas near the edges of the occupied range or areas recently occupied are also surveyed. Surveys follow consistent routes within survey segments, given that sea otters occupy small overlapping ranges of tens of kilometers of coastline, and thus there is little movement within an established area. Thus by following consistent methods and protocols the resulting counts are assumed to provide a representative index of abundance. These counts are used to estimate population growth, and the distribution of the surveyed animals informs maps of the overall range of sea otters in BC. The most recent surveys of the occupied range were done in 2017. Surveys north of the occupied range survey segments were also completed – with no indication of sea otter occupation. Range maps are updated following coast wide surveys.

Questions/discussion

Question about whether the sea otter range maps are updated each year.
Answer: Range maps are updated every 5 years after the range wide surveys are completed or when surveys are done at the edge of the range where expansion is expected.

A brief discussion followed about whether the sea otter observations could be summarized to produce maps that show otter densities or proportions of the population. One suggestion was to summarize counts by survey segment to show segments that have higher densities of otters. Several participants commented on the utility of a sea otter density map for their initiatives. However, the answer was that this is not possible to do at fine spatial scales based on the existing sea otter survey data. It was also noted that for conservation planning purposes it may also be useful to differentiate recovering versus established components of the population.

Presentation Title: Trends in Abundance and Distribution of Pinnipeds in BC
Presenter: Strahan Tucker (Research Scientist, Ecosystem Sciences Division, Aquatic Ecosystems and Marine Mammal Section)

The objective of the program is to understand the drivers of population trends in pinnipeds, their feeding ecology and their influence on prey/predator population dynamics. Two pinniped species breed in BC and are the focus of population assessment and monitoring: harbour seals and Steller sea lions. Standardized aerial surveys have been ongoing since the early 1970's. GPS telemetry based correction factors are used to convert counts to abundance and account for the proportion of animals in the water during the survey window. The schedule of surveys varies by species. Because of SARA requirements, Steller sea lions are assessed every 4 years. The Strait of Georgia is the principle index site for harbour seals and they are assessed every 5 years; coast wide surveys are undertaken every 10 years. The data are used to provide science advice on population recovery, bycatch, potential impacts of pinnipeds on fishery resources, proposed developments, oil spill response planning and MPA planning. California sea lions are counted opportunistically during Steller sea lion surveys because the two species often share haul outs. The following data are available on OpenData:

- Harbour seal surveys up to 2014; the most recent Strait of Georgia survey in 2019, as well as coast wide surveys 2016-2018 will be uploaded in the near future
- Steller sea lion surveys up to 2013 (2017 data will be uploaded in the near future)
- California sea lion opportunistic data will be uploaded after the upcoming winter survey and include caveats about the opportunistic nature of the data.

Presentation Title: Southern Resident Killer Whale distribution and habitat use data
Presenter: Sheila Thornton (Research Scientist, Ecosystem Sciences Division, Aquatic Ecosystems and Marine Mammal Section)

The Southern Resident Killer Whale (SRKW) population in Canadian Pacific waters is listed as endangered under the Species at Risk Act. Critical habitat (the habitat necessary for survival and recovery of the population) has been identified and extends from La Perouse Bank to the west to the southern part of Strait of Georgia, and encompasses waters of Juan de Fuca Strait, Boundary Pass, Haro Strait, and the southern Gulf Islands. Primary threats include acoustic and physical disturbance, prey accessibility and contaminants. Understanding the co-occurrence of SRKW and their threats involves identifying and mapping SRKW distribution, habitat use, and threats to survival and recovery. Research is guided by requests for science information and advice (RSIAs) such as identifying candidate areas for SRKW protection, acoustic and physical mitigation, sanctuaries, MPAs, and areas where vessels could be slowed and/or laterally displaced to mitigate impacts to SRKW. Work is ongoing to effort correct presence-only platform of opportunity data (BC Cetaceans Sightings Network and OrcaMaster data) and integrate it with presence/absence scientific survey data to provide a more accurate overview of SRKW distribution. Behavioural data surveys have been conducted using group behaviour and focal follow methodologies to provide further insight into duration and use of habitat. Behaviour and habitat use can then be correlated with bathymetry, substrate, and/or oceanographic features such as tides, currents, chlorophyll, sea state, etc. Work is also ongoing to analyze acoustic detections and develop a means of analyzing sightings and acoustic data to produce effort-corrected maps of multiple data sources. Acoustic monitors also collect data on ambient noise and analyses are underway to identify natural and anthropogenic sound sources in SRKW environment and support the development of metrics for impacts and quantify loss of listening and echolocation space. Vessel density information is also collated from aerial surveys, Automatic Identification System and information from creel and fisheries management surveys to assess areas of potential physical disturbance.

Presentation Title: Spatial Data Overview: Mammals
Presenter: Katie Gale (Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis Section)

An inventory of spatial data products that support MSP is currently underway. Four broad categories of spatial data were highlighted as useful for MPA network planning in the Northern Shelf Bioregion, and examples of mammal spatial data products used in MPA network planning was provided:

- Distribution Data
    - Observations/catch records measuring abundance, presence, presence-absence
    - Can be point data, aggregated into grids or spatially interpolated
    - Do not involve predictions and are limited to the spatial extent of input data
    - Examples of mammal distribution data used in MPA Network planning in the NSB:
        - Cetacean density maps derived from effort corrected opportunistic ship data.
- Species distribution/habitat suitability models
    - Single or multi-species observations are correlated with environmental variables to predict presence our abundance outside the sampled area
    - SDMs used in MPA Network planning in the NSB:
        - Sea otter modelled habitat[41]
- Significant Areas
    - EBSAs
    - Areas important for spawning/breeding, rearing/nursery, feeding, migrating, aggregations[5]
    - Hotspots of diversity/productivity
    - Areas important for vulnerable or threatened species (e.g. Critical Habitat)
    - Sensitive Benthic Areas
    - Areas with rare features or unique genetic populations
    - Examples of mammal Significant Areas used MPA Network planning in the NSB:
        - Identification of Important Areas in the Pacific North Coast Integrated Management Area[42, 43]
        - Habitat of special importance for transient killer whales and fin whales[44]
        - Critical habitat for Northern and Southern Resident Killer Whale and humpback whale
- Habitat Proxies

General Discussion and MS Teams Chat
A general discussion about gaps, potential synergies and priorities for future work followed. The discussion was guided by the following six questions, however not all were explicitly addressed as the discussion evolved.

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[41] Gregr, E. J., Nichol, L. M., Watson, J. C., Ford, J. K., & Ellis, G. M. (2008). Estimating carrying capacity for sea otters in British Columbia. *The Journal of Wildlife Management*, *72*(2), 382-388.

[42] Clarke, C.L., and Jamieson, G.S. 2006. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase II – final report. Canadian Technical Report of Fisheries and Aquatic Sciences 2686.

[43] Clarke, C.L., and Jamieson, G.S. 2006a. Identification of Ecologically and Biologically Significant Areas in the Pacific North Coast Integrated Management Area: phase I - Identification of Important Areas. Can. Tech. Rep. Fish. Aquat. Sci. 2678

[44] Ford, J.K.B, E.H. Stredulinsky, J.R. Towers and G.M. Ellis. 2013. Information in Support of the Identification of Critical Habitat for Transient Killer Whales (Orcinus orca) off the West Coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/155. iv + 46 p.

1. *Can you think of any spatial data products that have not been identified that would help inform ongoing efforts?*

There was a request for more information about how the Marine Mammal Conservation Physiology Program is processing Automatic Identification System data to produce spatial data products. Broadly, the group is using CCG Automatic Identification System data and is currently in the process of determining the scope and an analysis plan with the goal of quantifying vessel density within areas of interest.

A discussion followed about whether there are plans for future systematic PRISMM surveys. DFO is legally obligated to repeat the surveys every 8 years as per the US Marine Mammal Protection Act agreement. The first PRISMM surveys were successful in establishing a baseline, however significant effort and resources were required. Future surveys will likely involve partitioning the survey into smaller and more manageable surveys.

2. *Are there other spatial data products that would be useful for other initiatives that participants are involved in?*

Question not explicitly addressed in discussions.

3. *Are there particular spatial data products (either existing data or those discussed in the presentations earlier today) that would help your initiative? If so, are there any steps that would be needed to make the data more useful for your initiative?*

The cetacean density maps produced from the PRISMM surveys were of interest to several participants, which led to a discussion about the best and most streamlined approach for requesting/sharing spatial data products when there is broad interest. The cetacean density mapping work is available on the CSAS website[45], and that the spatial data products will be made available on OpenData or GIS Hub (or other platforms). It was noted that some initiatives are interested in data that is publicly available (e.g. SSI) while other initiatives are focused on internal data (e.g. PIER).

4. *How can we work together to create spatial data products that would be more broadly useful to the multiple federal initiatives?*

Question not explicitly addressed in discussions.

5. *Are there any specific tools or other additional resources needed to better support coordination and collaboration?*

One of the deliverables for the MSP Initiative is an inventory of spatial data products. As the inventory is developed and updated, it would be useful to other initiatives. The inventory should include where the data is housed (e.g. OpenData, GIS Hub, internally).

6. *Is there a preferred mode of communication for staying current on each other's progress and/or new initiatives?*

Data for internal programs such as PIER and CEBP could be housed and documented on GIS Hub. The GIS Hub has a notification system that emails GIS Hub users when new data sets are uploaded, which could be useful for coordinating data sharing and updates with a broad audience. The MSP Program can facilitate and coordinate data sharing through platforms such as the GIS Hub. The MSP Initiative is focused on making data publicly available. The GIS Hub is a good place for getting data organized and useful for other initiatives. Data can then be pushed through to OpenData and other sharing platforms. It

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[45] Wright, B.M., Nichol, L.M., Doniol-Valcroze, T. 2021. Spatial density models of cetaceans in the Canadian Pacific estimated from 2018 ship-based surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/049. viii + 46 p.

was noted that there are considerations/restrictions for sharing data collected under Fisheries Act/SARA permits. The new National data catalogue will be coming online that will allow internal-only datasets to be uploaded which may help address restraints related to sensitive data.

Table 7: Mammals Data Session Agenda

Time	Agenda Item	Lead
1:00 pm	**Welcome and Introductions** • Workshop Overview • Roundtable	Stratos; Carrie Robb
1:10 pm	**Overview of current projects** • Overview of marine mammal data, PRISMM - Thomas Doniol-Valcroze • Pinniped surveys – Strahan Tucker, Sheena Majewski • Whales Initiative – Sheila Thornton • Otters – Linda Nichol • Spatial data overview – Katie Gale **Questions (following each presentation)**	Data experts
2:00 pm	**Discussion** • Review of existing data • Other data sources or data efforts currently underway	All participants
2:45 pm	**Future Directions** • Priorities for new spatial data products for the different initiatives • Possibilities for collaboration, future work	All participants
3:00 pm	**Adjourn**	

Algae, Plants, Habitats Data Session

Date: October 5th, 2020 (9-11 am)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Barb Sweazey
Rapporteur: Beatrice Proudfoot

Objectives

- Build relationships among science staff, highlight ongoing work and discuss data needs and priorities
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary

This section summarizes the presentations and discussions that occurred during the Algae/Plants/Habitats Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Emily Rubidge and Barb Sweazey. Joanne Lessard, Jessica Nephin, Jessica Finney, Sharon Jeffery and Emily Rubidge provided speed talks on the surveys, analyses and current/ongoing projects that they are involved in. A group discussion followed where participants discussed gaps, data sharing/availability and potential synergies. Key messages from this data session were:

- The need for a central and accessible inventory of algae/plant/habitat spatial data products
- The importance of continual communication between data producers and data users. A notification system that informs data users when spatial data products are updated/added to central repositories would be useful.
- The BC coast wide kelp maps are of interest to multiple federal initiatives.

Data Overview Presentations

Presentation Title: Substrate: Bottom Patches, Substrate Model
Presenter: Joanne Lessard (Research Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An overview on the development and status of two substrate models for the BC Coast was provided.
1. Bottom Patches[46]
   a. Spatial Extent: BC Coast, from high intertidal to 50m depth
   b. Resolution: Polygon shapefile
   c. Method: The bottom patches were produced by gathering available substrate data from a variety of sources (ShoreZone, CHS, DFO dive surveys, Parks Canada surveys), assigning a depth class and common classification developed by the Nearshore Habitat Working Group and producing polygons from the points. In areas where no observations are available, predicted bottom type values (substrate model; see below) are used.
   d. Classification System: 6 classes (3 Primary levels; 2 secondary levels; Figure 7).
   e. Data Availability: GIS Hub

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[46] Gregr, E. J., Lessard, J., & Harper, J. (2013). A spatial framework for representing nearshore ecosystems. *Progress in Oceanography*, *115*, 189-201. *Note that the Strait of Georgia was re-analyzed in 2016

Primary & 2ndary categories	Code	Description
Hard	**1**	Immobile substrates
Bedrock dominant	**1a**	Largely (>80%) bedrock
Boulder dominant	**1b**	Largely (>80%) boulders and cobbles
Mixed	**2**	Mix of hard and soft substrate;
Soft surface with patchy distribution of larger particles	**2a**	Soft sediments with patchy distribution (<80%) of cobble, boulder
Soft surface overlaying hard substrate	**2b**	Bedrock with veneer (< 80%) of soft sediments
Soft	**3**	Unconsolidated bottom type; negligible hard components
Sand/shell	**3a**	Sand/shell dominant (>80%)
Mud	**3b**	Mud dominant (>80%)

Figure 7: Bottom Patch Classification

2. Substrate Model[47] – a comprehensive model for coastal BC in the nearshore and shelf at 70-76% accuracy
    a. Spatial Extent: BC Coast divided into five nearshore regions and one shelf region.
    b. Resolution: 20m (nearshore regions); 100m shelf region
    c. Method: Random Forest Classification using the following environmental predictors: bathymetry, slope, slope (std. dev.), curvature, rugosity, bathymetric position index (BPI), ocean circulation, tidal speed and fetch. Substrate observations were sourced from CHS, Natural Resources Canada (NRCAN), and DFO dive and ROV surveys.
    d. Classification System: Rock, Mixed, Sand, Mud
    e. Data Availability: GIS Hub.

Questions/Discussion:
Question about the threshold depths at which the nearshore model outperforms the shelf model (and vice-versa).
Answer: It is variable across geographic space. It is recommended to use the 20 m model for nearshore species/habitat work and the 100 m model for species/habitat that are deeper than 50 m. However this can be challenging for species with depth distributions shallower and deeper than 50 m.

Presentation Title: Using bathymetry to locate rocky areas and assess benthic complexity
Presenter: Jessica Nephin (Aquatic Science Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An overview of two different projects that both relied on bathymetry derivatives to predict benthic habitat or complexity was provided.
1. Using bathymetry to locate rocky areas (results from Pac2017-0930 Survey)[48]
    • Objective: To locate coastal areas with high benthic diversity and coral and sponge aggregations using environmental proxies (e.g. rock, high rugosity, high current) and then validate that proxy using ROV imagery.

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[47] Gregr, E. J., Haggarty, D. R., Davies, S. C., Fields, C., & Lessard, J. (2021). Comprehensive marine substrate classification applied to Canada's Pacific shelf. *PloS one*, *16*(10), e0259156.

[48] Nephin, J., Jeffery, S., Thiess, M., Archer, S., Murdock, I., Boschen-Rose, J., and Dudas, S. 2020. Methods and results from remotely operated vehicle (ROV) survey PAC2017-030: Exploring high and low current areas in the Salish Sea. Can. Tech. Rep. Fish. Aquat. Sci. 3405: vi + 39 p.

- Environmental Data: Modelled bottom current, bathymetry, slope, BPI (fine and broad)
- Environmental Proxy: Areas with relatively high rugosity, high tidal current and either with a slope greater than 5° or where ridge or mound features were present.
- Results from ROV ground truthing surveys indicated that high current areas were found to have a greater abundance of corals and some sponges, however rocky, high rugosity areas could not be consistently identified using the environmental proxy approach, suggesting that different methods are required to identify areas of highly complex, rocky substrate.

2. Assessing benthic complexity (Rockfish Conservation Area (RCA) example)
   - Objective: Categorize RCAs based on habitat variables, including benthic complexity (surface roughness, rugosity, relief, terrain heterogeneity).
   - Complexity was calculated using bathymetric derivatives (slope and curvature), rugosity/ruggedness measures (Arc-Chord, vector ruggedness measure), relative position measures (BPI, relative difference to mean depth) and variability measures (standard deviation, interquartile range). Rugosity/ruggedness, relative position and variability measures were calculated at a range of neighbourhood sizes and scales.
   - Results of complexity calculations were used to rank RCAs by complexity. Results were affected by the quality and resolution of the bathymetry data and the neighbourhood size for moving window calculations.

Questions/Discussion
Question about whether the RCA complexity analyses could be ground truthed using ROV surveys.
Answer: Good suggestion – will have to determine the habitat variables assessed in the ROV surveys.

Presentation Title: Species Distribution Modelling: Algae, Plants, Habitats Data Layers
Presenters: Jessica Finney (Aquatic Research Biologist, ESD, Marine Spatial Ecology and Analysis)

An overview of how the Species Distribution Modelling Framework[49] has been applied to predict the distribution of algae, plants and habitats in the nearshore region of the BC Coast was provided. Species distribution modelling is a rapid and cost-effective approach for estimating suitable habitat for a species of interest. The framework provides a standardized approach to model development and facilitates the model building process by providing guidance on all stages of the model building process (including providing R code available on the MSEA Gitlab page). A knowledge-based habitat suitability modelling approach is taken for data deficient species. The MSEA Gitlab also has code for spatializing dive survey data to give quadrats geographic coordinates. Species distribution models (SDMs) were produced for eelgrass (*Zostera marina*) and pterygophora kelp. Future SDM work will refine the eelgrass SDM by using additional information (towed camera and drone survey work).

Outputs of the eelgrass and pterygophora SDMs will be available on the GIS Hub. The environmental data layers used in the models are available by on GIS Hub.

Questions/Discussion:
A discussion occurred on MS Teams about the CHS NONNA-10 (Non-Navigational 10m resolution) bathymetric data. There was a comment that the NONNA-10 data only contain data that are currently in

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[49] Nephin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. 2020. Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.

the CHS bathydatabase and that restricted data and some legacy datasets are missing. Restricted datasets are available internally.

Presentation Title: Protection by Proxy: Assessing tidal current as an indicator of biodiversity
Presenter: Sharon Jeffery (Aquatic Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

The goal of this work is to characterize invertebrate and algal diversity and richness using current speed as a proxy, with the expectation that high tidal current areas will support higher diversity and richness. High current areas could only be accessed by divers safely at slack tides, while low current areas were accessible at any time. Fourteen rocky sites (7 high current and 7 low current) in the Southern Gulf and Discovery Islands were sampled using transects (3 per site) and 1 m quadrats. Current speed, invertebrate and algal species presence, total invertebrate biomass and algal percent cover were recorded at each site. Data analyses are currently underway. Results suggest that invertebrate richness and biomass are higher at high current sites, while no significant difference in algal species was observed between high and low current sites, however algal richness was significantly higher in shallow depths compared to deeper depths.

Questions/Discussion:
Question about whether maps of high tidal current areas could be used in MSP to accurately represent areas with high invertebrate diversity.
Answer: Probably, however there are caveats. For example, one high current site had little diversity, suggesting that while current is important, there may be other factors (e.g. slope) that are important. Replicate surveys in other regions of the coast could help determine if the patterns persist.

Presentation Title: Canopy-forming Kelp: Efforts towards coast wide map
Presenter: Emily Rubidge (Research Scientist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An overview of a collaborative coast wide kelp mapping project was provided. Comprehensive kelp distribution data is required for MPA network planning, to support oceanographic modelling by informing nearshore hydrodynamic analyses, to identify important fish habitat and to quantify ecosystem services such as shoreline protection and carbon sequestration. The following methods are being used to map the distribution of kelp in BC:
- Comparing Satellites for Mapping Kelp: remote sensing approaches using Landsat8 and WorldView2 and validated using kelp transect and quadrat data. This work is done in partnership with Simon Fraser University and the Hakai Institute. Kelp is mapped using the normalized difference vegetation index (NDVI), which reflects the density of kelp at the surface. Comparative results are outlined in Table 8.

Table 8: Comparison of Landsat8 and Worldview2 satellites for kelp mapping purposes

Satellite	Resolution	Coverage	Cost	Pros	Cons
Landsat8	30m	Whole coastline	Free to access online	• Can examine trends over decades • Can be used to map whole coastline	• Cannot differentiate species • Cannot map kelp close to shore
Worldview2	1.2m	Smaller tasked regions	Cost to task satellite	• Can map part of coastline where satellite is tasked • Can map kelp closer to shore • Can differentiate kelp species	• Cost associated with tasking satellite • Difficult to map entire regions

- Google Earth Engine Kelp (GEEK) mapping tool[50]: Automates extracting, sorting and mapping kelp (using NDVI) from the Landsat Archive hosted on the Google Earth Engine The tool is available on Hakai's internal ArcGIS online. The tool can be used to quantify kelp persistence and changes in distribution over time (measured as the number of kelp detections in a pixel over time).
- Historical Kelp Distribution[51]: Kelp distribution was digitized from historical marine charts. The historical distribution data is available on OpenData and is useful for validating suitability models and may be useful for hindcasting models.
- Integrating local knowledge and multi-scale remote sensing data to map coastal habitats: The objectives of this program, funded through a Grants and Contributions agreement with MSP, are to identify consistent field methods for mapping and monitoring kelp from Baja to Alaska, to support and train Coastal Guardian Watchmen and First Nations in kelp monitoring, to update the spatial inventory of distribution and abundance of canopy forming kelp species and to develop analytical tools that integrate remote sensing and traditional and local knowledge. The program is led by Margot-Hessing-Lewis (Hakai Institute) and Rebecca Martone (MaPP).

Questions/Discussion

A discussion on MS Teams followed about the cost and feasibility of acquiring coast-wide WorldView2 imagery. Kim Tenhunen (CHS) indicated that CHS has orthophotos of the whole BC coastline at various resolutions. However, the images do not have the near infrared information required for kelp mapping because the images are used for extracting high and low waterlines only. It was also noted that the CHS has LiDAR data from Haida Gwaii (2018 and 2019) that may be useful for mapping kelp. Requests for CHS data can be done through the CHS Data Centre: CHSDataCentre.XPAC@dfo-mpo.gc.ca. The original kelp charts are available on OpenData and the CHS has continued digitizing the historical charts to add to the historic kelp distribution data set.

Archived WorldView2 data is cheaper (0.46m resolution). However, a large number of archived images would need to be acquired and examined to get full coverage of the BC coast at the appropriate season and tide height.

Presentation Title: Spatial Data Overview – Algae, Plants Habitats
Presenter: Katie Gale (Biologist, Ecosystem Sciences Division, Marine Spatial Ecology and Analysis)

An inventory of spatial data products that support MSP is currently underway. Four broad categories of algae/plant/habitat spatial data were highlighted as useful for MSP and MPA network in the Northern Shelf Bioregion
- Distribution Data
    - Observations/catch records measuring abundance, presence, presence-absence
    - Can be point data, aggregated into grids or spatially interpolated
    - Do not involve predictions and are limited to the spatial extent of input data
    - Examples of algae/plant/habitat distribution data used in previous planning exercises:

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[50] Nijland, W., Reshitnyk, L., & Rubidge, E. (2019). Satellite remote sensing of canopy-forming kelp on a complex coastline: a novel procedure using the Landsat image archive. *Remote Sensing of Environment*, *220*, 41-50.

[51] Costa, M., Le Baron, N., Tenhunen, K., Nephin, J., Willis, P., Mortimor, J. P., ... & Rubidge, E. (2020). Historical distribution of kelp forests on the coast of British Columbia: 1858–1956. *Applied Geography*, *120*, 102230.

- - - Eelgrass, kelp and surfgrass bioband data from ShoreZone mapping compiled by the British Columbia Marine Conservation Analysis (BCMCA)
    - Bull kelp, giant kelp and eelgrass beds compiled by the BCMCA
    - Estuary polygons from Pacific Estuary Conservation Program
  - Spatial data derived from remote sensing and predictive modelling approaches
    - Single or multi-species observations are correlated with environmental variables to predict presence our abundance outside the sampled area
    - Examples of algae/plant/habitat species distribution/habitat suitability models used in previous planning exercises:
      - Chlorophyll-a concentration and bloom frequency in the Northern Shelf Bioregion[52]. Chlorophyll-a concentration and bloom frequency data for the BC Coast are available on GIS Hub. Note that nearshore areas are less certain due to cloud cover.
      - Eelgrass and pterygophora kelp species distribution models[53]
  - Proxies for high species diversity
    - Examples of algae/plant/habitat species distribution/habitat suitability models used in previous planning exercises:
      - Areas of high rugosity (BCMCA)
      - Areas of high tidal current[54]
      - Habitat richness hotspots[50]
  - Physical/Ecological Classifications
    - Examples of algae/plant/habitat species distribution/habitat suitability models used in previous planning exercises includes
      - Bottom Patches[44]
      - Pacific Marine Ecological Classification System (PMECS)[55]
      - BC Marine Ecological Classification System (BCMEC)[56]

Questions/Discussion

Question about whether the chlorophyll-a satellite data are ground truthed with CTD or water column analyses of chlorophyll-a.
Answer: This would be a good approach to validating – but not sure if work is currently underway or planned to validate the chlorophyll-a layers. There is a group at the Bedford Institute of Oceanography that is processing and validating satellite data for use by DFO Science[57] using several methods, including the NASA standard product.

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[52] Rubidge, Emily, Nephin, J, Gale, K.S.P., & Curtis, J. 2018. Reassessment of the Ecologically and Biologically Significant Areas (EBSAs) in the Pacific Northern Shelf Bioregion. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/053. xii + 97 p.

[53] Nephin, J., Gregr, E.J., St. Germain, C., Fields, C., and Finney, J.L. 2020. Development of a Species Distribution Modelling Framework and its Application to Twelve Species on Canada's Pacific Coast. DFO Can. Sci. Advis. Sec. Res. Doc. 2020/004. xii + 107 p.

[54] Rubidge, E., Jeffery, S., Gregr, E.J., Gale, K.S.P., and Frid, A. 2020. Assessment of nearshore features in the Northern Shelf Bioregion against criteria for determining Ecologically and Biologically Significant Areas (EBSAs). DFO Can. Sci. Advis. Sec. Res. Doc. 2020/023. vii + 63 p.

[55] Rubidge, E., Gale, K.S.P., Curtis, J.M.R., McClelland, E., Feyrer, L., Bodtker, K., and Robb, C. 2016. Methodology of the Pacific Marine Ecological Classification System and its Application to the Northern and Southern Shelf Bioregions. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/035. xi + 124 p.

[56] https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/nr-laws-policy/risc/bcmec_version_2.pdf

[57] Clay, S., Peña, A., DeTracey, B., & Devred, E. (2019). Evaluation of Satellite-Based Algorithms to Retrieve Chlorophyll-a Concentration in the Canadian Atlantic and Pacific Oceans. *Remote Sensing*, *11*(22), 2609.

Question about efforts to improve point data on eelgrass and kelp observations, such as those included in the BCMCA dataset.

Answer: A contractor is updating the BCMCA/MPATT data to incorporate newer data sources and, as part of this work, features are separated out based on buffered points or lines. We are retaining those data as a separate source because, while less precise, they might be useful for some purposes.

General Discussion and MS Teams Chat

Four questions guided the group discussion about gaps, potential synergies and priorities for future work. The discussion was guided by the following four questions, however not all were explicitly addressed as the discussion evolved.

1. *Can you think of any spatial data products that have not been identified that would help inform ongoing efforts?*

A habitat template and grain size model was developed for the BC coast[58] and may be useful for participants working on species distribution modelling or to refine/validate existing substrate classifications.

2. *Are there other spatial data products that would be useful for other initiatives that participants are involved in?*

and

3. *Are there particular spatial data products (either existing data or those discussed in the presentations earlier today) that would help your initiative? If so, are there any steps that would be needed to make the data more useful for your initiative?*

A coast-wide kelp dataset that delineates the location of the kelp in the water column (e.g. canopy forming vs. understory) and its persistence over multiple years would be useful for PIER, although likely time and resource intensive to produce. The goal of the GEEK tool (discussed above) is to map kelp using available satellite imagery to track and monitor changes in kelp persistence and sea otter reestablishment of kelp. The tool was able to detect changes in kelp canopy cover over a 30 year time series. The GEEK tool is currently being tweaked to address commission issues due to the differing quality/conditions for the imagery tiles and to modify the tool for Sentinel-2 Satellite data (10m resolution). There are plans to create a canopy kelp SDM using data from the shellfish database, the benthic habitat mapping program and Hakai.

A brief discussion about understory kelp mapping followed. Data collected through the Benthic Habitat Mapping program would likely be appropriate for mapping understory kelp.

4. *How can we work together to create spatial data products that would be more broadly useful to the multiple federal initiatives?*

A discussion about data access, availability, and challenges associated with maintaining and up-to-date inventory followed. Some of the data sources discussed during this session are available on OpenData, while others such as the SDMs discussed will be available the GIS Hub before they are added to OpenData. DFO Staff can obtain access to the GIS Hub by contacting Cole Fields. CHS data is stored across several websites and portals. Contact the CHS Data Centre for data requests: CHSDataCentre.XPAC@dfo-mpo.gc.ca

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[58] Gregr, E.J., Gryba, R., Li, M.Z., Alidina, H., Kostylev, V., and Hannah, C.G. 2016. A benthic habitat template for Pacific Canada's continental shelf. Can. Tech. Rep. Hydrogr. Ocean Sci. 312: vii + 37 p.

There was considerable participant interest in having an inventory of existing data that could be hosted on Teams or on the R: drive that could be accessed and updated by those producing the spatial data products and avoid versioning challenges. Steve Schut has been working on an authoritative inventory of spatial data products relevant for MSP that will include information on the data custodian and platform where the data are hosted, but has not determined where the inventory will be housed once it is complete. It was noted that the ReSDaC team might be a good option for posting updates related to data inventories.

Table 9: Algae, Plants, Habitats Data Session Agenda

Time	Agenda Item	Lead
9:00 am	**Welcome and Introductions** • Workshop Overview • Roundtable	Stratos; Emily Rubidge
9:10 am	**Overview of current projects** • Substrates and Bottom Patches - Joanne Lessard • Rocky Areas and Bottom Complexity - Jessica Nephin • Species Distribution Models - Jessica Finney • High/Low Current Habitat Research – Sharon Jeffery • Kelp Mapping - Emily Rubidge • Spatial data overview – Katie Gale **Questions (following each presentation)**	Data experts
10:00 am	**Discussion** • Review of existing data • Other data sources or data efforts currently underway	All participants
10:45 am	**Future Directions** • Priorities for new spatial data products for the different initiatives • Possibilities for collaboration, future work	All participants
11:00 am	**Adjourn**	

Salmon Data Session

Date: October 20th, 2020 (9-11 am)
Location: Virtual (MS Teams)
Organizers: Cathryn Murray, Carrie Robb and Emily Rubidge
Facilitator: Barb Sweazey
Rapporteur: Beatrice Proudfoot

Objectives
- Build relationships among science staff, highlight ongoing work and discuss data needs and priorities
- Identify opportunities to align spatial data efforts and outputs among science staff working on spatial data

Session Summary
This section summarizes the presentations and discussions that occurred during the Salmon Data Session that was part of the Spatial Data Contributions to Federal Initiatives in the Pacific Region workshop series. The session began with a brief welcome, introduction and workshop overview provided by Steve Schut and Barb Sweazey. Diana Dobson, Sue Grant, Jackie King, Cameron Freshwater and Chrys Neville provided speed talks on the surveys, analyses and current/ongoing projects that they are involved in. A group discussion followed where participants discussed gaps, data sharing/availability and potential synergies. Key messages from this data session were:

- The need for a regional salmon database that is routinely updated and uses common naming protocols and consistent units of assessment.
- The need for resources to reconcile mismatched and inconsistent naming protocols across current databases.
- The need for simplified broad-scale products that could help a more general audience understand salmon research in addition to stock-focused spatial data products.

Data Overview Presentations
Presentation Title: Salmon Data
Presenter: Diana Dobson (Stock Assessment Biologist, Stock Assessment and Research Division, Salmon Coordination Section)

An overview of salmon population data, habitat/ecosystem assessments and issues related to data alignment was presented.
- Overview of Salmon Population Data: Salmon data are stored across multiple databases and spreadsheets and collected and analyzed by multiple sectors. A single master database of all salmon data does not exist, which means that in order to produce a stock recruitment assessment, for example, analysts need to pull from approximately 15 different data sources/databases. Periodic attempts to bring the salmon data together into a regional database have not been successful. The flow charts shown during the presentation were developed to produce a proposal for a project that would help build a regional database that is routinely updated.
- Importance of Habitat/Ecosystem Data: Understanding the limiting environmental factors/sources of mortality is required in order to strategically inform effective salmon rebuilding. Broad access to these results requires regional support and coordination.

- Alignment Issues: Uncommon units of assessment that are linked to various management frameworks is a key issue in terms of regional coordination of salmon spatial analysis efforts. For example, Conservation Units (CUs) are currently being updated and rolled up to produce Stock Management units (SMU). SMUs will be completed in the coming months. Fisheries Management Units (FMUs) will also need to be developed. The development common units of assessment that are linked to various management frameworks are needed and should be a coordinated effort across DFO sectors.

Questions/Discussion

One challenge to combining, aggregating, or integrating data across databases is differences in the scale at which data is collected (stream, reach, river, watershed, etc), and differences in naming protocols among databases and analysts (i.e. names for the sites differ slightly among databases). This becomes a major challenge when there are 1000s of sites to integrate. In one effort to combine abundance data across the New Salmon Escapement (NuSEDS), Enhancement and Planning (EPAD) and Mark-Recovery-Program databases, ("sdsynopsis" = Salmon Data Synopsis), a list of these mismatched names among databases was created. This was a big issue when the CUs were first developed and needs to be solved through reconciled look-up tables and that the new CU layer will help back check some of the naming issues. The work to reconcile the naming protocols could be overcome if there were resources available to undertake the work, however the end goal (e.g. juvenile abundance time series, spawner abundance time series) needs to be clearly outlined before the names are reconciled. Part of the performance of the salmon programs is that the data are available to others in DFO and currently this is not the case. The Pacific Salmon Explorer is a tool that makes some of the salmon data available, however it relies on static downloads. A system to efficiently product spatial data products on an annual basis is required.

Presentation Title: State of the Salmon Program
Presenter: Sue Grant (Program Head, Ecosystem Sciences Division, State of the Salmon)

An overview of DFO's State of the Salmon (SOS) Program and current activities was provided. One of the key goals of the SOS Program is to track and understand Pacific salmon trends and statuses. This is achieved through processes led by this Program that including integrative meetings and reports on the state of the salmon (listed below).

Data visualization tools are also central to the SOS Program to produce accessible and interactive mapped data on salmon statuses and trends. One key tool developed is their Salmon Status Scanner Tool for Pacific Salmon. This tool is an interactive data visualization tool designed using the R Shiny Application. Through questionnaires and user testing, this tool was specifically designed for salmon and ecosystem biological and research experts. It enables the accessibility of high quality Pacific Salmon data and information on abundance trends, and annual information on Wild Salmon Policy (WSP) rapid salmon statuses. Trend and status information is mapped onto BC/Yukon interactive watershed maps, to explore, compare, and identify key threats to salmon numbers, and to track salmon responses to environmental and climate change, and also responses to various habitat, hatchery, and fisheries management actions. Salmon data are presented at the WSP conservation unit (CU) and population scales, and can be aggregated by fisheries management unit, habitat, life-history type, etc.

A marine component will be added that includes information on where species are rearing. Salmon data sets of interest can be extracted from this tool to support more detailed analyses, and used in combination with the State of the Salmon spatial pattern analysis tool to explore covariation in trends, and identify factors contributing to salmon trends in more detail.

Key State of Salmon publications in recent years:

Grant, S.C.H., MacDonald, B.L., and Winston, M.L. 2019. State of Canadian Pacific Salmon: Responses to Changing Climate and Habitats. Can. Tech. Rep. Fish. Aquat. Sci. 3332. ix + 50 p.

Grant, SCH, MacDonald, BC, Middleton, K., Anderson, L., Sloan, L. (2019) State of the Canadian Pacific salmon: Responses to changing climate and habitats e-book: http://www.dfo-mpo.gc.ca/species-especes/publications/salmon-saumon/state-etat-2019/ebook/index-eng.html

MacDonald, B.L., Grant, S.C.H., Wilson, N., Patterson, D.A., Robinson, K.A., Boldt, J.L., King, J. Anderson, E., Decker, S., Leaf, B., Pon, L., Xu, Y., Davis, B., & Selbie, D.T. 2020. State of the Salmon: Informing the survival of Fraser Sockeye returning in 2020 through life cycle observations. Can. Tech. Rep. Fish. Aquat. Sci. 3398: v + 76 p

Questions/Discussion:

Question about whether the Scanner will be available for external use.
Answer: The Scanner will be available to select external users with technical expertise. The tool is not intended for the general public but rather for analysts working to answer specific questions. It is anticipated that the Scanner will be useful for the US-Canada Pacific Salmon Treaty process, in recovery and rebuilding planning processes and other risk assessment processes where technical analyses are required.

Question about whether the Scanner uses the same data as the Pacific Salmon Explorer
Answer: The Scanner uses similar data to the Pacific Salmon Explore, with some gaps filled using data specific to internal DFO Wild Salmon Policy work. There might be slight differences in base data, though going forward there is a real need to coordinate data and make it connected and available so that we all pull from the same core database. The salmon explorer is designed more for the general public whereas the Scanner is designed for technical end users to interact with the data and information to explore hypotheses on what is driving salmon trends.

Question about how the Scanner relates to Fisheries Information Summary System (FISS).
Answer: The data used in the Scanner is obtained directly from biologists who have expertise about the data and incorporate information from multiple databases into their datasets. The Scanner does not pull directly from any central database because the databases are not interlinked at the level required by the Scanner. The integrative work is currently done by biologists in stock assessment.

Presentation Title: Coastal Juvenile Salmon Surveys
Presenter: Jackie King (Research Scientist, Ecosystem Sciences Division, Regional Ecosystem Effects on Fish and Fisheries)

The coastal juvenile salmon trawl surveys occur in all areas except the Strait of Georgia. Coastal and migratory corridors (e.g. Johnstone Strait, Strait of Juan de Fuca) are surveyed less frequently. The WCVI continental shelf and Queen Charlotte Sound are surveyed most frequently while Hecate Strait and the west coast of Haida Gwaii are surveyed less frequently. The surveys have been ongoing since 1998, however the research objectives, focal areas and sampling design have evolved:

- 1998-2004: Surveys focused on migratory behaviour of juvenile salmon in the high seas to define cross-shelf/off-shelf distribution and migration rates. Standard transects extended from the WCVI to southeast Alaska.
- 2004-2016: Surveys focused on determining factors driving growth, survival and condition of juvenile salmon in the high seas. Standard transects were surveyed on the WCVI, Queen Charlotte Sound, Johnstone Strait and Juan de Fuca Strait.
- 2017-present: Surveys focus on salmon in the broader ecosystem, particularly climate forcing on biomass, distribution and growth and juvenile salmon in the pelagic ecosystem. Random stratified surveys occur on the WCVI and Queen Charlotte Sound.

Summer, fall and winter surveys occurred in 2001-2015. Since 2015, only summer and fall surveys are done. Chinook, Coho and Sockeye are the three main salmon species of interest. Data are published to OpenData, and include catch (counts and weights), length, weight, coded wire tag and hatchery marking. Since 2017, otoliths, stomach contents, genetic stock ID, energy density estimates and stable isotope analyses are collected for all species (including bycatch). Bycatch catch and length has been recorded since 2005. Oceanographic data is also collected (CTD, plankton, water chemistry, chlorophyll-a, dissolved oxygen). Field data is stored within the program as an MS Access database (data collected akin to GFBioField database).

Questions/Discussion
Question: Have there been any efforts to map/model juvenile salmon habitat along the coast
Answer: Yes, this work is currently underway with a number of DFO initiatives. Juvenile mapping of marine habitat use has strong links to aquaculture management, which is not integrated with planning and assessment work conducted by other DFO sectors.

Question about how to request bycatch data from these surveys
Answer: The data is held within the program and is available. Full collaboration is required.

Presentation Title: Marine Distributions of Chinook Salmon in Southern BC
Presenter: Cameron Freshwater (Biologist, Ecosystem Sciences Division, Regional Ecosystem Effects on Fish and Fisheries)

The focus of this relatively new research program is to examine how adult Chinook salmon abundance varies through space and time. The impetus for the program is SRKW recovery. SRKW critical habitat is utilized by many different Chinook stocks and life history stages. Because the program is relatively new, there is little time series data available. However this means there is flexibility to design new surveys. The research focuses on the following three datasets:
1. Fisheries- dependent catch, effort and stock composition data
   - Spatially coarse
   - Temporally comprehensive (long time series)

- Used to estimate stock- and region-specific estimates of abundance over the seasonal cycle
2. Fisheries-independent catch, effort and stock composition data
    - Spatially precise
    - Temporally limited (2 year time series)
    - Used to estimate stock-specific distributions within SRKW critical habitat
3. Movement data from acoustic tags
    - Somewhat spatially precise
    - Flexible
    - Temporally ambiguous (2 year time series)
    - Ability to capture a large proportion of seasonal cycle for each fish.
    - Used to estimate individual movement rates and stage-specific survival

Questions/Discussion

Question about whether there is any discussion around collecting fisheries-dependent data at a finer scale.
Answer: Most of the recreational catch/effort data are available as estimates at the sub-area level. However, commercial harvesters will often fish multiple zones between landings making it difficult to partition the dater into finer units. It becomes even trickier when trying to account for stock composition because individual fish are often sampled from a landing where fish from multiple vessels are pooled meaning that assigning catch to a given latitude/longitude is not feasible.

Question about how the range in areal extents of the Pacific Fisheries Management Areas (PFMAs) is accounted for.
Answer: Differences in areal extent among PFMAs aren't currently incorporated into estimates of abundance but is something we're considering adding. It's not straightforward because it is confounded by the type of fisheries that are active in those areas and the fact that some areas are utilized as migratory corridors while others are maturation grounds. When direct sampling methods are used to sample fisheries, sample information is often available at the sub-PFMA, or even site level. However, just like population data, there are issues around nomenclature (as discussed in earlier presentations).

Presentation Title: Salmon Marine Interactions Program – Formerly "Strait of Georgia Program"
Presenter: Chrys Neville (Biologist, Ecosystem Sciences Division, Regional Ecosystem Effects on Fish and Fisheries)

An overview of the Salmon Marine Interactions Program surveys, analyses and recent outputs was provided. Two survey programs have been collecting data since 1998 to determine how changes in climate are impacting salmon stocks, particularly in the first year of life:
1. Trawl Survey (early summer and fall):
    - Trawls conducted on CCG and commercial charter vessels
    - Objective: Examine the abundance, distribution and condition of juvenile Pacific salmon rearing in the Strait of Georgia
    - All bycatch species are identified and sampled
2. Salmon Marine Interactive Survey (early summer and fall)
    - Fishing conducted on standard track line during each early summer and fall survey with additional sets in associated waters
    - CTD, zooplankton, hydroacoustic and eDNA data is collected.
    - Bycatch directed sampling is depended on total catch and crew availability

Data is currently stored in excel files, and work is underway to transfer the data into a GFBio format. Work is also underway to upload the standard data to OpenData. Examples of the information that can be derived from the surveys was presented as mapped and plotted outputs:

- Distribution and CPUE by species
- Distribution and CPUE by stock (e.g. Cowichan Chinook salmon 2015)
- Migration timing (e.g. Fraser River sockeye)
- Distribution and CPUE by season (e.g. early summer vs. fall)
- CPUE and condition (length) by year (e.g. Coho salmon in September)

The list of species that are regularly captured as bycatch was also presented with the caveat that the trawl sets occur in the day time only, which means that species that concentrate in surface waters at night are missed. Pacific herring is the most abundant bycatch species. Small numbers of northern anchovy have historically been caught in the surveys, however large catches have occurred in the Strait of Georgia in the summer and fall surveys since 2015.

General Discussion and MS Teams Chat
Four questions guided the group discussion about gaps, potential synergies and priorities for future work.

1. *Can you think of any spatial data products that have not been identified that would help inform ongoing efforts?*

It was noted that habitat/ecosystem layers would be informative for integrated assessments, ecosystem based management. This requires considering what kind of habitat/ecosystems monitoring programs and/or additional population monitoring should be implemented more systematically on a regional basis. There is a chlorophyll-a layer on the GIS hub that is currently being validated by Maycira Costa's group at UVic. Fine scale spatial products representing seasonal climatologies for the coast (e.g. temperature anomalies, lower trophic levels, zooplankton, primary productivity, temperature at depth, oxygen) would be useful. Seasonal climatologies of the Northeast Pacific Ocean and Canadian Pacific EEZ (1980-2010) are in the process of being published to OpenData. More recent data is also required, ideally at a fine scale and incorporating seasonality. Andrea Hillborn (OSD) is working on producing a satellite-derived sea-surface temperature layer.

2. *Are there other spatial data products that would be useful for other initiatives that participants are involved in?*

From an MSP perspective, there is a desire for a simplified broad scale products that could help a more general audience understand salmon research. Work is underway to create broad catch and distribution maps. However, understanding stock specific trends is necessary for population recovery but may not be necessary for broader ecosystem-based management. The desired spatial product depends on the question being addressed (e.g. stock-focused or ecosystem-focused).

A project focused on examining freshwater characteristics and changes in hydrology in response to climate change to develop risk assessment tools to help understand impacts to freshwater salmon habitat is currently underway. ECCC has online maps of discharge, but it is not integrated with the SSET tool.

3. *Are there particular spatial data products (either existing data or those discussed in the presentations earlier today) that would help your initiative? If so, are there any steps that would be needed to make the data more useful for your initiative?*

The PIER initiative is interested in the fine scale and local distribution of juvenile and adult salmon by stock and season for spill response planning. The SSI requires publicly available spatial data products that can be used by a more general audience

4. *How can we work together to create spatial data products that would be more broadly useful to the multiple federal initiatives?*

There have been efforts to compile and analyze salmon data as per the [GFSynopsis approach](#), which produces fully transparent, reproducible and visual outputs. The State of the Salmon Program has also been working toward creating spatial summaries similar to those produced in the GFSynopsis reports.

Table 10: Salmon Data Session Agenda

Time	Agenda Item	Lead
9:00 am	**Welcome and Introductions** • Workshop Overview • Roundtable	Stratos; Steve Schut
9:10 am	**Overview of current projects** • Sue Grant • Diana Dobson • Jackie King • Cameron Freshwater • Chrys Neville **Questions (following each presentation)**	Data experts
10:00 am	**Discussion** • Review of existing data • Other data sources or data efforts currently underway	All participants
10:45 am	**Future Directions** • Priorities for new spatial data products for the different initiatives • Possibilities for collaboration, future work	All participants
11:00 am	**Adjourn**	

Acknowledgements

Appendix 1: Workshop Participants

Participant	Introductory	Groundfish/ Rockfish	Pelagic Fish	Invertebrates	Mammals	Algae/Plants/ Habitats	Salmon
			Session Attended				
Agbayani, Selina	x	x	x	x	x	x	x
Anderson, Erika							x
Anderson, Sean		x					
Andrews, Chris (Stratos)	x	x	x	x	x	x	
Araujo, Andres				x			
Ashbrook, Chelsea	x						
Barton, Leslie	x			x			
Baxter, Bruce	x						x
Beckett, Janine	x	x			x	x	x
Benner, Keri		x	x	x		x	x
Benoy, Nick		x	x	x	x	x	x
Berry, Kathryn	x				x	x	x
Best, Merlin	x						
Bigg, Michelle	x			x	x	x	x
Boldt, Jennifer	x		x				
Breton, Michel	x				x		
Brown, Tamara			x	x			
Bureau, Dominique				x			
Burke, Lily	x	x	x	x	x	x	x
Candy, John	x						
Clyde, Georgia	x						
Cornthwaite, Maria		x					
Covert, Paul	x			x		x	
Dangerfield, Neil	x			x			
Davies, Sarah	x			x		x	
Detering, Jackie	x						
Dobson, Diana							x
Doniol-Valcroze, Thomas	x				x		
Dudas, Sarah				x		x	
Edwards, Andrew			x				
English, Philina		x					

Participant	Introductory	Groundfish/ Rockfish	Pelagic Fish	Invertebrates	Mammals	Algae/Plants/ Habitats	Salmon
Evans, Rhian		x					
Favaro, Corinna	x	x			x	x	x
Fields, Cole	x				x	x	
Finney, Jessica	x			x		x	x
Flemming, Rob				x			
Flostrand, Linnea			x				
Fong, Ken				x			
Forrest, Robyn		x			x		
Fraser, Tamara		x			x	x	x
Freshwater, Cameron							x
Gale, Katie	x	x	x	x	x	x	x
Galus, Michal	x						
Ganton, Amy		x	x	x	x	x	xx
Gauthier, Stephane			x				
Gillespie, Kayleigh		x	x	x	x	x	x
Grant, Sue							x
Grinnell, Matthew			x				
Guan, Lu	x	x	x	x	x	x	x
Gunderson, Rebecca	x	x	x	x			
Haggarty, Dana	x	x					
Hannah, Lucie	x						
Herunter, Herb				x			
Hilborn, Andrea	x					x	
Hodes, Vanessa			x	x	x	x	x
Hodgson, Emma	x						x
Holmes, John	x						
Holt, Carrie							x
Howard, Brett	x			x			
Hunter, Karen	x						
Iacarella, Josephine	x						x
Irvine, Jim	x						x
Jarjour, Jasmine	x						
Jeffery, Sharon						x	x

Participant	Introductory	Groundfish/ Rockfish	Pelagic Fish	Invertebrates	Mammals	Algae/Plants/ Habitats	Salmon
Johnston, Terry		x		x	x	x	
Kennedy, Eddy	x						
Khan, Reziah	x						
King, Jackie							x
Klaver, March	x						
Konrad, Christine	x	x			x		x
Kronlund, Rob	x						
Lacko, Lisa		x					
Lafontaine, Rebecca (Stratos)							x
Lazin, Gordana						x	
Lemieux, Jeffrey	x	x		x		x	
Lessard, Joanne	x	x	x	x	x	x	x
Lewis, Dawn	x						
Liao, Xiangjun	x						
Lochead, Janet				x			
Longtin, Caroline	x	x	x	x	x	x	x
MacConnachie, Sean	x						
MacNeill, Shaun	x			x			
Marentette, Julie	x						
Matsushiba, Jay					x		
McCorquodale, Brenda	x						
McMillan, Christie			x				
Morgan, Erin	x						
Mortimor, James	x						x
Mossman, Janet	x			x	x	x	
Murray, Cathryn	x	x	x	x	x	x	x
Nelson, Jocelyn	x	x	x	x	x	x	x
Nephin, Jessica		x	x	x	x	x	
Neville, Chrys			x				x
Nguyen, Hai				x			
Nichol, Linda					x		
Norgard, Tammy	x			x	x	x	
Nutton, Byron	x						

Participant	Introductory	Groundfish/ Rockfish	Pelagic Fish	Invertebrates	Mammals	Algae/Plants/ Habitats	Salmon
O, Miriam	x				x		
O'Brien, Claire	x						
Ogden, Athena							x
Ollerhead, Neil						x	
Olsen, Norm		x					
Park, Ashley	x	x	x	x	x	x	x
Patten, Bruce	x						
Pegg, James	x						
Peña, Angelica		x					
Peramaki, Liisa	x						
Poehlke, Travis							x
Ponader, Karin	x						
Porszt, Erin				x			
Proudfoot, Beatrice	x	x	x	x	x	x	x
Robb, Carrie	x	x	x	x	x	x	x
Robinson, Cliff	x		x				
Rooper, Chris	x	x	x				
Ross, Andrew	x						
Ross, Tetjana	x						
Rubidge, Emily	x	x	x	x	x	x	x
Salter, Natasha	x		x	x		x	
Sastri, Akash	x						
Schut, Steve	x	x	x	x	x	x	x
Shartau, Ryan		x					
Shaya, Lana	x	x	x	x	x	x	
Shervill, Dan					x		x
Shimomura, Miki	x						
Simpson, Kyle	x						
St. Germain, Candice				x		x	
Stewart, Hannah		x		x		x	
Stiff, Howard							x
Stoneman, Mike	x						
Stredulinksy, Eva					x		

Participant	Introductory	Groundfish/ Rockfish	Pelagic Fish	Invertebrates	Mammals	Algae/Plants/ Habitats	Salmon
Sweazey, Barb (Stratos)	x	x	x	x	x	x	x
Sweeten, Ted	x						
Tabata, Amy							x
Templeman, Nadine	x						
Tenhunen, Kim	x					x	
Thompson, Matthew			x				
Thompson, Patrick	x	x	x	x	x	x	
Thornton, Sheila					x		
Toews, Scott					x	x	x
Tucker, Strahan					x		
Verrin, Stacey	x						
Warawa, Devon	x						
White, Hilary	x						
Williams, David	x						
Wills, Pete	x						
Workman, Greg	x	x					
Wright, Brianna					x		
Wyeth, Malcolm		x					
Young, Kelly	x						
Zhang, Zane				x			