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Report of the Study Group on Marine Pollutants

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Report of the Study Group on Marine Pollutants

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Executive Summary

The Study Group on *Marine Pollutants* (SG-MP, 2011–2013) brought together participation and feedback from all six PICES member countries. This report reflects the Terms of Reference established for the SG-MP in 2011.

Following a kickoff workshop on "*Pollutants in a changing ocean: Refining indicator approaches in support of coastal management*" at PICES-2011 (Khabarovsk, Russia), the SG-MP has since convened a workshop on "*Traditional seafoods of coastal aboriginal communities in the North Pacific*" at PICES-2013 (Nanaimo, Canada) and two Topic Sessions on "*Environmental contaminants in marine ecosystems: Seabirds and marine mammals as sentinels of ecosystem health"* at PICES-2012 (Hiroshima, Japan) and "*Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans"* at PICES-2013.

Despite some variations in the priorities of member countries, there was broad agreement on a list of important marine pollution issues for the North Pacific Ocean. The expressed support of multilateral groups with shared interests, including ICES (International Council for the Exploration of the Sea), GESAMP (Group of Experts on Scientific Aspects of Marine Pollution) and NOWPAP (Northwest Pacific Action Plan), provides a basis for collaborative efforts in the future.

Based on SG-MP recommendations, a new Working Group on *Emerging Topics in Marine Pollution* was established to build on the foundation of past and current activities regarding marine pollution in the North Pacific. This Working Group plans to convene several Topic Sessions and workshops at PICES Annual Meetings during 2014–2016, which is expected to lead to three special issues in international peer-reviewed journals, and to make a contribution to the next PICES North Pacific Ecosystem Status Report.

1 Introduction

During a workshop on "*Pollutants in a changing ocean: Refining indicator approaches in support of coastal management*" held at PICES-2011 in Khabarovsk, Russia (see Appendices 8.4 and 8.5), participants recommended to the Marine Environmental Quality Committee (MEQ) that a Study Group on *Marine Pollutants* be established to identify opportunities for a revitalized PICES interest in this topic area. The proposal was supported by MEQ and Science Board and subsequently approved by Governing Council. In order to allow its parent committee, MEQ, time to re-align its Action Plan with PICES' integrative science program, FUTURE, and for the SG-MP to follow suit for making recommendations, the mandate of the Study Group was extended in 2012 to a second year. This report summarizes the discussions carried out by the SG-MP in support of its Terms of Reference (Appendix 8.1) during 2011–2013.

Marine pollution is widely considered to be one of the main threats from human activities to the world's oceans. Contaminants may enter the ocean through direct, point source releases (ships, municipal waste water effluent, industrial discharges, and accidental spills), or through indirect, non-point source means (atmospheric deposition, river discharges, and terrestrial runoff).

Some of the 'hot topics' pertaining to marine pollution in the North Pacific Ocean include:

- Long-range transport and deposition of atmospheric pollutants,
- Catastrophic and episodic pollutant releases,
- Effects of climate change on pollutant transport, fate and effects,
- Oil spills, oil and gas exploration,
- Maritime transportation management (emissions, antifoulants, and ballast water),
- Seafood safety (risk-benefit),
- Biomagnification of pollutants in food webs,
- Marine debris and microplastics,
- Aquaculture,
- Radiation,
- 'Pathogen pollution' from agricultural runoff and municipal waste effluent.

While the term 'contaminant' describes the release of a substance from human activities into the environment, the term 'pollutant' is typically used when the contaminant impacts the health of biota or humans. Since the 'poison is in the dose', the extent to which any one contaminant elicits adverse effects depends on the sensitivity of the organism in question and the concentration of the contaminant in its habitat.

The use, release, and/or disposal of approximately 100,000 chemicals on the global market has direct implications for the health of the world's oceans since they represent the ultimate 'sinks' for anthropogenic pollutants. While risk assessments and/or technical documentation provide decision makers in national governments with elementary chemical, physical, and toxicological information in support of national regulations, there is very little information on the fate and effects of chemicals in the marine environment. This underscores the distinct need for research, and for information sharing, in the area of marine pollution in the North Pacific.

While monitoring of specific contaminants entering the ocean typically reflects the need to assess the adequacy of regulations or compliance with discharge permits, research tends to be carried out by scientists in support of a management question, the needs of a granting agency, or a government priority. However, curiosity has often created the impetus for research pursued by individual investigators.

This report does not provide a comprehensive overview of all pollution issues that are relevant to the PICES community. However, it does give input to the broader PICES community on:

- some of the priority pollutants in the North Pacific Ocean as identified by scientists from PICES' six member countries.
- some of the promising indicator approaches or 'sentinel species' that are being used within the PICES community, or elsewhere, and could be used more widely across PICES member countries.
- some of the opportunities to share technical information on logistical, analytical, and/or field study methods in support of improved and/or standardized methodologies that could be used by all PICES member countries.

Feedback from national representatives of the six PICES member countries (Appendix 8.2) throughout 2011–2013 (Appendix 8.3) provided the basis for this document. Deliberations were used to answer the points above, and to identify activities and opportunities for PICES to build on its marine pollution capacity, alone or in partnership with select international organizations. A framework document prepared prior to PICES-2012 in Hiroshima served as a basis for a one-day SG-MP meeting (see Appendix 8.4). Participants at this meeting strengthened and clarified the framework for the report, drafted and annotated final draft text for the report, and developed proposals for consideration by MEQ and Science Board. Further discussions during 2012–2013 culminated in a final meeting at PICES-2013 in Nanaimo, Canada. The ultimate objective of the SG-MP was to design a proposal (plan) for future PICES activities related to marine pollution.

2 Pollutant Priorities

The diversity of contaminants entering the ocean from human activities makes it necessary to summarize and prioritize contaminants by broad category. While SG-MP members from each PICES member country provided slightly divergent lists of top pollutant concerns, there was broad agreement on a basic list of common interests in the North Pacific Ocean. There was also tacit recognition that contaminants are not measured in environmental matrices simply to describe their presence, absence, or trends but more importantly because they can present risks to the health of wildlife and/or humans.

The evaluation of status, trends, and effects of different pollutants of concern in the North Pacific Ocean provides ecosystem-based information in support of chemical regulations, source control, seafood consumption guidelines or advisories, and fisheries management. The ultimate goal of marine pollution research and monitoring is to reduce the release of pollutants that can affect commercial and recreational fisheries, endangered wildlife, and human health. Major categories of pollutants in the North Pacific include the following.

2.1 Persistent bioaccumulative and/or toxic contaminants

Definition

Persistent bioaccumulative and/or toxic (PBT) chemicals, consisting of both 'legacy pollutants' and 'emerging pollutants', represent a group of substances that are not easily degraded, accumulate in organisms, and exhibit an acute or chronic toxicity. They may, therefore, pose serious concerns for human and environmental health.

Context

Many PBT compounds are also semi-volatile, a property which permits these compounds to vaporise, undergo long-range transport through air and water, and finally deposit far from their point of release, such as a neighbouring country, the open ocean, polar regions, and alpine environments. Because of these features, PBTs are considered a major global environmental concern. While the Stockholm Convention facilitated the development of national regulations which have reduced the concentrations of many 'legacy' pollutants, the persistence of these pollutants means that many continue to present risks to biota. Research is also needed to document the trends and effects of many unregulated 'emerging pollutants'. PICES member countries will all benefit from an ocean-wide approach to examine priority marine pollutants.

Relevance

Contamination of the marine environment by PBT substances degrades the integrity of valuable ecosystem components and threatens seafood safety. PBT substances have been shown to accumulate in abiotic matrices in coastal areas adjacent to sources, amplify in high trophic level organisms (some fish, seabirds and marine mammals), and in commercially available invertebrates and fish. The accumulation of PBT substances in marine organisms has been shown to cause mutation, cancer, endocrine disruption, immunosuppression and developmental abnormalities.

Study in the Pacific region

Monitoring of PBT substances in coastal environments is carried out by individual nations, with few examples of information sharing or international cooperation in the North Pacific Ocean.

Important PBT pollutants of concern identified by SG-MP members were:

- Polychlorinated biphenyls (PCBs),
- Organochlorine pesticides,
- Dioxins/furans,
- Organic flame retardants (PBDEs, HBCD),
- Perfluorinated compounds,
- Current-use pesticides and formulants,

- Antifoulants (organotins, creosote, wood preservatives, copper, zinc pyrithione, irgarol),
- Pharmaceuticals and personal care products (PPCPs).

2.2 Hydrocarbons

Definition

Organic compounds are comprised of hydrogen and carbon, and usually do not contain an oxygen atom. Hydrocarbons are classified into two main groups according to chemical structure: aliphatics and aromatics.

Context

Hydrocarbons are the primary components of petroleum such as crude oil and fuel, sometimes derived from coal. Alkane, the main aliphatic hydrocarbon, is very abundant in petroleum and susceptible to microbial degradation in marine environments. There are fewer aromatic hydrocarbons than aliphatics in petroleum. However, aromatic hydrocarbons are more resistant to microbial degradation such that some recalcitrant aromatic hydrocarbons remain in marine environments for prolonged periods of time. There are two groups of polycyclic aromatic hydrocarbons (PAHs) according to their origins: petrogenic and pyrogenic. Hydrocarbon contamination in marine environments is considered an index of human activity. PAHs are regarded as mid- or long-range (trans-boundary) transport air pollutants.

Relevance

Some aromatic hydrocarbons are known to exert adverse effects in aquatic biota, and some high molecular weight PAHs such as benzo(a)pyrene are known to be potent carcinogens. Concentrations of PAHs in sediments can readily exceed sediment quality guidelines near industrial centers (*e.g.*, harbours, sewage outfalls, steel works, and petroleum refineries).

Study in the Pacific region:

PAHs are studied in some locations by PICES member countries, but there exist no multi-national or international monitoring networks or programs in the North Pacific region. PAH measurements are carried out following oil spills.

A number of approaches to measuring the thousands of naturally-occurring and anthropogenic PAHs exist, but Study Group members categorized the determination of PAHs as follows:

- Pyrogenic and petrogenic PAHs (*e.g.*, 16 U.S. EPA PAHs and alkylated PAHs),
- Total petroleum hydrocarbons (TPHs) as a bulk indicator during spills.

2.3 Metals or elements of concern

Definition

A number of elements have been identified that may pose risks to the health of marine biota or humans. These include metals such as mercury (Hg), lead (Pb) and cadmium (Cd), which occur naturally in marine food webs but can reach harmful levels through both natural processes (*e.g.*, Cd in shellfish due to geology and upwelling; methyl-Hg in high trophic level biota from biomagnification) and human activities (*e.g.*, Hg due to release from coal-fired generating stations).

Context

Metals/elements.

Relevance

High levels of certain elements can present a risk to some wildlife and humans. Depending on the element, these risks can be attributed to point sources or activities, feeding ecology (*e.g.*, filter-feeders which can concentrate some elements), specific tissues (some elements are concentrated in the liver or other organs), or high trophic levels (such as the amplification of methyl-Hg in marine food webs).

Study in the Pacific region

Important elements of concern identified by Study Group members were:

- Mercury (Hg) and methyl-Hg,
- Lead (Pb),
- Cadmium (Cd),
- Radionuclides.

2.4 Microplastics and marine debris

Definition

These 'structural pollutants' may be defined as any manufactured or processed solid waste material (typically inert) that enters the marine environment from any source (marine litter, floatables) (Coe and Rogers, 1997). Microplastics are small plastic marine debris less than 1 or 5 mm in size (depending on criteria for size definition). Microplastics are either intentionally manufactured ('primary microplastics', *e.g.*, pellets, scrubbers, and abrasives) or result from the breakdown of larger items ('secondary microplastics', *e.g.*, plastic fragments, fibers and sheets).

Context

Marine debris, especially microplastics, is a global concern, as it transcends national boundaries and can lead to trans-Pacific movement. Plastic debris in the ocean is persistent and is expected to last for hundreds of years. The global production of plastics is increasing, suggesting that the North Pacific may face increasing pressures from plastic pollution.

Relevance

Marine debris causes direct adverse effects on a variety of marine animals (seabirds, marine mammals, sea turtles, and fish) by entanglement and ingestion. While 'macroplastics' can cause obvious and lethal effects, microplastics present a more poorly understood risk to biota. Microplastics may be ingested and may contain absorbed toxic chemicals and additives. There is increasing evidence of the occurrence of microplastics in various marine animals, from invertebrates to marine mammals, including seafood stuffs (mussel, crab and fish stomachs). In addition, marine debris can transport non-indigenous species across the ocean. Marine debris, including microplastics, currently causes visible and tangible socio-economic impacts by affecting tourism, the fisheries industry, maritime safety, and ecosystem services.

Study in the Pacific region

The identification of the 'North Pacific Garbage Patch' highlights the pan-Pacific nature of this problem. There are increasing numbers of reports about marine debris in coastal areas of the Pacific, but few documenting microplastics. There exist no multi-lateral or international efforts to document or track marine debris or microplastics trends or effects in the North Pacific Ocean.

2.5 Biological pollution

Definition

Because of the high population density in some parts of the North Pacific Rim, coastal environments face a variety of pollution problems involving marine organisms, *e.g.*, bacteria contamination which is mostly caused by fecal coliform, and harmful algal blooms caused by eutrophication which may lead to human health risk by shellfish toxins.

Context

Fecal coliform is commonly used as an indicator of fecal contamination, more specifically of *E. coli* which is an indicator microorganism for other pathogens that may be present in feces.

Eutrohpication is caused mainly by excess nutrients, with the two most important kinds being nitrogen and phosphorus.

In shellfish, five groups of toxins have been distinguished: paralytic shellfish toxins causing paralytic shellfish poisoning (PSP), diarrhetic shellfish toxins causing diarrhetic shellfish poisoning (DSP), amnesic shellfish toxins causing amnesic shellfish poisoning (ASP), neurotoxic shellfish toxins causing neurotoxic shellfish poisoning (NSP), and azaspiracid shellfish toxins causing azaspiracid shellfish poisoning (AZP). All these toxins have been recorded to cause mortality in people consuming shellfish.

Relevance

High concentrations of fecal coliform can harm marine environments and the human dimension (*e.g.*, aquaculture, recreational beaches). Large quantities of fecal coliform bacteria in coastal areas, especially in bathing areas and coastal resorts, may indicate a higher risk of pathogens being present in the waterbody. Some waterborne pathogenic diseases that may coincide with fecal coliform contamination include ear infections, dysentery, typhoid fever, viral and bacterial gastroenteritis, and hepatitis A. The

presence of fecal coliform tends to affect humans more than it does aquatic organisms, though not exclusively. Therefore, it is a compulsory indicator monitored for beach and coastal recreation areas.

Although nutrients are essential for organisms to live, too much in the ocean, especially in the coastal area, *e.g.*, a bay, can cause some problems. In the North Pacific Rim, excess amounts of nitrogen and phosphorus are the main cause of the poor health of the oceans, *e.g.*, eutrophication or algal blooms. Some species of harmful algal blooms can produce shellfish toxins, which can not only do harm to marine biota, *e.g.*, mussels, scallops, crabs, and fish but can also pose a risk to human health *via* the seafood containing the toxins, resulting in adverse social and economic effects for coastal communities.

Study in the Pacific region

In the PICES member countries, fecal coliform has to be monitored in bathing areas and coastal recreational areas. Nutrients, especially nitrogen and phosphorus, are the most important items for the regular monitoring program, and shellfish toxins have to be assayed to ensure the safety of seafood. Biological pollutants of potential concern include:

- Fecal coliform,
- Nutrients,
- Shellfish toxins.

3 Pollutant Indicators

Indicators of pollution represent approaches to pollution research and monitoring that are practical, relevant, scientifically defensible, and cost-effective. The choice of indicator varies with the pollutant(s) being targeted. They can provide an effective integrated message to managers (*e.g.*, response to regulations, source control, remediation, risk-based evaluation of seafood safety, general ecosystem indicators). While a variety of matrices supply measures of environmental contamination (air, water, sediments), indicators give broader context, *e.g.*, toxicological, physiological, ecological, health. SG-MP members reviewed some of the indicator approaches that are being used in some countries, but could also be applied more broadly in support of data sharing in PICES.

3.1 Status and trends of pollutants over space and time

Water is both a route of exposure to organisms and a transport pathway for pollutants. As a matrix or medium, water can be limited due to the dilution of, for example, hydrophobic pollutants, leading to low concentrations and analytical challenges. Recent studies of both persistent organic contaminants and specific current-use pesticides have reported net deposition to the North Pacific (Ding *et al.*, 2007; Cai *et al.*, 2012).

Sediments are habitat for infauna and other benthic organisms, a sink/reservoir for many pollutants, and a route of exposure. Sediments are valuable for indicating both recent localized accumulation of contaminants, and through use of cores, temporal trends from long-term deposition. Sediments have been used to demonstrate the increased deposition of PAHs to the East China Sea (Guo *et al.*, 2006). Sediment cores have shown the long-term history of PCB and PBDE contamination to the Salish Sea (Johannessen *et al.*, 2008).

Air is a pathway of dispersion and transport as well as a potential route of exposure for many pollutants. Air sampling is valuable for documenting episodic events due to fast dispersion and transport time and short sampling periods. Recent examples have documented outflow of organic pollutants from sources in Asia and deposition to the North Pacific (Primbs *et al.*, 2007) or to the Arctic.

Shellfish are effective accumulators and integrators of pollutants adhered to particles suspended and transported in the water column. Therefore, they indicate specific particle-bound pollutants such as PAHs, other organic pollutants, and heavy metals. Recent studies have made effective use of mussels and other shellfish to show temporal trends of heavy metals in coastal and open waters of the Northwest Pacific (Kavun *et al.*, 2002; Kovekovdova *et al.*, 2006).

Marine mammals are often long-lived top predators, with large habitat needs and can, therefore, serve as sentinels of marine food web contamination (Ross *et al.*, 2000). Recent studies of harbour seals have revealed declining temporal trends in a number of flame retardant contaminants, reflecting response to regulations (Ross *et al.*, 2013).

Seabirds are widely distributed, feeding on a range of marine organisms from zooplankton to fish, and so can effectively sample pollutant accumulation in different components of the marine environment. They can also be active biotransporters of pollutants. A variety of recent studies have reported temporal and spatial trends of organic pollutants and heavy metals in marine birds from the North Pacific (Harris *et al.*, 2003; Ueno *et al.*, 2003; Finklestein *et al.*, 2006).

Fish, due to their biodiversity and economic value, contribute extensively to marine ecosystem services. Fish integrate contaminants over the full range of benthic to pelagic compartments and can act as biotransport vectors from marine to terrestrial ecosystems. Many recent studies have used fish as bioindicators of organic and inorganic pollutants (Boyarova *et al.*, 2004; Cullon *et al.*, 2009; Lukyanova, 2013).

Benthos, such as polychaetes or crustaceans, accumulate pollutants mainly from detritus in sediments. Thus, they indicate/reflect the pollution in sediments. They are also important in benthic–pelagic coupling processes through being eaten by other marine organisms such as flatfish.

Seaweeds accumulate heavy metals effectively in their cell walls and can be used for site-specific monitoring of local contamination from mining and other natural and anthropogenic sources (Khristoforova and Kozhenkova, 2002; Khristoforova and Chernova, 2005; Kozhenkova *et al.*, 2012).

Microplastics are plastic particles from industrial feed stock for plastic products or degraded plastics discharged along with human activities. Although they are considered as pollutants themselves, their persistence in the marine environment and their capacity to attract hydrophobic pollutants enable them to serve as an indicator of pollutant transfer in the North Pacific. Recent studies demonstrate the ability to monitor PCBs, DDTs, and HCHs worldwide, including the North Pacific (Ogata *et al.*, 2009; Andrady, 2011).

3.2 Pollutant-related risks and effects in biota

Evidence of specific effects of contaminants from subtle early-warning molecular responses to population- or community-level impacts leading to loss of ecosystem stability, productivity, diversity, and other services include the following.

Shellfish have been extensively used in, for example, Mussel Watch programs to test for levels of both pollutants and endpoints such as metabolic disturbances, *e.g.*, oxidative stress, and formation of DNA adducts (Choi e*t al.*, 2010; Lukyanova *et al.*, 2009).

Marine mammals have some of the highest levels of persistent contaminants found in the world's animals. While the complex contaminant mixtures to which marine mammals are exposed make it difficult to identify effects attributed to single chemicals, carefully controlled studies have observed PCB-related effects in free-ranging harbour seals, ringed seals and killer whales using cellular and molecular techniques (Mos *et al.*, 2006; Routti *et al.*, 2010; Buckman *et al.*, 2011). Life history-based modelling techniques have described the PCB risks to long-lived marine mammals wherein killer whales from the Northeast Pacific will not be 'protected' from the adverse effects of PCBs until the end of the 21st Century (Hickie *et al.*, 2007).

Seabirds and aquatic counterparts have been widely used to study the effects of persistent bio-accumulative and toxic (PBT) compounds on biota. Endpoints investigated range from molecular biomarkers such as induction of specific P450 enzymes to critical life history parameters, reproduction and survival, and even population stability (Sanderson *et al.*, 1994; Harris *et al.*, 2003).

Fish, especially flatfish, given their ecologic and commercial importance, have been extensively researched for the effects of pollutants. Endpoints include molecular biomarkers, neoplasia, endocrine disruption, reproduction, survival and population stability, including commercially important species, and subsequent impacts on fisheries and coastal communities.

Benthos have been used extensively to assess the extent of organically rich conditions. For example, specific polychaete species become abundant in such conditions. In meiobenthic communities, copepods are more vulnerable than nematodes to low oxygen and higher concentration of PCBs.

3.3 Pollutant-related risks and effects in humans

The North Pacific supplies food for many people, with coastal and aboriginal communities relying on seafood much more heavily than other segments of the population. While seafoods provide an important source of nutrients, they also represent a dietary source of contaminants of potential concern. This implies the need for an evaluation of both risks and benefits associated with the various foods consumed. Protecting these aquatic foods from contamination is in the best interest of people or populations that depend heavily on fish and other seafood.

The general population

While contaminants (notably those with PBT properties) are found in all foods, aquatic foods can have higher contaminant concentrations compared to terrestrial foods. This is due to the preferential partitioning into the lipids of aquatic food webs and the food web-based amplification of many persistent contaminants. Studies have documented adverse

effects in humans, but typically such reports have been limited to occupation and/or accidental exposures.

Vulnerable communities or segments of the population

Some segments of the general population or some communities are at increased risk of heightened exposure to persistent contaminants. Neonates are typically exposed to higher levels of persistent contaminants than adults at a time when they are most sensitive. Studies have found that PCBs and related compounds are associated with 'small for gestational age' at birth, disruption of endocrine systems, reduced immune function, lasting spatio-motoral skills deficits, and reduced I.Q. in the more exposed individuals (Koopman-Esseboom *et al.*, 1996, 1997). In addition, some communities with individuals who consume large quantities of seafoods have been shown to be more contaminated and to exhibit increased frequencies of adverse health outcomes (Jacobson and Jacobson, 1996). These communities can include coastal populations, sportfishers, recreational fishers, and immigrant communities.

Aboriginal communities

The surprising discovery in the 1980s that Canada's Inuit people in the Far North were some of the world's most contaminated people underscored the capacity of chemicals to undergo long-range transport and the special vulnerability of people who consume large quantities of fish and marine mammals (Dewailly *et al.*, 1989).

4 Method Development, Sharing and Inter-calibration for Marine Pollution Research and Monitoring: Opportunities for PICES

4.1 Analytical techniques

There exists a variety of means of detecting and quantifying trace amounts of chemicals, biological markers and measures of individual or population health. However, there is an urgent need to improve comparability across studies and laboratories. Some examples where such a need is evident include:

- Standardized methods to characterize and quantify microplastics,
- Inter-laboratory calibration exercises for chemical analysis,
- Sediment chemistry normalization techniques,
- Hydrocarbon fingerprinting,
- Biomarkers for exposure and effect (*e.g.*, imposex from organotins, endocrine disruption in fish and wildlife),
- Pathogen identification (biological pollution, bacterial source tracking),
- New approaches to considering the cumulative risks associated with complex mixtures (humans and wildlife).

4.2 Study designs

There exists a variety of field methodologies, survey designs or sampling regimes that generate new insight into ocean pollution. However, there is a distinct need to adopt Pacific-wide approaches in order to improve comparability of results, as well as new approaches to evaluating the cumulative impacts of pollution:

- New risk assessment approaches for wildlife using data from environmental media (water, sediment, prey),
- A North Pacific monitoring program (*e.g.*, International Pellet Watch, U.S. Mussel Watch, passive air and water samplers, seabird eggs and feathers, marine mammal blubber),
- Sampling of marine mammals and seabirds using non-destructive techniques,
- Looking at confounding factors in study design and how to avoid them,
- Improvement of ship-based sampling techniques, especially air,
- Development of a rapid response strategy (equipment, personnel, protocol).

5 Collaborative Opportunities with Other International Organizations

Two international organizations, ICES (International Council on the Exploration of the Sea) and GESAMP (Group of Experts on the Study and Assessment of Marine Pollution) have thus far indicated an interest in the outcomes of the SG-MP. NOWPAP (Northwest Action Plan) has also shown an interest in possible collaboration. Joint activities (topic sessions, workshops, inter-laboratory calibration exercises, and integrated assessments) between PICES and other organizations will provide leveraging and added value. Current expert groups and activities on marine pollution for ICES include:

- WG on Marine Litter (WG-ML; proposed for 2014),
- WG on Biological Effects of Contaminants (WGBEC),
- WG on Marine Chemistry (MCWG),
- WG on Marine Sediments (WGMS),
- WG on Pathogens and Diseases of Marine Organisms (WGDMO),
- SCICOM Steering Group on Human Impacts on the Environment (SSGHIE),
- Integrated assessments on ecosystems (5 regional WGs),

GESAMP provides independent assessment of global datasets, advising the UN and sponsors, and identifying new and emerging chemicals (foresight). GESAMP efforts usually involve expert groups in a 3-year term. These currently include:

- WG 1: EHS Working Group (evaluating the transport of hazardous substances),
- WG 34 on Ballast Water,
- WG 37 on Mercury and Its Compounds (metal inputs, distribution and fate, particularly Hg),
- WG 38 on Atmospheric Input of Chemicals to the Ocean (open ocean; nutrients, dust and iron; ship emissions; CO_2 drawdown/acidification),
- WG 39 on Global Trends in Pollution of Coastal Ecosystems (history of ocean pollution through sediment cores (IAEA dated cores; may expand to corals, mussels, *etc*. using laser ablation),
- WG 40 on Sources, Fate and Effects of Micro-plastics in the Marine Environment – A Global Assessment.

6 Conclusions and Recommendations

While the SG-MP pondered some of the many pollution concerns in the North Pacific, the members concluded that it would be worth targeting a few selected topics for examination. In this light, the SG-MP proposed to establish a new Expert Group on *Emerging Topics in Marine Pollution* (EG-ETMP) in order to provide leadership on this topic in PICES by convening a series of Topic Sessions and workshops, by organizing special issues in international peer-reviewed journals, and by contributing to the next PICES North Pacific Ecosystem Status Report. The active engagement of all six PICES member countries throughout the two years of activities convened by the SG-MP suggests that there exists broad support for this new Expert Group, the proposal of which is provided below.

General objectives

Pollution can adversely affect the health and abundance of marine biota, especially in densely-populated coastal areas. The downstream socio-economic consequences can be significant, with numerous examples of consumption advisories, commercial fishery closures, commercial trade interdictions and diminished aboriginal access to food resources around the North Pacific Ocean. The protection of ecosystem health and services requires an ability to detect emerging pollutant issues before serious adverse impacts arise. Regulations, policies and other management actions resulting from marine pollution research in the past have led to dramatic declines in environmental concentrations of a number of harmful pollutants, subsequently improving the health of marine biota.

The proposed EG-ETMP will provide leadership on emerging pollution issues to the PICES community, reporting through the MEQ Committee. The group will convene a series of timely Topics Sessions and workshops, and coordinate special issues in international peer-reviewed journals. The EG-ETMP will ensure the continued availability of expertise on marine pollutants within PICES, and deliver guidance to the FUTURE Advisory Panels (notably AP-AICE and AP-SOFE). The group will collaborate with other PICES expert groups in co-convening activities or compiling data. Importantly, the proposed EG will address the question identified in the FUTURE Science Plan "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*"

Terms of Reference

1. Document and profile emerging marine pollution issues in the North Pacific Ocean within the PICES community by:
   a. convening Topic Sessions and workshops on new and emerging pollutants and pollution issues;
   b. coordinating a series of special issues in international peer-reviewed journals based on Topic Sessions.
2. Compile data on pollution indicators describing spatial and temporal status, trends and impacts in the North Pacific Ocean in support of a contribution to the next edition of the PICES North Pacific Ecosystem Status Report.
3. Strengthen partnerships to deliver Topic Sessions/workshops and to publish special issues with:
   a. other PICES expert groups, especially those identified in the FUTURE Science Plan;
   b. other multilateral organizations, including the International Council for the Exploration of the Sea (ICES), the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), and the Northwest Pacific Action Plan (NOWPAP).
4. Contribute to FUTURE by publishing a final report summarizing results of Expert Group deliberations.

Proposed activities 2014–2016

The Expert Group on *Emerging Topics in Marine Pollution* will engage in specific activities that will identify contaminants of emerging concern, prioritize pollutants from the many sources, and assess the relative importance of pollutants among other natural and anthropogenic stressors. Members will contribute to discussions and strategic planning with the MEQ Committee as well as through other PICES expert groups. The proposed group will build on the success of a number of activities carried out by the SG-MP, including two workshops (2011, Khabarovsk: *Pollutants in a changing ocean: Refining indicator approaches in support of coastal management* and 2013, Nanaimo: *Traditional seafoods of coastal aboriginal communities in the North Pacific: Insight into food, social and ceremonial uses at Snuneymux'w First Nation in Nanaimo, British Columbia*) and two Topic Sessions (2012, Hiroshima: *Environmental contaminants in marine ecosystems: Seabirds and marine mammals as sentinels of ecosystem health*; 2013, Nanaimo: *Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans*). The proposal for establishing this Expert Group will benefit from the current support of ICES and GESAMP.

Topic Sessions at PICES Annual Meetings

- 2014: *Marine debris in the North Pacific Ocean: source, transport, fate and effects of macro- and micro-plastics* (solicit expert input from WG 29 on the role of ocean currents in shaping marine debris transport and fate; co-sponsored by NOWPAP, GESAMP and ICES);
- 2015: *Indicators of emerging marine pollution issues in the North Pacific Ocean* (co-convene a session with WG 28 on multiple stressors, WG 30 on radiation, and S-HD, and with support of AP-SOFE, AP-AICE and AP-MBM);
- 2016: *Sources, transport and fate of hydrocarbons in the marine environment*, including oil spills, vessel emissions, long-range transport (co-convene a session with partners to be determined, and with support of AP-AICE).

Meetings/Workshops

- 2014: EG-ETMP meeting, data compilation;
- 2015: *Indicators of emerging marine pollution issues in the North Pacific Ocean* (co-convene a data compilation workshop with WG 28, and with support of AP-MBM);
- 2016: *Oil spill monitoring and characterization* (co-convene a workshop with the Korean Institute of Ocean Science and Technology (KIOST)).

Special journal issues

- 2015: Marine debris in the North Pacific;
- 2016: North Pacific pollution indicators;
- 2017: Sources, transport and fate of hydrocarbons in the North Pacific.

Compilation of data for marine pollution

Compiled data for marine pollution indicators and findings will be delivered to multiple PICES expert groups, in particular to AP-SOFE, in support of the next North Pacific Ecosystem Status Report.

The Expert Group will directly address the following questions of the FUTURE program:

3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

3.1 What are the dominant anthropogenic pressures in coastal marine ecosystems and how are they changing?

- By characterizing emerging pollution priorities in the North Pacific Ocean.

3.2 How are these anthropogenic pressures and climate forcings, including sea level rise, affecting nearshore and coastal ecosystems and their interactions with offshore and terrestrial systems?

- By documenting the impacts of emerging pollutants in the North Pacific Ocean, especially in coastal environments, and in a changing ocean environment.

3.3 How do multiple anthropogenic stressors interact to alter the structure and function of the systems, and what are the cumulative effects?

- By collaborating with other expert groups to document importance of marine pollution relative to multiple stressors.

3.4 What will be the consequences of projected coastal ecosystem changes and what is the predictability and uncertainty of forecasted changes?

- By developing approaches to pollutant indicators that account for climate variability and change.

- By characterizing changing pollution risks as climate changes.

3.5 How can we effectively use our understanding of coastal ecosystem processes and mechanisms to identify the nature and causes of ecosystem changes and to develop strategies for sustainable use?

- By prioritizing pollutant sources and types in support of source control, regulations and best practices.
- By translating compiled data and findings through the PICES North Pacific Ecosystem Status Report to formats that are understandable to the general public and a wider audience.

Proposed membership*

Recommended Co-Chairmen:

Peter S. Ross (Canada)
Won Joon Shim (Korea)
Olga Lukyanova (Russia)

Proposed members:

John Elliott (Canada)
Zhengguo Cui (China)
Zijun Xu (China)
Ziwei Yao (China)
Shigeru Itakura (Japan)
Hideaki Maki (Japan)
Sang Hee Hong (Korea)
Hyo-Bang Moon (Korea)
Mikhail Simokon (Russia)
Joel Baker (USA)
Staci Simonich (USA)
Gina Ylitalo (USA)

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*The additional members for new Expert Group on *Emerging Topics in Marine Pollution* will be designated by each PICES member country based on their expertise related to the new EG topics.

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8 Appendices

8.1 Study Group on *Marine Pollutants* Terms of Reference

Statement of Purpose

The purpose of the Study Group on *Marine Pollutants* (SG-MP) is to identify novel or promising approaches to monitoring pollutant trends over space and time, and to evaluate impacts on biota at the population level. The Study Group will establish a list of priority substances and pollutant indicators in PICES member countries using a series of case studies (*e.g.*, microplastics in seawater, seabird egg monitoring for persistent organic pollutants (POPs) over time; risk-based ranking of complex pollutant mixtures in sediments). This will help identify those methods or approaches that would benefit from harmonization (*e.g.*, characterization of heterogeneous microplastic content in seawater or biota), and improve data delivery and scientific advice to managers and stakeholders.

While the SG-MP will focus on impacts to biota, linkages will be established with those efforts that describe socio-economic impacts of pollution (*e.g.*, fisheries closures, consumption guidelines, impacts on endangered species, special vulnerability of coastal and indigenous peoples). Input from regional and international bodies such as ICES (International Council for the Exploration of the Sea), GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) and NOWPAP (Northwest Pacific Action Plan), will increase efficiencies and the scientific value of the SG-MP outcome.

The establishment of the SG-MP is consistent with the FUTURE Science Plan component 3 (*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*), and contributes insight into the structure, function and resilience of ecosystems as in components 1 and 2. This will allow a critical evaluation of highly complex pollutant mixtures, clarify priority concerns in the North Pacific, and provide a platform to assess the relative importance of pollutants compared to other stressors.

Terms of Reference

1. Identify novel or promising approaches to operational marine pollution assessment in PICES member countries by:
   a. establishing a list of priority pollutant concerns for each of the PICES member countries;
   b. identifying useful indicators of status, trends and effects; and
   c. identifying those issues or methods that would benefit from harmonization.
2. Identify interactions within PICES scientific committees and expert groups that will complement the Study Group and will be consistent with the ecosystem approach espoused by FUTURE.
3. Explore potential partnerships with other professional or multilateral organizations (*e.g.*, ICES, GESAMP, NOWPAP) which could lead to joint activities (working group, sessions, publications), improve efficiencies and strengthen scientific outcomes.
4. Develop recommendations for a possible PICES expert group on marine pollutants.

8.2 Study Group on *Marine Pollutants* membership

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8.3 Detailed national feedback by PICES member countries

Below are detailed country-by-country responses from which summaries in sections 2, 3, and 4 were produced.

Q1: Pollutant priorities

Canada:
- Persistent organic pollutants (*e.g.*, PCBs, PBDEs, HBCD, PFOA) as per Stockholm Convention,
- Emerging POPs (*e.g.*, deca BDE, HBCD, replacement flame retardants),
- Mercury (Hg; methyl-Hg),
- Petroleum hydrocarbons,
- Microplastics.

China:
- Nutrients (nitrate, nitrite, ammonia, phosphate, silica in water column; N:P ratio, N:Si ratio),
- Total petroleum hydrocarbons (TPHs): TPHs in water column and sediments,
- Fecal pollution in recreational waters (*E. coli*, fecal coliform, and *Enterococcus* in seawater),
- Shellfish toxins: PSP, DSP, ASP, Ciguatera fish poisoning, *etc*.

Japan:
- PBDEs,
- HBCDs,
- TBT,
- HBCD.

Korea:
- Organochlorine compounds (especially PCBs and DDTs),
- Brominated flame retardants (especially PBDEs and HBCD),
- Perfluorinated compounds (especially PFOA and HBCD),
- Microplastics.

Russia:
- POPs,
- Hydrocarbons,
- Microplastics and other marine debris,
- Heavy metals (Cd, Pb).

USA:
- Combustion-derived contaminants (PAHs, PCDDs, PCDFs, Hg and other metals,
- Episodic events (*e.g.*, large-scale fires, oil spills, tsunamis),
- Marine debris including microplastics.

Q2: Indicators

Canada:
- Eggs of fish-eating birds (storm petrels, alcids, cormorants), feathers, regurgitate, blood,
- Marine mammal (harbour seals) biopsies (skin/blubber),
- Sediment (surficial, sediment cores).

China:
- Shellfish monitoring for organotins (mussels and oysters),
- PAH fingerprints in sediments,
- Antibiotics and antibiotic resistance in marine aquaculture waters and sediments, and in the harvested product,
- PBDEs in environmental media.

Japan:
- Contaminant measurements in sediments.

Korea:
POPs:
Concentrations and congener patterns of POPs and biomarker (*e.g.*, EROD activity) responses in the following marine organisms:
- Mussels or oysters,
- Fish (livers and muscles),
- Seabirds (eggs, feather and livers),
- Marine mammals (Cetacean: minke whale, common dolphin, finless porpoise and seals/blubbers and livers).

Microplastics:
Abundance of microplastics (< 1 mm) and mesoplastics (> 1 mm, < 25 mm) in the following matrices:
- Stranded-line on shore,
- Microlayer at sea,
- Subtidal sediments,
- Marine organisms (visceral mass of bivalves and stomachs of fish and sea birds).

Russia:
- Shellfish,
- Fish (flatfish),
- Marine mammals and seabirds,
- Sediments.

USA:
- Shipboard measurements to research magnitude of the flux of chemicals to the Pacific Ocean, as well as characterize their spatial distribution,
- Development of indicators or study designs aimed at monitoring or characterizing episodic events,
- No standardised methods currently available for microplastics characterization.

Q3: Methods

Canada:
- Characterization and quantification of microplastics in seawater, zooplankton, other biota (fish, seabirds, marine mammals),
- New approaches to characterizing risks to wildlife from contaminants in environmental media (prey, water, sediments) and in new chemicals (regulatory scrutiny).

China:
- Biomarkers for organotins,
- Fingerprint or source identification methods for PAHs in the marine environment. Identification of PAHs other than the 16 USEPA PAHs,
- Development of an indicator for the identification of pathogenic organism identification resulting from fecal pollution,
- Capacity building and inter-calibration exercises for analytical methods.

Japan:
- Methods to normalize concentrations in sediments (such as total organic carbon, median diameter),
- Methods to assess risks of PBDEs or HBCDs to marine organisms.

Korea:
POPs:
- Methods to collect samples from marine mammals, including live capture and release with biopsies or dart biopsies,
- Methods to collect samples from seabird eggs, preen gland oil, *etc*.
- Analytical methods for multi-residue contaminants and (or) their metabolites,
- Development of a POPs monitoring program (or network) in the North Pacific region.

Microplastics:
- Size classification and nomenclature of small plastics,
- Sampling method of microplastics on shore and at sea,
- Separation, isolation and identification methods of microplastics,
- Analytical methods of POPs on and in microplastics,
- Indicators of microplastic pollution,
- Establishment of a microplastic monitoring program (or network) in the North Pacific region.

Russia:
- North Pacific monitoring program,
- Sampling marine mammals and seabirds using non-destructive techniques,
- Methods to collect samples and avoid confounding factors in the field,
- Standardized methods to characterize and quantify microplastics.

USA:
- Improved methods to sample air pollutants (on ships) and avoid contamination from ship emissions of combustion by-products,
- A strategy of pre-deployed sampling equipment and trained personnel assembled in ‘rapid response teams’ to assess acute impacts of episodic events,
- Standardised sampling/assessment methodologies for marine debris, both large and small. Methods needed to assess debris sources, ages of debris (weathering), and impacts.

8.4 Topic Session/workshop summaries and reports from past Annual Meetings

PICES Twentieth Annual Meeting (PICES-2011)
October 14–23, 2011
Khabarovsk, Russia

Summary of Scientific Sessions and Workshops

MEQ Workshop (W3)
Pollutants in a changing ocean: Refining indicator approaches in support of coastal management

October 14, 2011

Co-sponsored by: *GESAMP, ICES and IOC*

Co-Convenors: *Kris Cooreman (ICES/Belgium), Peter Kershaw (GESAMP/UK), Olga Lukyanova (PICES/Russia) and Peter Ross (PICES/Canada)*

Background

Many anthropogenic pollutants impact marine environmental quality, with coastal zones being particularly vulnerable. Persistent organic pollutants (POPs) are a concern because they magnify in food webs and present health risks to humans and wildlife. Other chemicals are less persistent, but may nonetheless impact the health of biota. While some pollution indicators are ensconced into monitoring and management regimes in different nations over space and time, new pollutant concerns may not yet be captured by existing protocols. These include "micro-plastics", the breakdown products of debris and other forms of structural pollutants, which can clog the gills of invertebrates and fish, and asphyxiate seabirds and marine mammals. In addition, these micro-plastics may adsorb some of the other chemical contaminants and transfer them to marine organisms. This workshop reviewed ways in which chemical and structural pollutants enter the marine environment, are transported through ocean currents and/or biological transport, and impact marine biota. The workshop reviewed several examples of pollution indicators used by different nations, as a basis for improving and/or expanding indicator approaches in the North Pacific Ocean. These examples also critically evaluate the extent to which changing baselines (*e.g.*, climate variability) may impact on source/transport/fate processes and effects on biota, and recommend means of improving the utility and reliability of current indicator/ monitoring approaches in a changing world.

The objectives of this workshop were to:
(1) Critically review 3–5 examples of currently used indicators of marine contamination in different PICES member countries (*e.g.*, shellfish monitoring of PAHs, metals, persistent organic pollutants, fecal bacteria; POPs in seabird eggs and marine mammals); list advantages and disadvantages for each, and describe management/policy linkages; Consider the influence of changing climate on indicator performance and ways to address this.
(2) Review emergent pollutant concerns and in particular, examine the topic of plastics and micro-plastics as structural pollutants and as mechanisms for the transfer of contaminants to marine biota; examine existing and/or new opportunities to establish indicator approaches to plastic pollution, and review sampling and analytical methods.
(3) From these applied examples/case studies, identify opportunities for future PICES activities on the topic of marine pollution:

- evaluate feasibility of establishing Study Group on Marine Contaminants, including terms of reference, membership, and deliverables;
- describe the scope of PICES/FUTURE activities that focus on contaminants in the North Pacific marine environment;

- update and revise MEQ Action Plan elements on marine contaminants;
- identify potential interactions with IOC/ICES/GESAMP/NOWPAP/NOAA programs that focus on contaminants in the marine environment.

Summary of Workshop

Dr. Peter Kershaw (United Kingdom) described the mandate and activities of the United Nations-sponsored Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), which provides expert advice on priority topics, as well as assessments of regional and global environmental concerns. One activity that is relevant to PICES is the GESAMP effort to identify pollution indicators for the United Nations Transboundary Waters Assessment Programme (TWAP) in groundwater, rivers, lakes, Large Marine Ecosystems (LMEs) and open oceans. In addition, GESAMP has a number of Working Groups that are active in relevant areas, including 'mercury, cadmium and lead' (WG37), 'the historical inputs of contaminants into coastal ecosystems' (WG39), 'source, fate and effects of micro-plastics in the marine environment' (WG40). In addition, a new Correspondence Group is being established to evaluate the 'biomagnification of pollutants in top predators'.

Dr. Kris Cooreman (Belgium) described the aim within the ICES realm for integrated science in support of management. Dr Cooreman stressed that fisheries regulations were ineffectual when the root causes of reduced fish stocks are unrelated to fishing. In addition to a recent example of a population-level impact related to a single chemical (the antifoulant tributyltin and reduced shrimp stocks), other European examples include the effects of PCBs and DDT on reproduction and health of seabirds and marine mammals. A long history of interest in the area of marine pollution positions ICES well to partner with PICES on subjects of mutual interest into the future.

Dr. Joel Baker (USA) led discussions and activities on the topic of micro-plastics, which provided a basis for the field trip on the Amur River the following day. This pollutant category encompasses a wide variety of types, sizes, shapes, colours and origins for 'structural pollutants', highlighting the need for improved standardization of assessment methods. Major challenges, and hence opportunities for collaboration in the North Pacific, include: methods to detect and quantify, distribution over space, and effects on biota (including invertebrates, fish, turtles, seabirds and marine mammals).

Dr. Annamalai Subramanian (Japan) delivered an overview of POPs and metals in the Asia-Pacific region. The concentrations of different contaminants of concern have been quantified in some of the hundreds of invertebrate, fish, seabird and marine mammal species for which samples have been stored at the Environmental Specimen Bank for Global Monitoring at Ehime University, Japan. Results reveal widespread environmental responses to the use, disposal and regulation of many of the POPs. Of note was the influence of the biology of the species selected on the contaminant message: sessile mussels provided evidence of 'local' contamination, while migratory albatross and northern fur seals provided a more regional or 'global' contaminant signal.

Local participants, including Olga Lukyanova, Mikhail Simokon and Vasiliy Tsygankov, described some of the priority concerns along the coastline of the Russian Far East and adjacent waters. While human population density is relatively low in this region, there exist concerns about offshore oil and gas exploration and development in the Sea of Okhotsk, metals related to local industrial activity, radioactive releases, and POPs and biological pollutants from global sources.

Workshop Recommendations

To recommend establishing a one-year Study Group on *Marine Pollutants* to:

- Identify novel approaches to operational marine pollution assessment by developing a list of priority pollutant concerns in each PICES nation; identifying indicators of status, trends and effects; harmonizing

methods to evaluate their effects on biota; and describing case studies which illustrate the effectiveness of indicators in informing the success of remedial actions.
- Identify interactions within PICES scientific committees and expert groups that will complement the SG-MP, and be consistent with FUTURE.
- Explore potential partnerships with other organizations which could lead to joint activities, improve efficiencies and strengthen scientific outcomes.
- Develop recommendations for a PICES expert group on marine pollutants.

List of papers

Oral presentations

Peter J. Kershaw (Invited)
Pollution indicators in the marine environment – A GESAMP perspective

Kris Cooreman, Roel Smolders, Yves Verhaegen, Koen Parmentier, Patrick Roose and Guy Smagghe (Invited)
Building expert knowledge to reach integrated scientific advice for marine management

Annamalai Subramanian and Shinsuke Tanabe (Invited)
Contamination by persistent organic pollutants in the Asia-Pacific region

Joel E. Baker, Julie Masura, Gregory Foster and Courtney Arthur (Invited)
Abundance, distribution, sources and potential implication of microplastic particles in coastal waters of the North Pacific region

Poster presentations

Natalia Pichugina and Vladimir Goryachev
The radioactive pollution of hydrobionts at the place of nuclear accident in the Chazhma Bay, the Japan Sea

Vasiliy Yu. Tsygankov, Margarita D. Boyarova, Peter A. Tyupeleev and Olga N. Lukyanova
Persistent organic pollutants (POPs) and mercury (Hg) in organs of the grey whale (*Eschrichtius robustus*) from the Bering Sea

Mikhail V. Simokon and Lidiya T. Kovekovdova
Mercury in the bottom sediments of Peter the Great Bay (Japan/East Sea)

Mikhail V. Simokon
Environmental pollution monitoring of Far Eastern Seas

Zou Ya-Rong, Zou Bin and Liang Chao
Multiple index marine oil spill information extraction research

Zou Ya-Rong, Zou Bin and Liang Chao
Using the SAR to analyze marine oil spill polarization characteristics

Extracted from:

2011 Report of the Marine Environmental Quality Committee

AGENDA ITEM 6
Proposed Study Group on *Marine Pollutants* (SG-MP)

Drs. Olga Lukyanova and Peter Ross convened workshop (W3) on "*Pollutants in a changing ocean: Refining indicator approaches in support of coastal management*" at PICES-2011) with contributed support from GESAMP, ICES, and IOC. The workshop included presentations by 4 invited speakers, a series of brief "power-talks", discussions sessions, and presentation of 6 posters. During the workshop, participants discussed the role and scope of international collaborative work on the issue of marine pollutants and contaminants, and developed a proposal for a Study Group to report through the MEQ Committee. It is widely recognized that pollution of the North Pacific marine environment has affected fish and wildlife in some regions at the population level, and has led to socio-economic impacts such as commercial fishing closures, barriers to commercial trade, and restrictions on seafood consumption. Improving approaches to pollution assessments among PICES member countries may help to alleviate many of these problems, and could better inform

managers and stakeholders in addressing emerging pollution issues. The purpose of the proposed Study Group is to identify novel or promising approaches to monitoring pollutant trends over space and time, and to evaluate impacts on biota at the population level. The Study Group will establish a list of priority substances and pollutant indicators in PICES member countries using a series of case studies (*e.g.*, microplastics in seawater, seabird egg monitoring for POPs over time; risk-based ranking of complex pollutant mixtures in sediments). This will help identify those methods or approaches that would benefit from harmonization (*e.g.*, characterization of heterogeneous microplastic content in seawater or biota), and improve data delivery and scientific advice to managers and stakeholders.

PICES Twenty-first Annual Meeting (PICES-2012)
October 12–21, 2012
Hiroshima, Japan

Summary of Scientific Sessions and Workshops

BIO/MEQ Topic Session (S6)
Environmental contaminants in marine ecosystems: Seabirds and marine mammals as sentinels of ecosystem health

October 17, 2012

Co-sponsored by: *JSPS*

Co-convenors: *Peter Ross (Canada), Hideshige Takada (Japan) and Yutaka Watanuki (Japan)*

Background

Urban and industrial developments in the world's coastal regions have led to the release of a large number of pollutants (heavy metals, POPs, plastics, oils, radioactive substances) into the marine environment. In some cases, these have detrimental effects on variety of marine resources in coastal and offshore areas. It is increasingly important to identify sources, subsequent transport through marine physical systems and resulting spatial patterns of these anthropogenic stressors. Compared to river-lake systems, knowledge of anthropogenic stressors in marine systems is less understood due to difficulties with detection over wide areas and in offshore regions. As top predators, such as many marine mammals and seabirds, bio-magnify some of these pollutants, these organisms can be used as bio-indicators of coastal, marine and/or food web contamination. The utility of these 'sentinels' was discussed at the PICES-2011 MEQ Workshop. This session: 1) identified spatial patterns and geographic areas of concern (high concentrations) of pollutants or other stressors in the PICES region using bio-indicator species, 2) examined mechanisms of transport, and ultimate disposition, of contaminants in marine ecosystems, and 3) discussed health risks for certain predators and human consumers. Review papers, case studies, and innovative methods papers on anthropogenic stressors in marine predators were invited, as well as papers that distinguished between the effects of natural and anthropogenic stressors. In particular, studies linking predator habitat use with spatial aspects of stressors in the environment and in predators were encouraged.

Summary of presentations

Ten talks (5 from Japan, 2 from Canada, 1 from Korea, 1 from Russia, and 1 from UK,) and 4 posters (all from Russia) were given. Spatial patterns and interannual changes in POPs (Persistent Organic Pollutants), including PCBs, DDTs, HCHs, and PBDs in marine birds and some terrestrial birds were presented, and their usefulness as bio-indicators were discussed. A common theme among many of the presentations was the need to consider age and the trophic level as important factors when evaluating and comparing contaminants levels among species or populations. Case studies of monitoring marine debris ashore and POPs in plastic pellets were also presented. Forty to 50 people, including bird and mammal researchers, geochemists, and biochemists attended the session and gave useful discussion. The co-convenors discussed the potential for a review paper on the usefulness and limitation of marine birds and mammals as indicators of marine pollutants, and the spatial patterns of POPs shown by them in the PICES region.

List of papers

Oral presentations

Andy Sweetman, John Crosse, Richard Shore, Gloria Pereira and Kevin Jones (Invited)
Long term trends in PBDE concentrations in gannet (*Morus bassanus*) eggs from two UK colonies

Rei Yamashita, Hideshige Takada, Mai Miyazaki, Takashi Yamamoto, Akinori Takahashi, Maki Yamamoto, Philip N. Trathan and Yutaka Watanuki (Invited)
Persistent organic pollutants (POPs) in preen gland oils from streaked shearwaters reflect exposure in overwintering areas

Sang Hee Hong, Gi Myung Han, Won Joon Shim, Sung Yong Ha and Nak Won Heo
Concentrations and profiles of persistent organic pollutants (POPs) in birds collected from an urbanized coastal region of South Korea

Annamalai Subramanian and Shinsuke Tanabe
Developing Asian countries as sources of pollutants to the Asia-Pacific region

John E. Elliott, Kyle H. Elliott, Melanie F. Guigueno, Laurie K. Wilson, Sandi Lee and Abde Idrissi (Invited)
Seabirds are indicators of persistent contaminants in the marine environment: Examples from the Pacific Coast of Canada

Peter S. Ross
Persistent Organic Pollutants (POPs) in marine mammals: Harmless chemicals or lingering poisons?

Vasiliy Yu. Tsygankov, Margarita D. Boyarova, Anna A. Lukashkina, Peter A. Tyupeleev, Ilya A. Shcherbakov, Yuri V. Prikhodko and Olga N. Lukyanova
Marine mammals as bioindicators of persistent toxic substance (PTS) contamination in Russian Subarctic marine ecosystems

Atsuo Ito, Rei Yamashita, Hideshige Takada, Takashi Yamamoto, Kozue Shiomi, Carlos Zavalaga, Takuya Abe, Shinichi Watanabe, Maki Yamamoto, Katsufumi Sato, Hiromi Kohno, Ken Yoda, Tomohiko Iida and Yutaka Watanuki
POPs in the preen gland oil of streaked shearwaters breeding on the islands in Japan reflect marine pollution in western North Pacific

Atsuhiko Isobe, Shin'ichiro Kako and Etsuko Nakashima (Invited)
Marine/beach plastic litter as a transport vector of pollutants

Kosuke Tanaka, Hideshige Takada, Rei Yamashita and Yutaka Watanuki (Invited)
Marine plastics: Monitoring matrix for persistent organic pollutants (POPs) and carrier of POPs to seabirds

Poster presentations

Andrey S. Neroda, Vasily F. Mishukov, Vladimir A. Goryachev, Denis V. Simonenkov and Anna A. Goncharova
Radioactive isotopes in atmospheric aerosols over Russia and the Sea of Japan following the nuclear accident at Fukushima nr. 1 Daiichi nuclear power station in March 2011

Tatiana Chizhova, Pavel Tishchenko, Liubov Kondratieva and Takuya Kawanishi
Polycyclic aromatic hydrocarbon (PAH) distribution in the Amur River estuary

Yulia Koudryashova, Natalia Prokuda, Natalia Khodorenko, Tatiana Chizhova and Pavel Tishchenko
PAHs in sediments of rivers of the Primorsky Region, Far East of Russia

Mikhail V. Simokon
Ecological risk evaluation of metals in the coastal areas of Peter the Great Bay, Japan/East Sea

Report of the Study Group on *Marine Pollutants*

The Study Group on *Marine Pollutants* (*SG-MP Endnote 1*) met at PICES-2012 on October 12, 2012, in Hiroshima, Japan, to finalize its report to the MEQ Committee and to formulate recommendations for future PICES activities. A draft of the Study Group report comprised input on research needs and priorities for the North Pacific Ocean, and identified opportunities for future collaboration. The SG-MP brought together participation and feedback from all six PICES member countries, and built on the successful workshop held at PICES-2011 in Khabarovsk, Russia.

The SG-MP:
i) identified pollution priorities for the North Pacific Ocean,
ii) proposed a selection of indicator (sentinel) approaches to pollution research and monitoring,
iii) recommended efforts to carry out inter-laboratory calibration and method sharing, and
iv) identified several existing or proposed multi-lateral or professional partnerships.

While the SG-MP noted variation in the responses (priorities) of PICES member countries, there was broad agreement on a common working list of important marine pollution topics for the North Pacific Ocean. These included:
i) identification of priority pollutants (persistent, bioaccumulative and toxic pollutants; hydrocarbons; metals, elements and radionuclides; microplastics; biological pollutants);
ii) evaluation of useful and relevant indicator approaches to assessing ocean pollution (water/air/sediments; marine mammals and seabirds; fish; benthos; seaweeds; plastics);
iii) identification of inter-laboratory method calibration opportunities and study design sharing; and
iv) multilateral collaboration opportunities (ICES, GESAMP, NOWPAP, SETAC).

Indicators of pollution can provide an effective integrated message to managers (*e.g.*, response to regulations, source control, remediation, risk-based evaluation of seafood safety, general ecosystem indicators).

Based on input of the six PICES member countries during the 2011–2012 year, and deliberations during the 2012 meeting at Hiroshima, the SG-MP proposed three activities to PICES (MEQ Committee):
i) establish a new Section on *Emerging Topics in Marine Pollution* (S-ETMP) (*SG-MP Endnote 2*);
ii) convene a ½-day Topic Session at PICES-2013 (Nanaimo, Canada) on "*Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans*" (*SG-MP Endnote 3*);
iii) organize a workshop/field trip on "*Traditional seafoods of the Snuneymux'w First Nation: Insight into food, social and ceremonial uses*" (*SG-MP Endnote 4*) to be hosted at the local aboriginal community during PICES-2013.

SG-MP Endnote 1

SG-MP participation list

Members	Observers
Sang Hee Hong (Korea)	Karin Baba (Japan)
Shigeru Itakura (Japan)	John Elliott (Canada)
Olga Lukyanova (Russia)	Yochiro Ishibashi (Japan)
Peter S. Ross (Canada, Chairman)	Sangjin Lee (NOWPAP)
Won Joon Shim (Korea)	Hideaki Maki (Japan)
Mikhail Simokon (Russia)	Vasiliy Tsygankov (Russia)
Staci Simonich (USA)	
Zijun Xu (China)	

SG-MP Endnote 2

Proposal to establish a new Section on *Emerging Topics in Marine Pollution*

The Study Group on *Marine Pollutants* proposes a new PICES Section on *Emerging Topics in Marine Pollution* that will provide an expert platform for the timely discussion of new pollution issues and priorities in the North Pacific Ocean. Marine pollution priorities vary over space and time, and as a function of human and industrial activities. In some cases, marine pollution can affect the socio-economic well-being of coastal communities by reducing the availability of safe and abundant seafoods, affecting the health of endangered species, and/or negatively impacting the value of the ecotourism sector. The protection of ecosystem health and services requires rapid and sensitive means to detect emerging pollutant issues before serious adverse impacts arise. Regulations and/or other management actions resulting from marine pollution research in the past has led to dramatic declines in environmental concentrations of a number of harmful pollutants, subsequently improving the health of marine biota. This Section will work with the MEQ and FIS committees and provide a leadership role in the provision of advice, and the planning of special sessions and workshops. The Section will identify new contaminants of concern, clarify priority pollutant concerns, and assess the relative importance of pollutants among other natural and anthropogenic stressors.

The establishment of this Section will ensure the continued availability of expertise on marine pollutants within PICES, and deliver guidance to the FUTURE Advisory Panels (AICE, COVE and SOFE). Since climate change is affecting the transport, fate and effects of marine pollutants, this Section will also be of value to other committees, working groups and sections. Importantly, the proposed Section will address the question identified in the FUTURE Science Plan "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*"

Terms of Reference

1. Identify emerging marine pollutants in the North Pacific Ocean by:
   a. convening timely Topic Sessions and workshops on new and emerging pollutants and pollution issues;
   b. identifying useful indicators of status, trends and effects; and
   c. providing ecosystem-based advice to PICES Sections, Working Groups and Advisory Panels, especially those identified in the FUTURE Science Plan (AICE, COVE and SOFE).
2. Establish partnerships with other professional or multilateral organizations (*e.g.*, ICES, GESAMP, NOWPAP and SETAC).
3. Conduct joint activities (working group, sessions, publications) with other parties.
4. Design and/or conduct special projects on emerging marine pollutants.

Proposed Co-Chairmen: Olga Lukyanova (Russia), Peter S. Ross (Canada), Joel Baker (USA)

Proposed membership:

John Elliot (Canada)
Zhengguo Cui (China)
Zijun Xu (China)
Ziwei Yao (China)
Shigeru Itakura (Japan)
Hideaki Maki (Japan)
Sang Hee Hon (Korea)
Hyo-Bang Moon (Korea)
Won Joon Shim (Korea)
Michail Simokon (Russia)
Staci Simonich (USA)
Gina Ylitalo (USA)

SG-MP Endnote 3

Proposal for a ½-day Topic Session on "*Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans*" at PICES-2013

Marine pollutants can impact the quality and/or abundance of invertebrates, fish, and wildlife. In addition, the contamination of seafood can diminish the viability of commercial species and/or deliver potentially harmful contaminants to human consumers. While pollutant topics vary geographically, a number of priority pollutants are common throughout the northern hemisphere. This session will highlight a number of practical approaches to assessing the status, trends and effects of emerging and/or priority pollutants in the PICES region, as well as examples from other parts of the world. Some of these approaches are presently being used as indicators of marine environmental quality in some jurisdictions. Examples include the 'Mussel Watch' program for monitoring metals and persistent organic pollutants (POPs), spatial and temporal trends in POPs in seabird eggs, and effects of POPs and hydrocarbons on the health of marine biota. Some of these efforts have proven very useful in revealing improvements to marine ecosystem health subsequent to the implementation of regulations, including the dramatic declines in PCB, DDT, dioxin and organotin levels and associated effects. Nevertheless, a number of pollutant concerns are emerging, such as replacement flame retardants, pharmaceuticals, and current use pesticides. Characterizing the status, trends and effects of marine pollutants in coastal ecosystem components can provide cost-effective means to guide regulations, source control and/or remediation strategies that will ultimately protect ecosystem health and services.

Sponsoring Committee/Program: MEQ, FUTURE

Co-convenors: Olga Lukyanova (Russia) and Won Joon Shim (Korea)

Invited speakers: TBD

SG-MP Endnote 4

Proposal for a 1-day Workshop and field trip on "*Traditional seafoods of coastal aboriginal communities in the North Pacific: Insight into food, social and ceremonial uses at Snuneymux'w First Nation in Nanaimo, British Columbia*" at PICES-2013

Seafoods are integral part of the nutritional, social and cultural fabric of many aboriginal communities inhabiting coastal regions of the North Pacific Ocean. The Snuneymux'w First Nation in Nanaimo, British Columbia, is home to 1,200 residents who have relied heavily on seafoods for thousands of years. Despite now living in an urban environment with ready access to supermarket foods, it has been recently estimated that the average individual from this aboriginal community consumes 12 to 15 times as much seafood as the average Canadian. Much of this is harvested locally by native fishers. Community members routinely express concerns about the quality and quantity of their local seafoods. It is becoming increasingly evident that the availability of nutritious and uncontaminated seafoods is important for food, social and ceremonial purposes in this other coastal communities in BC. This workshop will bring together local members of the Snuneymux'w First Nation and PICES participants, and provide an invaluable opportunity for sharing, learning and teaching about the importance of traditional seafoods to this aboriginal community. The workshop will involve discussions on science and traditional ecological knowledge.

This workshop is open to any participant attending the 2013 PICES Annual Meeting, but a maximum capacity is set at 45 persons. The workshop will be of interest to persons working on issues of marine stewardship, marine resource management, seafoods, and local cultures. Local practices, culture and traditions of First Nations will be showcased at this workshop, with additional input from resource persons from other communities. The workshop will feature:

- cultural welcome and prayer from representative of the Chief-in-Council, Snuneymux'w First Nation;
- song and drum opening from local community members;
- teachings from local community elders on marine resource management and sustainable harvesting;

- discussions on the role of traditional ecological knowledge (TEK) in a science-driven world (a panel of elders and scientists will be invited to prepare 4 × 15 minute talks, followed by discussions);
- a tour of the local seashore south of Nanaimo where practical demonstrations will take place on techniques to harvest seaweeds, shellfish and other seafoods;
- preparation of lunch foods using traditional aboriginal cooking techniques including a pit-cook and bentwood box; lunch and snacks comprising locally and seasonally-available foods as prawns, oysters, sea urchins, salmon, halibut, and a variety of crops and plants.

Sponsoring Committee: MEQ

Facilitator: Peter Ross (Canada) and local aboriginal community members

PICES Twenty-second Annual Meeting (PICES-2013)
October 11–20, 2013
Nanaimo, Canada

Summary of Scientific Sessions and Workshops

MEQ Workshop (W7)
Traditional seafoods of coastal aboriginal communities in the North Pacific: Insight into food, social and ceremonial uses at Snuneymux'w First Nation in Nanaimo, British Columbia

October 11, 2013

Co-Convenors: Peter Ross (Canada) and local community members

Background

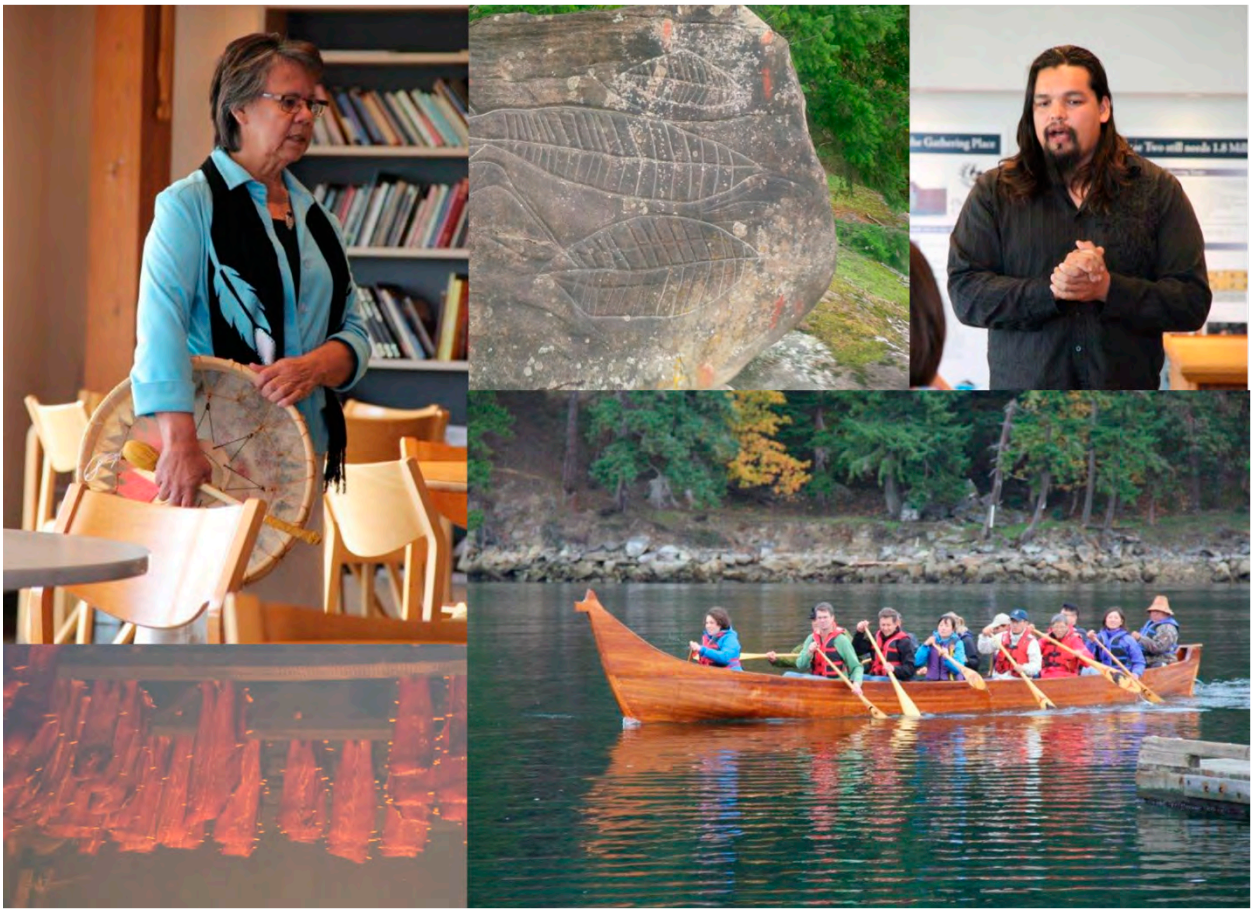
A one-day PICES workshop (W7) on indigenous seafoods was held in the traditional territory of the Snuneymux'w First Nation near Nanaimo, British Columbia (BC), on Friday October 11, 2013. The workshop touched on aspects of marine stewardship, marine resource management, seafoods, and local aboriginal culture. Seafoods are an integral part of the nutritional, social and cultural fabric of aboriginal communities inhabiting coastal regions of the North Pacific Ocean. The Snuneymux'w First Nation in Nanaimo is home to 1,200 residents who have relied heavily on seafoods for thousands of years. Despite now living in an urban environment with ready access to supermarket foods, it has been recently estimated that the average individual from this aboriginal community consumes 12 to 15 times as much seafood as the average Canadian. Much of this is harvested locally by native fishers. Community members routinely express concerns about the quality and quantity of their local seafoods. It is becoming increasingly evident that the availability of nutritious and uncontaminated seafoods is important for food, social and ceremonial purposes in this other coastal communities in BC.

Summary of Workshop

The morning session took place at the Vancouver Island University First Nations *Shq'aqpthut* ('Gathering Place'; http://www.viu.ca/gatheringplace/gallery.aspx). This session featured an opening prayer and song by Geraldine Manson, the Vancouver Island University elder-in-residence from Snuneymux'w. Geraldine described the importance of seafoods to her community, and recounted stories told by her parents and grandparents on topics of harvesting, cooking and stewardship. Geraldine then introduced Gary Manson, also an elder from Snuneymux'w. Gary described the historical importance of the Nanaimo River estuary for shellfish, crab and chum salmon harvesting. He also talked about the annual journey by canoe over the Strait of Georgia to the Fraser River for sockeye salmon harvesting. The importance of Gary's role as elder 'knowledge keeper' for the Snumeymux'w was evident in the afternoon when he led workshop participants on a tribal canoe journey over to salmon petroglyphs at Jack Point across the estuary.

John Rampanen, "naas-a-thluk", then narrated his family history in the Nuu-chah-nulth Nation – Ahousaht and Tla-o-qui-aht territories. John is an advocate for traditional foods and medicine. He combines traditional ecological knowledge with contemporary approaches and is dedicated to providing a strong sense of traditionally-oriented understanding and knowledge amongst First Nations youth and non-Native community partners. With a background in traditional medicinal practices, healthcare, counseling and indigenous foods, John has redeveloped a presence on his traditional territory (located on the western coast of Vancouver Island) where he now lives with his growing family.

After the tribal canoe journey, some workshop members feasted on tasty smoked and barbequed chum salmon at Snuneymux'w beach hosted by Paul Wyse-Seward and Chris Good. The success of the workshop was due to the kind assistance of Vancouver Island University (Geraldine Manson, Michele Patterson, Grant Murray, Cathy Fee and students), Snuneymux'w First Nation (Gary Manson, Chris Good, Paul Wyse-Seward and Theodore Barker), and the entire staff of the PICES Secretariat.



A one-day workshop on traditional seafoods was held at the PICES-2013 in Nanaimo. Clockwise from top left: Geraldine Manson, a Snuneymux'w Elder-in-Residence at Vancouver Island University opened the workshop with heartfelt prayer, song and stories; a visit to nearby petroglyphs highlighted the historical importance of chum salmon to the Snuneymux'w; John Rampanen described the strong inter-relationship between marine life and his communities on the west coast of Vancouver Island; some workshop participants got some exercise paddling a tribal canoe from downtown Nanaimo to Jack Point, where Gary Manson described the cultural importance of the 'salmon ceremony' at this site; a visit to a local smokehouse poignantly underscored the importance of chum salmon to the Snuneymux'w. Photo credits: Cathy Fee and Peter S. Ross.

MEQ/FUTURE Topic Session (S3)
Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans

October 16, 2013

Co-Convenors: *Olga Lukyanova (Russia) and Won Joon Shim (Korea)*

Invited Speakers:
Sandra O'Neill (NWFSC, NOAA, USA)
Lorrie Rea (University of Alaska Fairbanks, USA)

Background

Marine pollutants can impact the quality and/or abundance of invertebrates, fish, and wildlife. In addition, the contamination of seafood can diminish the viability of commercial species and/or deliver potentially harmful contaminants to human consumers. While pollutant topics vary geographically, a number of priority pollutants are common throughout the northern hemisphere. This session highlighted a number of practical approaches to assessing the status, trends and effects of emerging and/or priority pollutants in the PICES region, as well as examples from other parts of the world. Some of these approaches are presently being used as indicators of marine environmental quality in some jurisdictions. Examples include the 'Mussel Watch' program for monitoring metals and persistent organic pollutants (POPs), spatial and temporal trends in POPs in seabird eggs, and effects of POPs and hydrocarbons on the health of marine biota. Some of these efforts have proven very useful in revealing improvements to marine ecosystem health subsequent to the implementation of regulations, including the dramatic declines in PCB, DDT, dioxin and organotin levels and associated effects. Nevertheless, a number of pollutant concerns are emerging, such as replacement flame retardants, pharmaceuticals, and current use pesticides. Characterizing the status, trends and effects of marine pollutants in coastal ecosystem components can provide cost-effective means to guide regulations, source control and/or remediation strategies that will ultimately protect ecosystem health and services.

Summary of presentations

Session S3 was held on Wednesday, October 16, 2013 (half day). It was launched with two invited speakers, Sandra O'Neill (Washington Department of Fish and Wildlife, USA) and Lorrie Rea (University of Alaska Fairbanks, USA) and included other 6 oral presentations, 14 posters, and time for discussion. Approximately 30 to 40 people, including marine and geochemists, marine biologists, and bird and mammal researchers attended the session and provided useful comments.

The session covered a wide spectrum of pollutants (persistent organic pollutants, polycyclic aromatic hydrocarbons, tributyltin, mercury, arsenic, microplastics and infective human enteric virus) in the Pacific region from all six PICES member countries. There are on-going marine chemical pollution issues which affect salmon and stellar sea lion populations. O'Neill *et al.* found that the tissue residue levels and composition of persistent organic pollutants were distinctly different among five Pacific salmon species, depending their dwelling region, migratory route and diet. Rea *et al.* showed that Steller sea lions in the western Aleutian Islands had an apparent elevation in mercury and discussed its possible relationship with population decline in specific region. Simokon *et al*. reported on arsenic pollution originating from land-based activity in the coastal ecosystems of Far Eastern Seas. Polycyclic aromatic hydrocarbons contamination and their possible source and input pathways after the great tsunami in Japan were presented by Maki *et al*. Effective reduction of tributyltin levels in water and biota as well as its effects on marine organism was evaluated by Shim *et al*. after the implementation of total ban on tributyltin based antifouling paints in Korea. It could be a good example of proper management of marine chemical pollutants. A new emerging pollutant, microplastics in the marine environment in coastal British Columbia, was revealed by Desforges *et al*. An abundance of floating microplastics showed an obvious gradient from the coast to the open ocean. Watanuki *et al.* presented on a monitoring technique using feathers of tracked seabirds for investigating the spatial pattern of marine pollution was presented. Fan (Fan and Ming) discussed infective human enteric virus contamination

and its risk assessment in surface seawater of Bohai Bay, China, and demonstrated that it is required to manage pathogen pollution. Poster presentations included microplastic pollution and its biological effects, spatiotemporal distribution of persistent organic pollutants and heavy metals. Through this session, presenters and audience agreed that there is still a variety of marine pollution issues to be dealt with in the Pacific region. Legacy and emerging persistent organic pollutants and heavy metals and marine debris including microplastics are high priority issues and topics in the Pacific. There is a growing need to address these pollution issues in the North Pacific region through an expert group. Based on the proposal of the Study Group of *Marine Pollutants* (SG-MP), a new Working Group on *Emerging Topics in Marine Pollution* (WG-ETMP/WG 31) was established under the direction of the Marine Environmental Quality Committee during the Annual Meeting.

List of Papers

Oral presentations

Sandra O'Neill, Gina Ylitalo, David Herman and James West (Invited)
Persistent organic pollutant fingerprints in five Pacific salmon species (*Oncorhynchus* spp.): Evidence of distinct contaminant sources associated with their marine distribution and feeding

Lorrie D. Rea, J. Margaret Castellini, Lucero Correa, Brian S. Fadely, Vladimir N. Burkanov and Todd M. O'Hara (Invited)
Some maternal Steller sea lion diets elevate fetal mercury concentrations in the western Aleutian Island area of population decline

Yutaka Watanuki, Ai Yamashita, Mayumi Ishizuka, Yoshinori Ikenaka, Shouta M.M. Nakayama, Chihiro Ishii, Takashi Yamamoto, Motohiro Ito, Tomohiro Kuwae and Philip N. Trathan
Feathers of tracked seabirds reveal a spatial pattern of marine pollution

Mikhail V. Simokon, Lidia T. Kovekovdova and Denis P. Kiku
Arsenic in the coastal ecosystems of Far Eastern Seas

Won Joon Shim, Nam Sook Kim, Sang Hee Hong, Gi Myung Han and Sung Yong Ha
An almost successful story of TBT regulation to protect the coastal environments of Korea

Hideaki Maki, Gen Kanaya, Shin-Ichi Fukuchi,Kazuki Miura, Hisao Sasaki, Nobuyuki Tanaka, Nobuo Chiba and Osamu Nishimura
Petrogenic and pyrogenic PAHs contamination in the sediments in Tohoku coastal seas, Japan by the great tsunami on 3.11.2011

Jean-Pierre Desforges, Moira Galbraith, Neil Dangerfield and Peter Ross
Microplastics in the marine environment in coastal British Columbia

Jingfeng Fan and Hongxia Ming
The contamination and risk assessment of infective human enteric viruses in surface seawater from Bohai Bay, China

Poster presentations

Sangjin Lee
NOWPAP activities addressing marine litter

Young Kyoung Song, Won Joon Shim, Mi Jang, Sang Hee Hong and Gi Myung Han
Ship paint as a new input source of floating microplastics in surface microlayer

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Kyun-Woo Lee, Jung-Hoon Kang and Won Joon Shim
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Histopathology of Manila clams *Ruditapes philippinarum* surveyed in Korean waters

Guangshui Na, Zihao Lu, Wanru Zhang, Hui Gao, Jinqiu Du, Zhen Wang, Yaqi Cai, Ziwei Yao and Chuanlin Huo
Occurrence and distribution of five types of antibiotics and antibiotic-resistant *Escherichia coli* in Liao River estuary, China

Jianguo Du, Zhao Jiayi and Chen Bin
Assessing ecological risks of heavy metals to marine organisms by species sensitivity distributions

Report of the Study Group on *Marine Pollutants*

The Study Group on *Marine Pollutants* (SG-MP; 2011–2013) met for its final business meeting under the chairmanship of Dr. Peter Ross in Nanaimo, Canada, on Saturday, October 12, 2013 (see *SG-MP Endnote 1* for list of participants). This ½-day meeting followed the workshop (W7) on "*Traditional seafoods of the Snuneymux'w First Nation in Nanaimo, BC: Insight into food, social and ceremonial uses*".

At the meeting participants reviewed past activities of the SG-MP and

i) made changes to complete the SG-MP final report for submission to MEQ for approval;
ii) made changes to the proposal for a new Section on *Emerging Topics in Marine Pollution* (later recommended as a Working Group by Science Board; *SG-MP Endnote 2*). Included in the list of plans for the proposed Section were Topic Sessions and workshops, which will lead to special journal issues and a contribution to the 3rd PICES North Pacific Status Report during the period 2014–2016;
iii) finalized a proposal for a Topic Session on "*Marine debris in the ocean: Sources, transport, fate and effects of macro- and micro-plastics*" (*SG-MP Endnote 3*) for PICES-2014 in Yeosu, Korea (to be co-sponsored by NOWPAP, GESAMP and ICES).

SG-MP Endnote 1

SG-MP participation list

Members	Observers
Peter S. Ross (Canada, Chairman)	Hideaki Maki (Japan)
Shigeru Itakura (Japan)	Karin Baba (Japan)
Won Joon Shim (Korea)	
Staci Simonich (USA)	
Mikhail Simokon (Russia)	
Zijun Xu (China)	

SG-MP Endnote 2

Proposal for a Section on *Emerging Topics in Marine Pollution (S-ETMP)*

General objectives

Pollution can adversely affect the health and abundance of marine biota, especially in densely-populated coastal areas. The downstream socio-economic consequences can be significant, with numerous examples of consumption advisories, commercial fishery closures, commercial trade interdictions and diminished aboriginal access to food resources around the North Pacific Ocean. The protection of ecosystem health and services requires an ability to detect emerging pollutant issues before serious adverse impacts arise. Regulations, policies and other management actions resulting from marine pollution research in the past have led to dramatic declines in environmental concentrations of a number of harmful pollutants, subsequently improving the health of marine biota.

This proposed Section will provide leadership on emerging pollution issues to the PICES community, reporting through the MEQ Committee. The S-ETMP will convene a series of timely Topics Sessions and workshops, and coordinate special issues in international peer-reviewed journals. The Section will ensure the continued availability of expertise on marine pollutants within PICES, and deliver guidance to the FUTURE Advisory Panels (notably AICE and SOFE). The Section will collaborate with other PICES expert groups in co-convening activities or compiling data. Importantly, the Section will address the question identified in the

FUTURE Science Plan "*How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?*"

Terms of Reference

1. Document and profile emerging marine pollution issues in the North Pacific Ocean within the PICES community by:
   a. Convening Topic Sessions and workshops on new and emerging pollutants and pollution issues;
   b. Coordinating a series of special issues in international peer-reviewed journals based on topic sessions; and
   c. Contributing to the next edition of the PICES North Pacific Ecosystem Status Report by compiling data describing spatial and temporal trends for pollution indicators in the North Pacific Ocean.
2. Strengthen partnerships to deliver Topic Sessions/workshops and to publish special issues with:
   a. Other PICES expert groups, especially those identified in the FUTURE Science Plan.
   b. Other multilateral organizations, including the International Council for the Exploration of the Sea (ICES), the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), and the Northwest Pacific Action Plan (NOWPAP).

Proposed activities 2014–2019 (3 yr + 3 yr)

The Section on *Emerging Topics in Marine Pollution* will engage in specific activities that will identify contaminants of emerging concern, prioritize pollutants from the many sources, and assess the relative importance of pollutants among other natural and anthropogenic stressors. Members will contribute to discussions and strategic planning with the MEQ Committee as well as through other PICES expert groups. The S-ETMP will build on the success of a number of activities carried out by the SG-MP, including two workshops (2011, Khabarovsk: *Pollutants in a changing ocean: Refining indicator approaches in support of coastal management* and 2013, Nanaimo: *Traditional seafoods of coastal aboriginal communities in the North Pacific: Insight into food, social and ceremonial uses at Snuneymux'w First Nation in Nanaimo, British Columbia*) and two Topic Sessions (2012, Hiroshima: *Environmental contaminants in marine ecosystems: Seabirds and marine mammals as sentinels of ecosystem health*; 2013, Nanaimo: *Status, trends and effects of pollutants in coastal ecosystems: Implications for wildlife and humans*). The proposal for establishing a S-ETMP will benefit from the current support of ICES and GESAMP.

Topic Sessions at PICES Annual Meetings

- 2014: *Marine debris in the North Pacific Ocean: source, transport, fate and effects of macro- and micro-plastics* (solicit expert input from WG 29 on the role of ocean currents in shaping marine debris transport and fate; co-sponsored by NOWPAP, GESAMP and ICES);
- 2015: *Indicators of emerging marine pollution issues in the North Pacific Ocean* (co-convene a session with WG 28 on multiple stressors, WG 30 on radiation, and S-HD, and with support of AP-SOFE, AP-AICE and AP-MBM);
- 2016: *Sources, transport and fate of hydrocarbons in the marine environment*, including oil spills, vessel emissions, long-range transport (co-convene a session with partners to be determined, and with support of AP-AICE);
- 2017: *Climate influences on pollutant transport, fate and effects in the North Pacific Ocean* (co-convene a session with S-CCME on climate variability and change, and with support of AP-COVE);
- 2018: *Seafood safety in the Pacific Ocean: Risks vs benefits* (co-convene a session with WG 30 on radiation, S-HAB on natural toxins, and S-HD, and with support of AP-AICE).

Meetings/Workshops

- 2014: S-ETMP meeting, data compilation;
- 2015: *Indicators of emerging marine pollution issues in the North Pacific Ocean* (co-convene a data compilation workshop with WG 28, and with support of AP-MBM);

- 2016: *Oil spill monitoring and characterization* (co-convene a workshop with the Korean Institute of Ocean Science and Technology (KIOST), and with support of AP-AICE);
- 2017: *Status and trend of marine pollution in the coasts of North Pacific rim* (co-convene a data compilation workshop with NOWPAP, and with support of AP-MBM);
- 2018: *Monitoring and assessment of marine pollution in the coasts of North Pacific rim* (co-convene a data compilation workshop with NOWPAP, and with support of AP-MBM).

Special journal issues

- 2015: Marine debris in the North Pacific;
- 2016: North Pacific pollution indicators;
- 2017: Sources, transport and fate of hydrocarbons in the North Pacific;
- 2018: Climate–pollutant interactions in the North Pacific;
- 2019: Seafood safety in the North Pacific.

Compilation of data for marine pollution

Compiled data for marine pollution indicators and findings will be delivered to multiple PICES expert groups, in particular to AP-SOFE, in support of the North Pacific Ecosystem Status Report ~2016/17.

The S-ETMP will directly address the following questions of the FUTURE program:

3. How do human activities affect coastal ecosystems and how are societies affected by changes in these ecosystems?

3.1 What are the dominant anthropogenic pressures in coastal marine ecosystems and how are they changing?
- By characterizing emerging pollution priorities in the North Pacific Ocean.

3.2 How are these anthropogenic pressures and climate forcings, including sea level rise, affecting nearshore and coastal ecosystems and their interactions with offshore and terrestrial systems?
- By documenting the impacts of emerging pollutants in the North Pacific Ocean, especially in coastal environments, and in a changing ocean environment.

3.3 How do multiple anthropogenic stressors interact to alter the structure and function of the systems, and what are the cumulative effects?
- By collaborating with other expert groups to document importance of marine pollution relative to multiple stressors.

3.4 What will be the consequences of projected coastal ecosystem changes and what is the predictability and uncertainty of forecasted changes?
- By developing approaches to pollutant indicators that account for climate variability and change.
- By characterizing changing pollution risks as climate changes.

3.5 How can we effectively use our understanding of coastal ecosystem processes and mechanisms to identify the nature and causes of ecosystem changes and to develop strategies for sustainable use?
- By prioritizing pollutant sources and types in support of source control, regulations and best practices.
- By translating compiled data and findings through the PICES North Pacific Status Report to formats that are understandable to the general public and a wider audience.

Proposed membership*

Recommended Co-Chairmen: Olga Lukyanova (Russia), Peter S. Ross (Canada), Won Joon Shim (Korea), Staci Simonich (USA)

Proposed members:

John Elliott (Canada)
Zhengguo Cui (China)
Zijun Xu (China)
Ziwei Yao (China)
Shigeru Itakura (Japan)
Hideaki Maki (Japan)
Sang Hee Hong (Korea)
Hyo-Bang Moon (Korea)
Mikhail Simokon (Russia)
Joel Baker (USA)
Gina Ylitalo (USA)

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*The additional members for the proposed Section on *Emerging Topics in Marine Pollution* will be designated by each PICES member country based on their expertise related to the Section topics.

SG-MP Endnote 3

Proposal for a 1-day MEQ Topic Session on
"Marine debris in the Ocean: Sources, transport, fate and effects of macro- and micro-plastics"
at PICES-2014

Co-Convenors: Won Joon Shim (Korea), Peter S. Ross (Canada), Olga Lukyanova (Russia), Sangjin Lee (NOWPAP), Peter Kershaw (GESAMP), Jesus Manuel Gago Piñeiro (Spain)

Marine debris is increasingly recognized as a threat to biota in the ocean, which can have a range of socio-economic impacts from coastal areas to the open ocean. The majority of marine debris consists of synthetic polymers, or 'plastics', which readily float on the ocean surface or are suspended in the water column. Microplastics may be attributed to the intentional manufacture of commercial products or the fragmentation of plastic products. They can increase the bioavailable fraction of marine litter and act as a vector for the delivery of intrinsic or adsorbed toxic chemicals to exposed biota. Floating, submerged and beached debris have been documented in marginal seas and the adjacent coastal zone of the North Pacific Ocean. In addition, the North Pacific Ocean Gyre is known to accumulate floating debris in what has become known as the "Great Pacific Garbage Patch". Marine debris represents trans-boundary pollution which can also deliver associated chemicals and invasive organisms to regions far removed from source. The objective of this session is to present status and trend information for marine plastic debris pollution and its environmental consequences in the PICES region. Papers are invited that assess macro- or micro-plastic debris 1) hotspots in the PICES region, 2) source and input pathways, 3) long-range transport, 4) role as sink or source of associated toxic chemicals, and 5) biological and ecological effects. Recommendations on how to address growing problems associated with marine debris will be also considered.

8.5 PICES Press article

PICES-2011 Workshop on "*Trends in Marine Contaminants and their Effects in a Changing Ocean*"

by Peter S. Ross and Olga Lukyanova

The sheer number of contaminants entering the North Pacific Ocean from a combination of point and non-point sources provides a daunting backdrop to those concerned with the protection of aquatic biota. However, this did not deter the 16 participants at the workshop on "*Trends in marine contaminants and their effects in a changing ocean: Refining indicator approaches in support of coastal management*", who spent a productive day discussing topics related to the workshop theme, and a day sampling for microplastics on the Amur River. This workshop, co-sponsored by GESAMP (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) and ICES (International Council for the Exploration of the Sea), was held on October 14, 2011, in conjunction with the 2011 PICES Annual Meeting in Khabarovsk, Russia.

The workshop agenda included four invited presentations. Representatives from GESAMP and ICES delivered concise insight into their concerns, priorities, and activities. Dr. Peter Kershaw (Centre for Environment, Fisheries and Aquaculture Science, UK) described the mandate and activities of the UN-sponsored GESAMP, which is also supported by IMO, FAO, IOC-UNESCO, WMO, IAEA, UNEP and UNIDO. GESAMP provides expert advice on priority topics, as well as assessments of regional and global environmental concerns. One major activity of relevance to PICES is reflected in GESAMP efforts to identify and apply pollution indicators for the UN Transboundary Waters Assessment Programme (TWAP) in five categories: groundwater, rivers, lakes, Large Marine Ecosystems (LMEs) and open oceans. GESAMP currently has a number of Working Groups that are active in such areas as "mercury, cadmium and lead" (WG 37), "the historical inputs of contaminants into coastal ecosystems" (WG 39), and "source, fate and effects of microplastics in the marine environment" (WG 40). In addition, a new Correspondence Group is being established to evaluate the "biomagnification of pollutants in top predators". This concern for the scale of pollution impacts on the marine environment is shared by the general public (Fig. 1).

Dr. Kris Cooreman (Institute for Agricultural and Fisheries Research, Belgium) described the aim within the ICES realm for integrated science in support of management. He stressed that fisheries regulations were ineffectual when the root causes of reduced fish stocks are unrelated to fishing, and presented one case study on the decades-long decline in the abundance of shrimp (*Crangon crangon*) which had been attributed to overfishing. However, recent research suggests that the extensive contamination of coastal sediments in Europe by the antifoulant chemical tributyltin

Fig. 1 Over 10,000 people respond: "When you are thinking about the coastline or the sea, what are the three most important matters that come to mind?" (http://www.CLAMER.eu).

(TBT) historically used on vessel hulls caused reduced growth and survival of shrimp. In addition to this example of a population-level impact related to a single chemical, other European examples include the effects of PCBs (poly-chlorinated biphenyls) and DDT (dichlorodiphenyl-trichloroethane) on reproduction and health of seabirds and marine mammals. A long history of interest in the area of marine pollution positions ICES extremely well to partner with PICES on subjects of mutual interest into the future.

Dr. Joel Baker (Center for Urban Waters, University of Washington, U.S.A.) presented an overview on the emerging microplastics concern, which provided a basis for the field trip on the Amur River the next day (see photos). This one pollutant category encompasses a very wide variety of types, sizes, shapes, colours and origins for this "structural pollutant", highlighting the need for standardized assessment methods. "Microplastics" may be defined as any solid material < 5 mm that is primarily composed of synthetic polymers, but may also be considered from a practical perspective to be larger than 330 µm so as to be compatible with ichthyoplanktonic surveys. Microplastics include both primary (produced intentionally for consumer products) and secondary (generated by disintegration of larger materials) materials. Major challenges, and hence opportunities for collaboration in the North Pacific, are: methods to detect and quantify, distribution over space, and effects on biota (including invertebrates, fish, turtles, seabirds and marine mammals). Evidence of impact today is largely limited to the visually obvious macroplastics which have caused mortality in some stranded turtles, seabirds, and marine mammals.

Dr. Annamalai Subramanian (Ehime University, Japan) delivered an overview of persistent organic pollutants (POPs) and metals in the Asia-Pacific region. Dedicated sampling from multiple species over the past three decades has been carried out through the Environmental Specimen Bank for Global Monitoring at his university. Contaminants

A field trip to the Amur River near Khabarovsk on October 15, 2011, provided an opportunity for some of the workshop participants to conduct surface tows for microplastics from a small craft. Shown here clockwise, starting at top is the sampling platform, participants decanting microplastic samples from the plankton net on shore, workshop members examining samples using a dissecting microscope in the laboratory of the Khabarovsk Branch of Pacific Research Fisheries Centre, Russian Federal Agency on Fisheries, and Drs. Joel Baker and Olga Lukyanova with 330 µm mesh plankton net prior to deployment. Photos by A. Subramanian, P.S. Ross and O. Lukyanova.

have been determined for some of the many hundreds of invertebrate, fish, seabird and marine mammal species for which samples have been collected and preserved over time and space. Results reveal widespread environmental responses to the use, disposal and subsequent regulation of many of the POPs. Mussels have been utilized as sessile indicators of coastal pollution by POPs and metals throughout Asia. Albatross have been used to provide an integrated measure of POPs along their migratory corridor. Northern fur seals reveal improvements in the way of reductions in the concentrations of some POPs over time.

Russian scientists, including Olga Lukyanova, Mikhail Simokon and Vasiliy Tsygankov, provided insight into some of the priority concerns along the coastline of the Russian Far East and adjacent waters. While human population density is relatively low in this region, there exist concerns about offshore oil and gas exploration and development in the Sea of Okhotsk, metals related to local industrial activity, radioactive releases, and POPs and biological pollutants from global sources.

Because of the complexity of marine pollution issues in the North Pacific Ocean, workshop participants were focussed on defining concepts and strategies that would lead to pragmatic indicators. It was agreed that a series of basic concepts should be used to identify contaminant indicators that could be shared among PICES member countries. In

this way, the indicator must:

- involve a species (*e.g.*, mussels) or matrix (*e.g.*, sediment) which is well understood;
- involve a pollutant or class of pollutants for which analytical methods are available;
- provide the best available science to management;
- provide insight into spatial and temporal changes;
- have linkages to a risk of adverse effects;
- be responsive to regulations;
- be able to identify emerging contaminant concerns;
- be cost-effective.

Since there exists no single indicator which can adequately capture all contaminant concerns, workshop participants acknowledged the need for a suite of indicators which could capture different contaminant types including, for example, persistent, bioaccumulative contaminants (*e.g.*, POPs) in seabird eggs or marine mammals, metals and radionuclides in mussels, hydrocarbons in flatfish, and plastics in seawater. Several regional examples from researchers in different PICES member countries were cited as examples to build on, where opportunities to improve analytical techniques, exchange samples, collect new samples, and/or exchange expertise were considered.

During the next year, a new PICES Study Group on *Marine Pollutants* (SG-MP) will operate under the aegis of the Marine Environmental Quality (MEQ) Committee to identify novel approaches to operational marine pollution assessment with the aim of: establishing a list of priority pollutants; identifying indicators of status, trends and effects; harmonizing methods to evaluate impacts on biota; and describing case studies which demonstrate the effectiveness of indicators to inform the success of remedial actions. This effort will create opportunities for PICES scientists to participate in a renewal of the pollution topic and to identify emerging concerns, technologies and concepts into the FUTURE.

Following the workshop on marine pollution indicators, some workshop participants went on an excursion on the Amur River to collect microplastics under the guidance of Dr. Joel Baker (third from the left). Photo by O. Lukyanova

Dr. Peter S. Ross (peter.s.ross@dfo-mpo.gc.ca) is a Research Scientist with Fisheries and Oceans Canada (DFO) at the Institute of Ocean Sciences in Sidney, British Columbia, and Adjunct Professor at Simon Fraser University and the University of Victoria. Peter is an ecotoxicologist specializing in marine mammals. He conducts research on source, transport, fate and effects of environmental contaminants in Canada and internationally. Within PICES, Peter serves on the Advisory Panel on Marine Birds and Mammals and the Study Group on Maine Pollutants. He is also frequent participant at the meetings of the Marine Environmental Quality Committee.

Dr. Olga Lukyanova (onlukyanova@tinro.ru) is a Research Biologist at the Pacific Research Fisheries Centre (TINRO-Centre) in Vladivostok, Russia. Olga conducts research on marine pollution and its effects on biota in the Russian zone of Far Eastern seas in the North Pacific. She is wearing multiple hats within PICES being a member of the Section on Harmful Algal Blooms, Section on Human Dimensions of Marine Systems, Working Group on Development of Ecosystem Indicators to Characterize Ecosystem Responses to Multiple Stressors and Study Group on Marine Pollutants.

Continued from inside back cover

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PICES PUBLICATIONS

The North Pacific Marine Science Organization (PICES) was established by an international convention in 1992 to promote international cooperative research efforts to solve key scientific problems in the North Pacific Ocean.

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Front cover figure

A killer whale (*Orcinus orca*) breaching in the waters offshore from a paper mill in Malaspina Strait, near the northern part of the Strait of Georgia, British Columbia (photo credit: Graeme Ellis, DFO, Pacific Biological Station).