PICES Scientific Report No. 16
2001

Environmental Assessment of Vancouver Harbour Data Report for the PICES Practical Workshop

Edited by
Carla M. Stehr and Toshihiro Horiguchi

August 2001
Secretariat / Publisher
North Pacific Marine Science Organization (PICES)
c/o Institute of Ocean Sciences, P.O. Box 6000, Sidney, B.C., Canada. V8L 4B2
E-mail: secretariat@pices.int Home Page: http://www.pices.in

Table of Contents

Section I - Practical Workshop Description

Section II - Site Description and Oceanography

Section III - Extended Abstracts

Section IV - Comprehensive Data Tables

Tissue Chemistry – Fish

Tissue Chemistry – Bivalves

Lipid and Fatty Acids in *Mytilus trossulus*

Biochemical, Physiological and Histopathological Parameters

Biological Community Data – Fish and Mussels

Biological Community Data – Macrobenthos

Harmful Algae

Section I Practical Workshop Description

Colin D. Levings[1], Carla M. Stehr[2] and John E. Stein[2]

[1] Fisheries and Oceans Canada, Science Branch, West Vancouver Laboratory, 4160 Marine Drive, West Vancouver, B.C., Canada. V7V 1N6

[2] Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Environmental Conservation Division, 2725 Montlake Blvd. E., Seattle, WA 98112, U.S.A.

This report is a compilation of the data resulting from a collaborative research project conducted in Vancouver Harbour, Canada. This scientific study was part of a Practical Workshop sponsored by the Marine Environmental Quality Committee of the North Pacific Marine Science Organization (PICES). The goal of the workshop was to promote the exchange of information about approaches used by PICES member countries to assess the biological impact of marine pollution. Section I of this report provides an overview and history of the workshop, the work plan and methods used to conduct the workshop, and a summary that includes recommendations for future practical workshops of this nature. Section II provides a description of the physical and oceanographic characteristics of the sampling area, as well as information on contaminant sources. Results from the workshop, and preliminary data interpretations were presented at the PICES Ninth Annual Meeting (PICES IX) in 2000. Extended abstracts of these presentations are included in Section III. Tables containing the data from the workshop are included in Section IV.

Workshop overview

Working Group 8 of the Marine Environmental Quality Committee of PICES held a Practical Workshop on May 23-June 7, 1999, in Vancouver Harbour, Canada. Twenty-four scientists from all PICES member countries participated (see Figure 1.1 for a group photo). Workshop Co-Chairman Dr. Colin Levings and his staff hosted the workshop at the West Vancouver Laboratory, of Fisheries and Oceans Canada.

A wide variety of data were collected, including community structure of benthic invertebrates and fish, evaluation of fish health using biological markers and exposure data, evaluation of contaminant exposure in intertidal invertebrates, imposex in gastropods, and information about natural toxins produced by algae. The cooperative sample collections allowed participants to experience various methods for environmental assessment of marine pollution and its effects. Additional opportunities for exchange of information occurred through laboratory demonstrations of bioanalytical techniques and cooperative sample processing that took place at the laboratory. These activities provided an opportunity for PICES participants to gain an improved appreciation of the approaches and techniques used by other member countries to assess the effects of marine pollution.

The data resulting from the workshop will be used for interpretation of organismal, population, and community responses to marine pollution. The biological responses are evaluated in the context of exposure to different classes of chemical contaminants such as polycyclic aromatic hydrocarbon (PAHs), pesticides, chlorinated hydrocarbons, selected metals and organotins (e.g., TBT). The generic results of this Practical Workshop should be applicable to other coastal areas in the PICES region.

History of Working Group 8

Working group 8 (WG 8) was established by the Marine Environmental Quality (MEQ) Committee in 1994 to promote the collection and exchange of information about approaches PICES member countries use to assess the biological impact of marine pollution. To address this issue, WG 8 organized a Practical Workshop, where participants could work together to evaluate methods used to assess ecological effects of pollution. The format of the Workshop was developed along the lines of the successful

Fig. 1.1 Group photo taken in front of the West Vancouver Laboratory. Back row: Dan Lomax, Colin Levings, Alexander Tkalin, Richard Addison, Terry Sutherland. 2nd row: Zhengyan Li, Jihyun Yun, Tatyana Belan, Beradita Anulacion, Beth Piercey, Seiichi Uno, Toshihiro Horiguchi, Stelvio Bandiera. Front row: Carla Stehr, John Stein, Jong Jeel Je, Gina Ylitalo, Tatyana Lishavskaya, Tian Yan, Brian Bill.

Intergovernmental Oceanographic Commission/ Group of Experts on the Effects of Pollutants (IOC/GEEP) workshops whose results have been published elsewhere (Bayne *et al*. 1988, Addison and Clarke 1990, Stebbing and Dethlefsen 1992).

Plans were originally made to hold the practical workshop in Jiaozhou Bay, China. However, it became impractical for the workshop to be held at this location, so the workshop was relocated to Vancouver Harbour, Canada, and work plans were revised. After considerable preparation (obtaining supplies, laboratory space, research vessel support, sampling equipment, affordable room and board, travel arrangements, sample permits etc.) the workshop was held from May 24 to June 7, 1999. Early results of the workshop were presented at PICES VIII in Vladivostok, Russia, in October, 1999. Workshop results were formally presented at PICES IX in Hakodate, Japan, in October 2000. Plans for publication of the results were finalized, and include publication of this data report, and individual papers in a special issue of Marine Environmental Research.

Work Plan for the Vancouver Harbour Practical Workshop

Site locations

Seven sites were sampled within Vancouver Harbour for sediment, benthos and intertidal invertebrates (Figs. 1.2 and 1.3). Fish were collected by trawl at five of these sites (Fig. 1.4). After field collections were initiated, it was found that gastropod species for imposex evaluations were not present at these sites, so an additional 3 sites near Victoria and one near Mission Point (near the town of Sechelt, not shown on map) (Fig. 1.5) were added to the sampling plan for imposex investigations.

Research vessels

The research vessel used for conducting sediment/benthos grabs and trawling for bottom fish was the R/V *Harold W. Streeter* (14 m, or 46 feet) (Fig. 1.6) of the Northwest Fisheries Science Center (NWFSC), National Marine

Fisheries Service, National Oceanic and Atmospheric Administration, U.S.A. The vessel was operated by US scientists participating in the workshop. A second research vessel, an outboard powered launch operated by staff of the Habitat Enhancement Branch, Fisheries and Oceans Canada, was used to transport scientists to the intertidal collection sites.

Study plan and methods

Several biological responses were evaluated. A list of studies and investigators is shown in Table 1.1. The Workshop activity schedule is shown in Table 1.2 and Table 1.3 contains a detailed list of the samples collected.

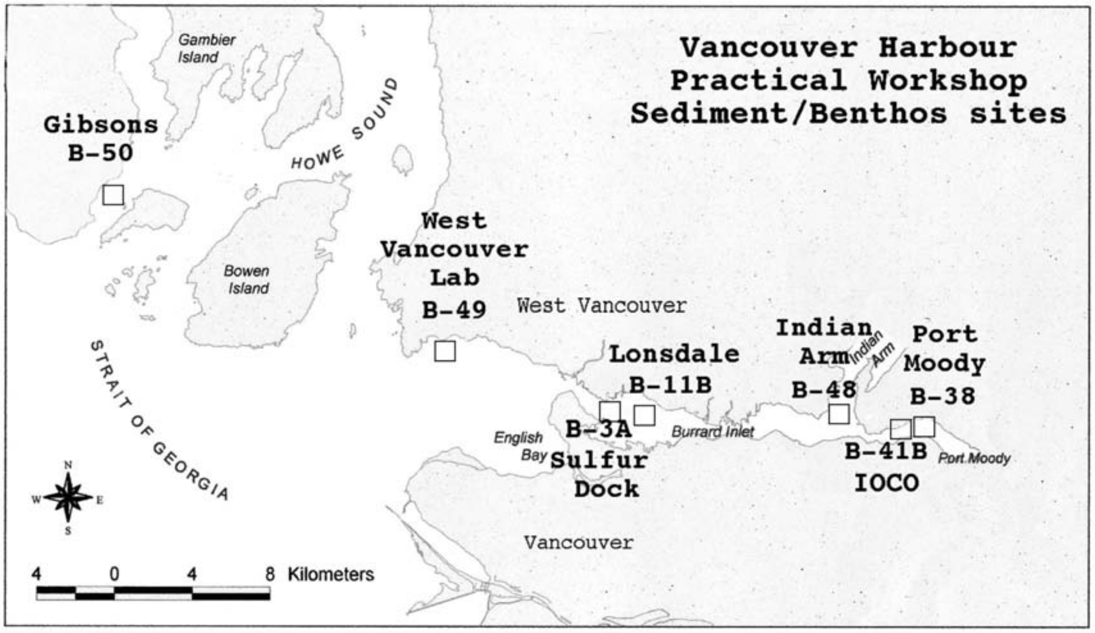


Fig. 1.2 Sediment and benthos collection sites.

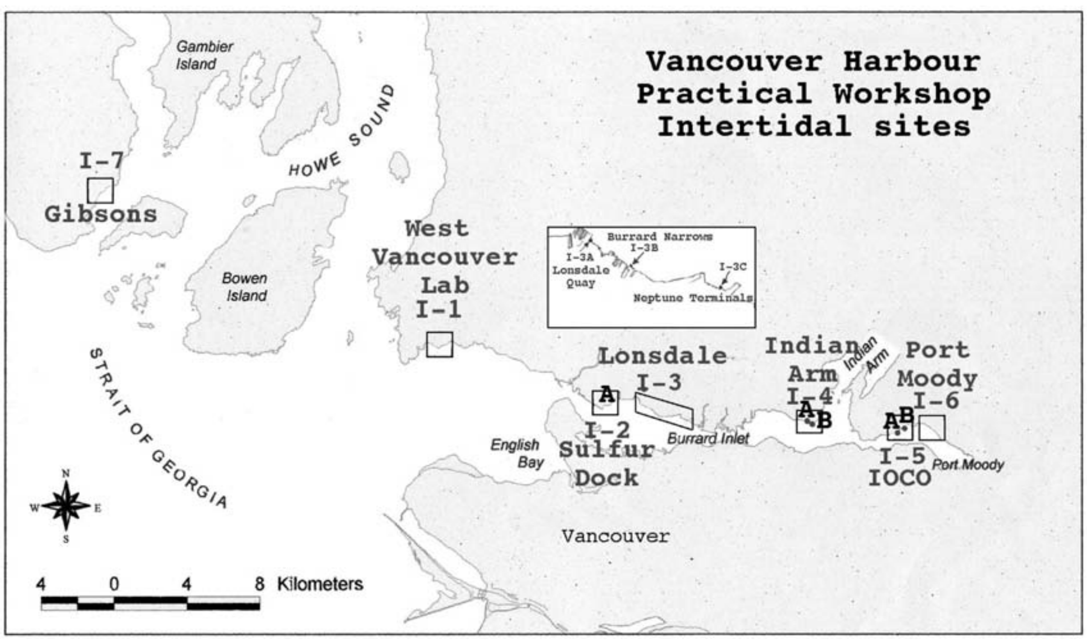


Fig. 1.3 Intertidal collection sites.

<u>Benthic fish</u>
Bottom fish were captured with an Otter trawl at the five sites where there was sufficient space to conduct trawling operations. Species composition, number of individuals, and biomass was determined for the demersal fish catch in each trawl (Fig. 1.7). A target indicator species was retained to examine the relationship between fish health and contaminant exposure. English sole (*Pleuronichthys vetulus*) was selected as the indicator species because this species is common in Vancouver Harbour, and it feeds on benthic organisms living in the sediment (Fig. 1.8). This species is also known to be sensitive to contaminant exposure, and much is known about the relationship between health of English sole and contaminants based on previous studies from other areas similar to Vancouver Harbour (Myers *et al*. 1987, 1994, 1998).

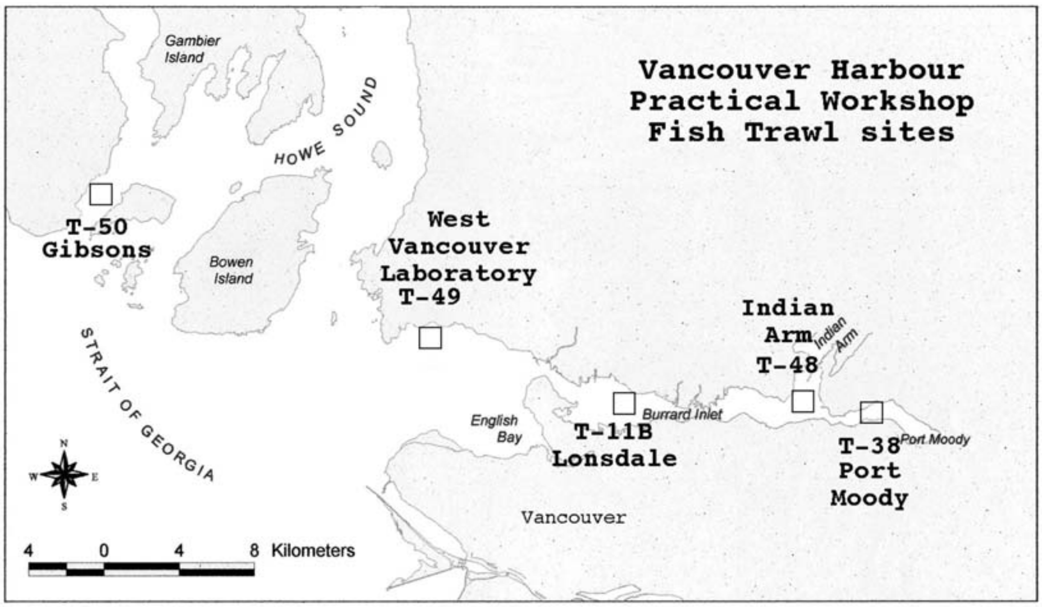


Fig. 1.4 Fish (trawling) collection sites.

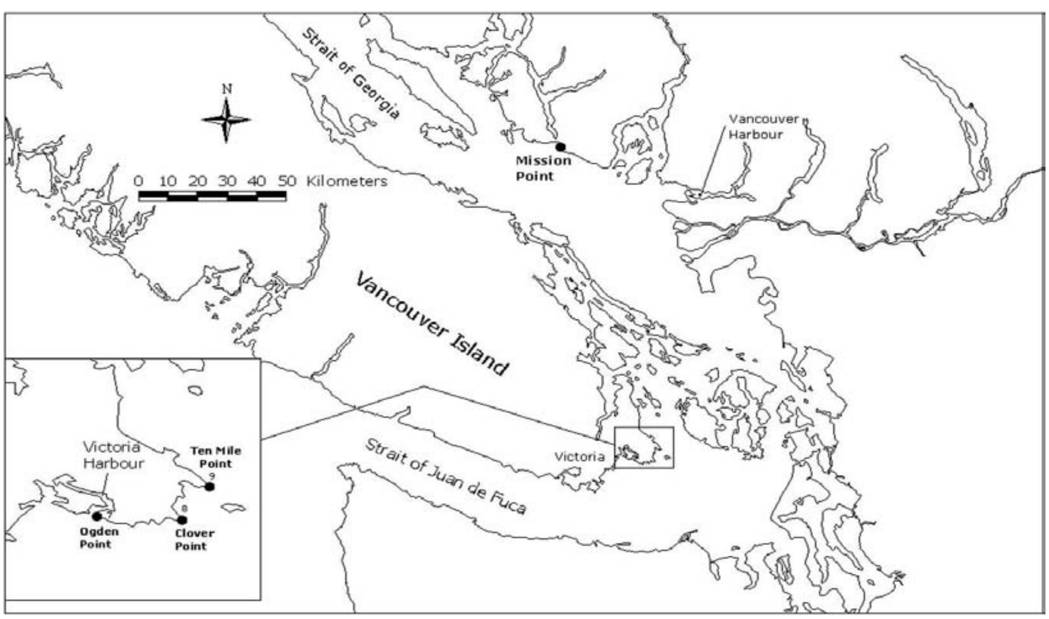


Fig. 1.5 Gastropod collection sites.

Fig. 1.6 The research vessel *Harold W. Streeter*, at anchor while workshop participants collect bottom sediment samples. Yellow material in the background is elemental sulfur.

Fig. 1.8 English sole was the target species collected for several of the fish studies.

Fig. 1.7 Sorting the catch captured with the bottom trawl (Colin Levings, Bernadita Anulacion, Dan Lomax, Mark Myers, Sean Sol).

Fig. 1.9 Tissue samples from English sole were prepared in the shipboard laboratory (Mark Myers).

Two or more trawls were conducted at each site until 30 adult English sole were collected. The English sole were maintained alive in seawater filled containers until tissue samples could be collected. Immediately after trawling operations were complete, the shipboard laboratory was used to collect and preserve fish samples (Fig. 1.9). Otoliths were removed to determine age. Blood was collected from a subset of fish from two sites for vitellogenin assays. Bile was collected for analyses of fluorescent hydrocarbon metabolites, as an indicator of aromatic hydrocarbon (AH) exposure. Liver tissue was collected for cytochrome P450, metals, chlorinated hydrocarbon (CH) and histopathological analyses. Muscle was collected for AH, CH and metal analyses, and gonads were collected for AH and CH analyses. The stomach was removed from each fish and preserved in 10% formalin. Table 1.4 shows more detailed information about the samples collected from English sole.

Table 1.1 List of studies and investigators.

Study	Lead Investigators	Country
Benthic community structure	Dr. Tatyana Belan Dr. Jong Geel Je	Russia Korea
Organic and metal analyses of fish and bivalve tissues	Dr. John Stein (organics in fish) Dr. Seichii Uno (organics in fish and bivalves) Dr. Alex Tkalin (metals in fish and mussels)	USA Japan Russia
Organic and metal analyses of sediment	Dr. John Stein (organics) Dr. Alex Tkalin (metals)	USA Russia
Demersal fish health (using English sole as an indicator species);Indicators of biochemical changes (e.g., induction of cytochrome P-4501A (CYP1A), bile metabolites, vitellogenin	Dr. John Stein (histopathology, bile metabolites, vitellogenin) Dr. Stelvio Bandiera (CYP1A) Dr. Munetaka Shimizu (vitellogenin)	USA Canada Japan
Fish community structure (species distributions, biota age and size relationships, stomach contents)	Dr. Colin Levings	Canada
Community structure of mussels	Ms. Hyun Yun	Korea
Gastropod imposex	Dr. Toshihiro Horiguchi Dr. Zhengyan Li	Japan China
Presence of natural toxins from harmful algae	Dr. Tian Yan (PSP, ARTOX) Dr. Terry Sutherland (cysts)	China Canada
Sediment analyses	Dr. John Stein (organics) Dr. Alex Tkalin (metals)	USA Russia

Table 1.2 Vancouver Practical Workshop schedule.

May 24	Half-day meeting for introductions, laboratory safety training, tour of the lab, and to discuss oceanographic features of Burrard Inlet.
May 24	Half-day meeting for introductions, laboratory safety training, tour of the lab, and to discuss oceanographic features of Burrard Inlet.
May 24	Information about environmental monitoring approaches was presented by a representative from each country. Sampling plan was discussed. R/V *Harold W. Streeter* arrived.
May 26	Supplies and equipment were prepared for sampling. Participants received safety training for the Research Vessel.
May 27	The first site was sampled (trawl site T-49, benthic site B-49, intertidal site I-1). This site was located next to the West Vancouver Laboratory.

Table 1.2 continued

May 28	Sampled Inner Harbour at Lonsdale Quay (Trawl site T-11B, Benthic site B-11B, Intertidal site I-3 via launch).
May 29	Sampled Port Moody (Trawl site T-38, Benthic site B-38, Intertidal site I-6 via launch). Also sampled benthic site B-41B, (but there was insufficient space for trawling at this site).
May 30	Sampled Indian Arm (Trawl site T-48, Benthic site B-48, Intertidal site I-4 via launch).
May 31	Free day, except for scientists Dr. Horiguchi and Dr. Li, who travelled to Victoria to look for snails for imposex research since none were observed at any of the established sites. Snails were successfully located at three sites near Victoria.
June 1	Sampled sulfur dock site (Benthic site 3A, intertidal site I-2 via launch). Not enough room to trawl for fish at this site. Returned to Lonsdale Quay (site T-11B) for additional trawls for fish community data.
June 2	Sampled south through Thornbrough Channel to Howe Sound. One group travelled aboard the R/V *Harold W. Streeter*, another traveled to Gibsons via car and ferry (Trawl site T-50. Benthic site B-50. Intertidal site I-7). This is a reference site. Also collected snails for imposex studies from Mission Point near Sechelt.
June 3	Returned to West Vancouver Lab (site T-49) to get additional samples for fish community data. Demonstrated trawling and sediment collection techniques to scientists who may not have had an opportunity to observe these operations. Research vessel departed.
June 4-6	Processed samples in the laboratory, prepared samples for shipping.
June 7	Final meeting and barbecue at Workshop Co-Chairman Colin Levings' house.

Table 1.3 Sample collection synopsis.

Sites sampled

- 5 sites were sampled for fish.
- 7 sites were sampled for sediment and benthic invertebrates.
- 7 sites were sampled for intertidal invertebrates and algae.
- 4 sites were added for gastropod imposex studies. 3 sites were located on Vancouver Island, near Victoria and 1 site was near Sechelt (north of Howe Sound).

Number of samples collected

<u>**Fish**</u>

162	Otoliths (Canada)
152	Histology (liver, kidney, gonads) (US)
35	Plasma for vitellogenin (US and Japan)
143	Bile for fluorescent aromatic compound analyses (US)
150	Liver for organic chemical analyses (US)
93	Liver for organic chemical analyses (Japan)
25	Muscle for trace metals analyses (Russia)
49	Muscle for trace metals analyses (Russia)
150	Gonads for organic chemical analyses (Japan)
60	Liver for Cytochrome P450 1-A (CYP1A) (Canada)
60	Liver for DNA adducts (US)
95	Stomachs for taxonomy of contents (Canada)
500	Length/weight of English sole (Canada)
25	(trawls) for species composition and biomass data (Canada)

Table 1.3 continued

Sediment

Benthos

35 grabs (0.1 m^2) (5 grabs at each of 7 sites) for benthic community studies (Russia and Korea)

Sediment Chemistry

21 sediment (3 grabs at each of 7 sites) for trace metals (Russia)
21 sediment samples (3 grabs at each of 7 sites) for organic chemicals (US)
21 sediment samples (3 grabs at each of 7 sites) for total organic carbon (US)

Meiofauna and grain size

245 sediment samples (one grab at each site, 5 samples/grab, 7 slices from each sample with 4 for meiofauna, 3 for grain size) (Canada and Korea)

Microalgae

9 sediment samples (3 sites, 3 reps/site) to culture microalgae from surficial sediments (China and Canada)

Intertidal

Mussels – 7 sites

30/site for trace metals (Russia)
500 g/site whole mussel for algal toxin (China)
50 animals/site (9 sites including Clover Point, Victoria, and Mission Point, Sechelt) for organotin (Japan) (composites will be analyzed)
50 animals/site for OCs and PAHs and lipids (8 sites) (Japan)
4 sites sampled for mussel community data using quadrats (Korea)
100 random mussels collected from 7 sites for condition factor (Korea) and lipid analyses (Japan)

Molluscs for organotin analyses (Japan)

Site	Bivalves collected
I-1	mussel, oysters
I-2	mussel, native littleneck, butter clams, pointed macoma
I-3a	mussel
I-3b	mussel
I-3c	mussel
I-4a	mussel, native littleneck, butter clam, pointed macoma, cockle
I-4b	native littleneck, butter clam, pointed macoma, cockle, horse clam
I-5	mussel
I-6	mussel, softshell, native littleneck, butter clam, oyster
I-7	mussel, softshell, dark mahogany clam, oyster
Ogden Pt.	*Nucella* spp.
Clover Pt.	*Nucella* spp., mussel
Ten Mile Pt.	*Nucella* spp.
Mission Pt.	*Nucella* spp.

(mussel = *Mytilus trossulus*)
(oysters = *Crassostrea gigas*)
(native littleneck clam = *Prototheca staminea*)
(butter clam = *Saxidomus giganteus*)
(cockle = *Clinocardium nuttali*)
(horse clam = *Tresus capax*)
(softshell clam = *Mya arenaria*)
(pointed macoma = *Macoma inquinata*)
(dark mahogany clam = *Nuttallia obscurata*)

Snails for Imposex analyses (Japan and China)

300–400 snails were collected at 3 sites in Victoria including: Ogden Pt., Clover Pt., and Ten Mile Pt., and one site at Mission Pt., Sechelt. Of those collected, approximately 80 were *Nucella emarginata*, 80 were *Nucella lamellosa*, and 100 were *Nucella canaliculata*. The *Nucella canaliculata* could also be *Nucella lima*; Dr. Je will do chromosome tests for species ID.

Table 1.4 Fish tissue collection plan for the Vancouver Harbour Practical Workshop.

Vancouver PICES Practical Workshop Fish Tissue Collection 5/5/99

Randomly select up to **30 adult English sole/ site,** Weigh (g) and measure total length (mm).

Samples to be collected	Number/ species/ sex	Container	Storage
Collect **Blood** (USA and Japan) (1to 3 ml/fish) from male fish with heparinized syringe, centrifuge to separate plasma; aliquot. For vitellogenin samples, add 0.1 M PMSF - 10 ul / ml plasma. Collect at T-48 and T-11B sites only.	**10** or more individuals in glass tubes	cryo vials	ice bath to -20°C
Otoliths (Canada)	**30** per site	provided by W.Van Lab	in glycerin
Bile (USA)	**30** site	amber vial	ice bath to -20°C
Histology (USA) - **liver** - longitudinal section - **kidney** - longitudinal section - **gonad** - cross section -**spleen** - half of spleen (cut sections no thicker than 3mm)	**30** site	white cassette	NBF
If **nodules** are present collect separate section for LM. Also collect heart, spleen and intestine for (LM). Record on card.	as needed	white cassette	NBF
Liver chemistry Organics - USA (half of liver, after histo sample collected)	**30** site	7ml rinsed scint vial	ice bath to -20°C
CYP1A - Canada (half of liver, first 10-15 livers)	**10-15** site	minced in scint. vial	ice bath to -20°C
Organics - Japan (half of liver, rest of fish after CYP1A is collected)	**15-20** site	7ml rinsed scint vial	ice bath to -20°C
DNA adducts -USA (use 5% if whole liver available) for two sites - T-48 and T-49	**30** site	green cap cryovial	liquid N2 to -80°C
Stomach contents - Canada - taxonomy	**30** site	plastic containers	NBF
Gonad organics - Japan Place remaining tissue from histology in 20 ml vial	**30** site	20ml rinsed scint. vial	ice bath to -20°C
Muscle Organics - Japan	**10** site	rinsed glass jar	ice bath to -20°C
Metals - Russia	**5** site	Acid rinsed poly bottle	ice bath to -20°C

Sediment and benthos

A Van Veen grab was used to collect sediment for biological and chemical analyses (Figs. 1.10 and 1.11). Three grabs of sediment were collected and the surface layer (2 cm in depth) was removed and preserved for analyses of organic chemicals and metals. An additional 5 grabs were collected for benthic community studies. The sediment was immediately passed through a 0.5 mm sieve. Benthic organisms were removed from the sieve using forceps and preserved for further study (Fig. 1.12). Another grab was obtained for meiofauna samples. Five replicates cores (one cm diameter) to 10 cm depth were obtained, sectioned at one cm intervals, and preserved in 5% formalin for examination in the laboratory. These samples were archived for future analyses. The sections of one core from each station were used for grain size analyses. After evaporation of preservation fluid at air temperature, the sediment was analyzed for grain size at KORDI using standard sieving and settling tube techniques.

At sites where trawls were also obtained, the sediment/benthos site location was established in the center of the fish collection area. This ensured that the sediment chemistry, benthos and fish data could be correlated.

Fig. 1.10 Collecting sediment with the Van Veen grab (Jong Jeel Je).

Fig. 1.11 Sediment grab being lowered over the side of the research vessel.

Fig. 1.12 Sediment samples were sieved and sorted for benthic organisms (Mark Myers, Alexander Tkalin, Tatyana Belan).

Intertidal organisms

Intertidal clams, mussels, and algae were collected from the beach at each site (Fig 1.13). Site locations corresponded with those for the fish and sediment collections as much as possible, however, beach obstructions, or lack of suitable organisms, sometimes required the intertidal sampling station to be relocated to the next closest area. Clams were collected for hydrocarbon and tributyltin (TBT) analyses. Mussels were collected (Fig. 1.14) for analysis of hydrocarbons, metals including TBT, condition factor and toxins associated with harmful algae. Clams and mussels were cleaned, and removed from their shell. Tissues were frozen or freeze dried, and shipped to the workshop participants home laboratories for further processing and analyses.

Gastropods in the genus *Nucella* were also collected for TBT analyses and imposex evaluations. However, no *Nucella* could be found at any of the established sites. Therefore, four new imposex study sites were established, three were near Victoria, and the fourth was near Mission Point (Sechelt) (Fig. 1.5). Anatomical measurements of gastropods relating to imposex studies were made at the West Vancouver Laboratory shortly after collection. Snails were then frozen and shipped to the workshop participant's home laboratories for further analyses.

Natural toxins - Harmful algae

Sediment samples from the benthic sites were collected to determine if encysted harmful algae were present. Mussels and other bivalves were also collected from intertidal sites for natural toxin analyses. Macroalgae was also collected from intertidal sites, and microalgae was scraped from the surface of the macroalgae for ARTOX analyses. Occasional bivalves occurring as by-catch in the bottom trawl samples were retained for toxin analyses.

Workshop products

1. Data are being archived and are available to PICES country scientists in this report. The database can also be accessed electronically through the PICES Home Page at "www.pices.int". A limited number of CDs

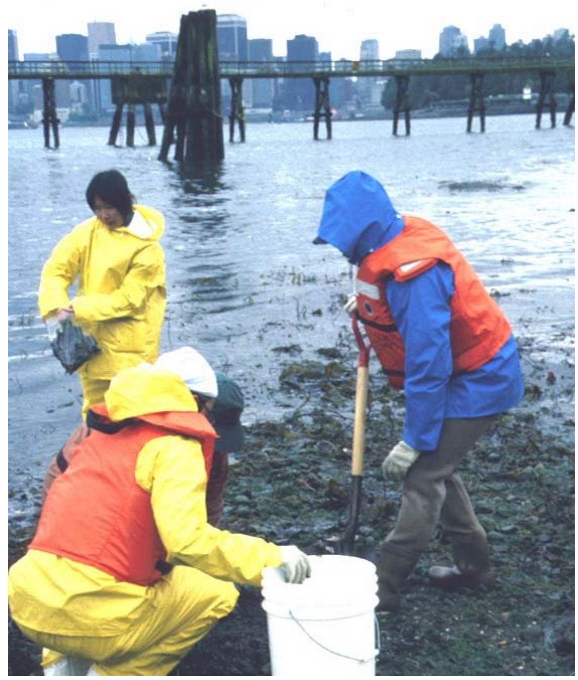


Fig. 1.13 Collection of intertidal clams and algae (Seiichi Uno, Tian Yan, Toshihiro Horiguchi).

Fig. 1.14 Collection of mussels (Alexander Tkalin).

will also be made of the data base, and can be requested from the PICES Secretariat.

2. Plans are in progress for publication of interpreted results in a peer-reviewed journal. Papers are being prepared, and will be considered for publication in a special issue of Marine Environmental Research. It is anticipated that the papers will be published in 2002.

3. PICES participants gained an improved appreciation of the approaches and techniques used by other member countries to assess the effects of marine pollution, and improved mutual understanding and technology transfer among scientists from PICES countries.

Summary

The Practical Workshop conducted by the Marine Environmental Quality Committee of the North Pacific Marine Sciences Organization (PICES) was the first step by member countries in harmonizing methods used to investigate the status of contamination in coastal marine systems and the associated effects on vertebrate and invertebrate species. Success in harmonizing methods should significantly improve our ability to compare data collected by multiple investigators working in diverse ecosystems in the North Pacific. Greater inter-comparability of data also improves our capacity to assess the status and trends in chemical contaminant levels and biological effects among PICES countries. Continued efforts by PICES to harmonize assessments of status and trends in contaminant levels and effects, should increase the level of scientific information available to individual member countries to evaluate the relative risks from chemical contaminants on the health of their coastal ecosystems.

This data report presents the results from the collaborative effort to share expertise and experience in sampling and analyzing both sediment and biota. The data presented here also demonstrates that, during the workshop, we used a wide variety of techniques to measure levels of contaminant exposure and effects across a broad range of biological organization — from biochemical endpoints to benthic and fish community structure. A substantive measure of the scientific success of the project was the commitment by the workshop participants to publish the findings from the workshop in the peer-reviewed scientific literature. Publication of the findings will make the data available to the broader scientific community, demonstrate the success of the workshop, and contribute an increased understanding of the effects of contaminants on biota of Vancouver Harbour.

The following is a list of lessons we learned in conducting this workshop:

- The time committed by the MEQ working group to developing workshop objectives, goals, and work plan was critical to the overall success of the workshop.

- Selection of Vancouver Harbour as the site for the workshop was important, because of the proximity to dry- and wet-lab facilities, availability of housing for workshop participants, and relatively short distances between sampling sites that exhibited a range in chemical contamination. Availability of an "operations room" for daily briefings and discussions of sampling plans by the group was also important as adjustments to logistics had to be made as the work progressed.

- Unrestricted use of a well-equipped research vessel and a small launch provided us with the flexibility to adjust daily plans as needed, and carry out a wide range of different sampling activities.

- The logistical support provided by our Canadian colleagues during the workshop was instrumental in the overall success of the sampling, sample processing and shipment of samples.

- Although we were successful in collecting a wide range of biotic samples, we were not able to conduct many of the chemical and biological analyses on a real time basis during the workshop. Because of the wide range of complex analyses needed, we could not assemble the specialized instruments needed to carry out many of these analyses at the site of the workshop. Therefore, participants could not demonstrate their analytical techniques or share as much data during the workshop as originally anticipated. However the present data report should facilitate the exchange of data by the workshop participants.

- The rather intense work schedule for the workshop made it difficult for participants to take time from their personal research to participate in projects being conducted by their colleagues. There were opportunities, however, for discussion among participants after daily sampling and sample processing activities were completed. This opportunity was important in initiating exchange of technical information on the analytical techniques being used.

In conclusion, the Vancouver Harbour Practical Workshop was successful in several areas: 1) it brought scientists from all PICES countries together for the first time to carry out a collaborative research project involving sample collection and analysis, 2) the careful planning and execution of the workshop has led to a data set that provides new information on the status of chemical contamination in the Harbour, and 3) the workshop was a key step in initiating efforts to compare and contrast techniques used by PICES member countries in assessing the status and trends of chemical pollution in coastal ecosystems.

There are two recommendations for future PICES activities that have a format similar to our Practical Workshop. First, focusing on a more limited research approach would provide greater opportunity for more in-depth exchange of technical approaches and for conducting analyses during the workshop. The ability to share data and demonstrate techniques in real time would be effective in furthering technology transfer. Second, it is our conclusion that the structure for the workshop we conducted is applicable to other PICES committees, and we encourage the committees to consider the value of a Practical Workshop format in meeting their scientific objectives.

Acknowledgements

Funding for workshop supplies, shipping of samples, and travel for some of the workshop participants were provided by PICES. Appreciation is extended to the Practical Workshop Co-Chairmen Drs. John Stein and Colin Levings, and to Dr. Richard Addison for developing and overseeing the planning of the Workshop. Thanks are also extended to Ms. Christine Elliott and Ms. Beth Piercy who assisted with logistics for lodging, obtaining supplies and helped host the Workshop at the West Vancouver Laboratory, Fisheries and Oceans Canada. Thanks also to Mr. Dan Lomax, Mr. Paul Plesha, and Mr. Brian Bill from the Northwest Fisheries Science Center, National Marine Fisheries Service, U.S.A., for operating the R/V *Harold W. Streeter*, and transiting the vessel to and from Seattle, WA, U.S.A., and Vancouver Harbour, Canada. Appreciation is also extended to launch operators Mr. Bruce Clark and Mr. Corino Salomi from the Department of Fisheries and Oceans, Canada. Thanks is also extended to Mr. Geoff Lang from the Alaska Fisheries Science Center, National Marine Fisheries Service, U.S.A., for developing the relational database so that the Practical Workshop data can be easily accessed. Thanks also to Nara Mehlenbacher, West Vancouver Laboratory, Canada, for assistance with GIS and mapping. Additional personnel who helped with sample collection included Ms. Bernadita Anulacion, Mr. Sean Sol, Ms. Gina Ylitalo, Mr. Mark Myers, and Mr. Larry Hufnagle. The Northwest Fisheries Science Center, U.S.A., provided funding for the operation of the research vessel. Fisheries and Oceans Canada provided funding for the operation of the launch and availability of the laboratory space.

References

Addison, R.F. and K.R. Clarke (eds.). 1990. Special issue on biological effects on pollutants in a subtropical environment. J. Exp. Mar. Biol. Ecol. Vol. 138: 1–8.

Bayne, B.L., Clarke, D.R., and J.S. Gray (eds.). 1988. Biological effects of pollutants. Results of a practical workshop. Mar. Ecol. Prog. Ser. Special Issue Vol. 46. 278 pp.

Myers, M.S., Rhodes, L.D., and B.B. McCain. 1987. Pathological anatomy and patterns of occurrence of hepatic neoplasms, putative preneoplastic lesions, and other idiopathic hepatic conditions in English sole (*Parophrys vetulus*) from Puget Sound. Journal National Cancer Institute 78(2): 333–363.

Myers, M.S., Stehr, C.M., Olson, O.P., Johnson, L.L., McCain, B.B., Chan S-L. and U. Varanasi. 1994. Relationships between toxicopathic hepatic lesions and exposure to chemical contaminant in English sole (*Pleuronectes vetulus*) starry flounder (*Platichthys stellatus*) and white croaker (*Genyonemus lineatus*) from selected marine sites on the Pacific Coast, USA. Environmental Health Perspectives 102: 200–215.

Myers, M.S., Johnson L.L., Olson, O.P., Stehr, C.M., Horness, B.H., Collier, T.K., and B.B. McCain. 1998. Toxicopathic hepatic lesions as biomarkers of chemical contaminant exposure and effects in marine bottomfish species from the Northeast and Pacific Coasts, USA. Mar. Poll. Bull. 37: 93–113.

Stebbing, A.R.D. and V. Dethlefsen. 1992. Introduction to the Bremerhaven workshop on biological effects of contaminants. Mar. Ecol. Prog. Ser. 91: 1–8.

Participation List

Canada
- Richard F. Addison*
- Stelvio Bandiera*
- Christine Elliott
- Colin D. Levings*
- Beth Piercy
- Terri Sutherland

China
- Zhengyan Li
- Tian Yan*

Japan
- Toshihiro Horiguchi*
- Makato Shimizu*
- Munetaka Shimizu
- Seiichi Uno*

Korea
- Jong Jeel Je*
- Ji Hyun Yun

Russia
- Tatyana Belan*
- Tatyana Lishavskaya
- Alexander V. Tkalin*

U.S.A.
- Bernadita Anulacion
- Brian Bill
- Larry Hufnagle
- Dan Lomax
- Mark Myers
- Paul Plesha
- Sean Sol
- Carla Stehr*
- John Stein*
- Gina Ylitalo

*Workshop organizers and project leaders

Section II Site Description and Oceanography

Colin D. Levings[1] and Steve Samis[2]

[1] Fisheries and Oceans Canada, Science Branch, West Vancouver Laboratory, 4160 Marine Drive, West Vancouver B.C., Canada. V7V 1N6

[2] Fisheries and Oceans Canada, Science Branch, Habitat and Enhancement Branch, 555 West Hastings Street, Vancouver, B.C., Canada. V6B 5G3

Vancouver Harbour

Vancouver Harbour, here defined as the waters to the east of Point Atkinson (Figs. 1.2-1.4), consists of three or four water bodies, namely Outer Burrard Inlet or English Bay, Inner Burrard Inlet, Port Moody Arm, and Indian Arm, a long fjord (22 km) which leads to the northeast from the main harbour. All of the PICES sampling stations were on the first three water bodies, except for a far field reference station located about 15 km to the north, in another part of the Strait of Georgia (see below). The approximate length of the inlet system is about 30 km with maximum width of approximate 4 km in English Bay. Inner and Outer Burrard Inlets are separated by a narrowing of the harbour, known as First Narrows. Further to the east, Inner Burrard Inlet and Indian Arm/Port Moody are separated by Second Narrows. Each narrows is about 0.5 km wide. Maximum depth ranges from about 45 m in Outer Burrard Inlet to about 10 m in Port Moody Arm.

The harbour is the largest port on the west coast of Canada. For administration purposes, the harbour comes under the jurisdiction of the Vancouver Port Authority, and includes port facilities on Roberts Bank and the Fraser River estuary, which is outside of the area where the PICES workshop was focused. In 1998 there were about 2500 deep sea ship landings in the harbour. About 8 million tons of ballast water was discharged into the harbour in 1999, and 71.2 million tons of cargo (containers and bulk goods) were handled, including 1.07 metric ton equivalent units of containers. Coal and sulfur are stockpiled in large volumes on docks and backup land adjacent to the docks. The shoreline of the harbour has been modified for dock construction, with 42.1 km out of the total shoreline length of 102.7 km converted to riprap revetment or docks. The undisturbed shorelines consist primarily of rock and cobble beaches, rocky shores, and mudflats, with the latter most common in Port Moody Arm.

The following description of the general oceanography of the harbour is adapted from Stockner and Cliff (1979) who relied extensively on Tabata (1971) for their text.

Tides and currents

Tides in Vancouver Harbour are of the mixed diurnal type, with mean range of 3.1 m and maximum of 4.9 m. At both First and Second Narrows, maximum tidal currents can range up to 11 $km \cdot h^{-1}$. These are the areas of greatest tidal mixing in the harbour. In a recent study currents at depth were found to be as high as 1.5 $m \cdot s^{-1}$ (Isachsen and Pond 2000). The average tidal prism for the inlet is approximately 8.4×10^7 m^3 (Davidson 1979 cited in Lewis and Thomas 1986).

Temperature and salinity

Figures 2.1a and b show sections of temperature and salinity through the harbour area obtained during a survey in July 1966. The pattern shown is supported by more recent work (eg Davidson 1979). The positions of the four stations sampled by trawling and the additional sediment sampling stations are also shown. Bottom water temperatures near the locations were about 10-11°C except for the shallow stations in Port Moody Arm (Stations T-38, B-38 and B-41B). Surface temperatures, which might represent conditions on the intertidal zone, ranged from 13-15°C in Outer Burrard Inlet to 16–18°C in Port Moody Arm.

Salinity in outer Burrard Inlet is strongly influenced by discharge from the Fraser River (annual mean discharge 3600 $m^3 \cdot s^{-1}$). During

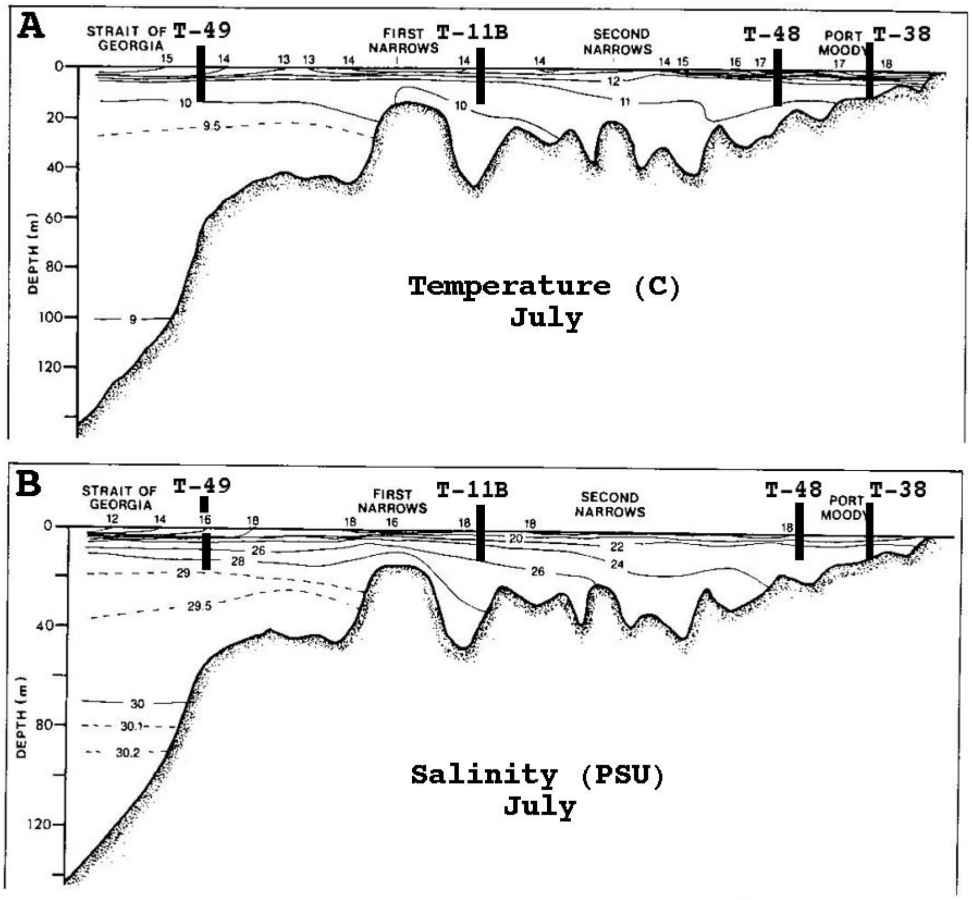


Fig. 2.1 Location of trawl and benthos sites in relation to longitudinal variation in bottom water temperature (A) and salinity (B) in Vancouver Harbour. Oceanographic section data are from Thomson (1981).

high discharge periods, the freshwater plume of the Fraser River occasionally penetrates through First Narrows, into the inner harbour. Other sources of freshwater include the Capilano River (regulated, discharge range 4.5 to 25.0 $m^3 \cdot s^{-1}$) and the Seymour River (regulated 2.8 to 23.3 $m^3 \cdot s^{-1}$) which enters the harbour near the First and Second Narrows, respectively. Bottom salinities in July 1966 decreased from about 29.5 psu in outer Burrard Inlet to between 22.0 and 24.4 psu in Port Moody Arm. Surface salinities ranged from 12 psu in outer Burrard Inlet to 18 – 22 psu in Port Moody Arm.

Dissolved oxygen

In the main harbour Stockner and Cliff (1979) recorded a seasonal dissolved oxygen (DO) range of 5.0 to 10.0 $mg \cdot l^{-1}$, well above the levels that would impair marine organisms. Early investigations of pollution in the harbour (Waldichuk 1965) established that even in shallow Port Moody Arm, at the landward end of the Inlet system, the estuarine circulation enabled a relatively rapid flushing of bottom water so bottom water DO was always > 6.0 $mg \cdot l^{-1}$. Recent investigations connected with dispersal of heated effluent in Port Moody Arm have tended to confirm Waldichuk's findings (Taylor *et al.* 2001).

Nutrients

Data from 1976 (Stockner and Cliff 1979) showed little evidence of eutrophication in Vancouver Harbour when their phytoplankton surveys were conducted in 1976. Nitrate levels in June were 0.120 $mg \cdot l^{-1}$ in Outer Burrard Inlet, 0.175 $mg \cdot l^{-1}$ and 0.120 $mg \cdot l^{-1}$ in Inner Burrard Inlet and Port Moody Arm, respectively. Since there is less discharge of untreated sewage into the harbour now relative to when their surveys were made, it is likely nutrient levels have not increased.

Sediments

Sediments in Vancouver Harbour range from fine mud in deposition areas such as Port Moody Arm, to coarse cobble and gravel at First and Second Narrows, and on river deltas such as the mouth of Capilano River. However all of the PICES stations were located on mud substrates, as shown in the benthic invertebrate study of Je *et al*. (this report). The sediment transport patterns are relatively well known. McLaren (1994) concluded that the west portion of Inner Burrard Inlet and the north portion of outer Burrard Inlet were essentially characterized by a counter-clockwise circulation with flood-directed sediment transport dominating the south side, and ebb-directed transport dominating the central and northern half. Dredging is needed at First Narrows to maintain the navigational channel, indicating net deposition at that location. In Port Moody Arm, sedimentation rates of about 1 cm y^{-1} have been documented (Pedersen and Waters 1989) and dredging of deep-sea berths is periodically needed in this area.

Thornbrough Channel (Howe Sound)

A far field reference area was chosen in Howe Sound, specifically on the southern end of Thornbrough Channel near Granthams Landing, about 2 km north of the town of Gibsons (population about 4000) (Figs. 1.2-1.4). Both trawling and intertidal collecting were conducted to match sampling in Vancouver Harbour. However, because of bottom conditions, the trawling could not be done at the same depth relative to the Outer Burrard Inlet station (T-49, 45 m) and hence the three trawls were completed at deeper depths, between 55 to 75 m. Thornbrough Channel is connected to the same water masses as Vancouver Harbour via deeper channels leading to the Strait of Georgia. Sediments in the deeper parts of the Channel are sand (see Je *et al*., this report) and beach substrates at Granthams Landing consist of sand and gravel.

Only a few data are available on the physical and chemical oceanography of southern Thornbrough Channel. Although part of Howe Sound, which is considered a true fjord, Thornbrough Channel is well outside the area of the sill in the fjord and thus shows characteristics similar to the adjacent Strait of Georgia.

Temperature, salinity and dissolved oxygen

Waldichuk *et al*. (1968) gave limited data from a station within one km of PICES station T-50. In September 1960, at 50 m depth, temperature was 8.6°C and salinity 29.6 psu. Dissolved oxygen was 6.2 $mg \cdot l^{-1}$.

Sediment transport

McLaren *et al*. (1993) concluded that sediment in southern Thornbrough Channel was moving from south to north and that deposition was occurring in the area of the PICES station. As shown by Je et al. (this report) sediments were sandy at the sampling site (mean grain size 0.25 µm). Some of this sediment may be transported to the area from nearby islands.

Victoria and Mission Point

Three sites in Victoria, Vancouver Island, and one on the eastern side of the Strait of Georgia north of Howe Sound (Mission Point, near Sechelt, Fig. 1.5), were chosen for imposex studies because suitable neogastropod monitoring organisms were absent at the time of sampling from Vancouver Harbour at the PICES stations. Victoria is situated at the south east point of Vancouver Is. (Fig. 1.5) and is exposed to tidal currents from the eastern Strait of Juan de Fuca. The “estuarine” circulation conditions attributable to the influence of the Fraser River discharges on the Strait of Georgia are probably at the limits of their influence at the most northerly Victoria sampling site at Ten Mile Point. All sites have moderately wave-exposed rocks and sand or sandy-mud beaches. Tributyltin contamination arising from large vessel traffic, either locally or through the Straits of Georgia and Juan de Fuca, is likely to have the most impact at the Breakwater and Clover Point sampling sites; Ten Mile Point is likely to be less affected. Mission Point is similarly located in an area where nearby vessel traffic is minimal.

Sources of Contamination

Vancouver Harbour

Shipping and industrialization began in Vancouver Harbour in the late 19th century. The first major cargo exported from the harbour was wood products from the forest industry. Other industries located around the shoreline after 1900 included petroleum refineries, shipyards, a chlorine plant, seafood processing industries, fuel loading docks, and marinas. Some of these industries are no longer present on the harbour but their footprints or remnant contamination may still be present, as described below.

Burrard Inlet has about 36 permitted discharges to the marine environment, comprised of municipal and industrial effluents. The largest discharge is from Burrard Thermal, a gas-fired electrical generator. The operator of Burrard Thermal has a permit to discharge 1,700,000 m^3/day of cooling water into Port Moody Arm at a temperature of 27ºC. Second in size is the Lion's Gate Waste Water Treatment Plant, the operator of which has a permit to discharge 102,000 m^3/day of primary treated sewage at First Narrows (Burrard Inlet Environmental Action Program, 1997).

Burrard Inlet also receives effluent from 32 unpermitted combined sewer overflows (CSOs), the largest of which is at Clark Drive. The two Clark Drive overflows (49º17.31′N, 123º4.65′W; 49º17.27'N, 123º4.69′W) discharge approximately 143 times per year, with an average annual discharge of 20,800,000 m^3 of mixed stormwater and untreated domestic sewage. Non-point source discharges in Burrard Inlet include those from 29 marinas, 11 ship repair facilities, 7 fueling operations, 29 ship loading facilities (sulfur, metal concentrates, coal, potash, phosphate rock, grain, forest products, chemicals, petroleum) and 38 anchorages. Sediments in Vancouver Harbour are contaminated with a variety of heavy metals and organics, as described by Tkalin et al. (this report) as well as several comprehensive recent reports by Canadian authorities (Boyd *et al*. 1998). The origins of these pollutants are likely a combination of the above point and non-point sources.

Thornbrough Channel

There are no industrial developments in southern Thornbrough Channel but there are residences on the shore. These homes have septic tanks that may contribute contaminants to the groundwater above the intertidal zone. Very large volumes of logs from elsewhere in BC are brought to the north end of Thornbrough Channel where they are dumped into the water, stored, and eventually towed for processing at sawmills in the lower Fraser River and elsewhere. A marina is located in the town of Gibsons. Sewage is treated in a secondary sewage treatment plant with an outfall discharge located at 49°23.13'N, 123°30.78'W. Permitted effluent volume is 1389 m^3/day. A pulp mill located at Port Mellon, about 12 km north of the PICES sample station has a permitted discharge of 106,500 m^3/day of pulp mill effluent, and 44,500 m^3/day of cooling water. The main diffuser outfall from Howe Sound Pulp and Paper at Port Mellon is located at 49º31.19′N, 123º28.50′W. This mill was upgraded to secondary treatment and chlorine substitution in response to amended and new federal Fisheries Act and Canadian Environmental Protection Act regulations enacted in May 1992. The Howe Sound pulp outfall diffuser has 6 ports ranging in depth from 30 m to 115 m below the low water mark. The outfall extends 277 m into the channel from shore into northern Thornbrough Channel where it enters a predominately northward flow. According to McLaren *et al*. (1993), Thornbrough Channel is entirely tidally dominated. As a result, the ebb and flood tidal currents probably disperse contaminants to the north and south of the discharge point.

Fisheries closures

Vancouver Harbour is closed for commercial trawling for fish but portions are open for shrimp trawling, primarily for smooth pink shrimp (*Pandalus borealis eos*). English Bay/Outer

Burrard Inlet has supported a shrimp fishery for over 75 years (Butler 1980). Until several years ago there was large by-catch of a variety of fish species in this fishery, including English sole (*Pleuronectes vetulus*), the target species for the ecophysiological studies in the PICES workshop. By-catch in the shrimp fishery has been reduced by the use of mandatory escape devices or extruders which are now built into the trawl nets. Inner Burrard Inlet was closed to crab fishing in May 1992, due to dioxin/furan contamination of crab hepatopancreas. The contaminant-related closure was lifted in August 1995, however, due to navigational risk, the area between First Narrows and Second Narrows is closed to all crab and shrimp fishing. Commercial and recreational crab fishing is permitted in Outer Burrard Inlet and east of Second Narrows, including Port Moody Arm.

Southern Thornbrough Channel is also closed for commercial trawling for fish but is an area for shrimp trawling. Howe Sound, including south Thornrough Channel, remains closed to commercial crab harvesting because of dioxin and furan contamination of hepatopancreas. Recreational crab harvesting is allowed with a consumption advisory issued to the public on crab hepatopancreas.

References

Boyd, J., Baumann, J., Hutton, K., Bertold, S. and B. Moore. 1998. Sediment quality in Burrard Inlet using various chemical and biological benchmarks. Prepared for the Burrard Inlet Environmental Action Program. Burnaby, BC. 87 p + app.

Burrard Inlet Environmental Action Program. 1997. Burrard Inlet point source discharge inventory. Environmental Quality Objectives and monitoring Action Team. 38 pp. + Appendices. ISBN 0-7726-3284-7.

Butler, T.H. 1980. Shrimps of the Pacific Coast of Canada. Can. Bull. Fish. Aquat. Sci.: 202.

Davidson, L.W. 1979. Physical oceanography of Burrard Inlet and Indian Arm, British Columbia. MSc thesis Univ. of British Columbia.

Isachsen, P.E, and S. Pond. 2000. The influence of the spring-neap tidal cycle on currents and density in Burrard Inlet, British Columbia Canada. Estuar. Coast. Shelf Sci. 51: 317–330.

Lewis, A.G. and A.C. Thomas. 1986. Tidal transport of planktonic copepods across the sill of a British Columbia fjord. J. Plankton Res 8: 1079–1089.

McLaren, P. 1994. Sediment transport in Vancouver Harbour: Implications to the Fate of Contaminated Sediments and/or dredged material disposal. Final Report to Burrard Inlet Environmental Action Program, Burnaby, BC. 25 pp. + app.

McLaren, P., Cretney, W.J. and R.I. Powys. 1993. Sediment pathways in a British Columbia fjord and their relationship with particle-associated contaminants. J. Coast. Res. 9: 1026–1043.

Pedersen, T.F. and R.D. Waters. 1989. Assessment of the enrichment of cadmium and other metals in the sediments of Port Moody and Indian Arm, British Columbia. Ocean Dumping Research Fund Report No. 15.2.2. 35 pp. Environment Canada.

Stockner, J.G. and D.D. Cliff. 1979. Phytoplankton ecology of Vancouver Harbour. J. Fish. Res. Bd. Canada 36: 1–10.

Tabata, S. 1971. A brief oceanographic description of the waters of Burrard Inlet and Indian Arm. MS Rep. to Mar. Sci. Dir., Pac. Reg., Dep. Environ. Canada: 48 pp.

Taylor, A.E, Fissel, D.B. and I.K. Birtwell. 2001. A Study of the Thermal Regime of Port Moody Arm, Burrard Inlet, BC. Can. Tech. Rep. Fish. Aquat. Sci. 2344, 48 p.

Thomson, R.E. 1981. Oceanography of the British Columbia Coast. Can. Spec. Publ. Fish. Aquat. Sci.: 56. 291 pp.

Waldichuk, M. 1965. Water exchange in Port Moody, British Columbia, and its effect on waste disposal. J. Fish. Res. Bd. Canada 22: 801–825

Waldichuk, M., Markert, J.R., and J.H. Meikle. 1968. Fraser River estuary, Burrard Inlet, Howe Sound and Malaspina Strait Physical and Chemical Oceanographic Data 1957-1966. Vol 1, September 1957 to February 1962. J. Fish. Res. Bd. Canada 939. 244 pp.

Section III – Extended Abstracts

The extended abstracts that follow are summaries of the interpreted results presented at the PICES Ninth Annual Meeting in Hakodate, Japan, October 24, 2000.

Environmental assessment of Vancouver Harbour: The results of an International Workshop – trace metals

Alexander V. TKALIN[1], T.S. Lishavskaya[1], L.T. Kovekovdova[2], M.V. Simakov[2], V.M. Shulkin[3], N.N. Bogdanova[3], T.L. Primak[3], and E.A. Slin'ko[4]

[1] Far Eastern Regional Hydrometeorological Research Institute (FERHRI), Vladivostok, Russia

[2] Pacific Research Centre of Fisheries and Oceanography (TINRO-Centre), Vladivostok, Russia

[3] Pacific Geographical Institute, Far East Branch, Russian Academy of Sciences (PGI FEB RAS), Vladivostok, Russia

[4] Pacific Oceanological Institute, Far East Branch, Russian Academy of Sciences (POI FEB RAS), Vladivostok, Russia

Materials and methods

Sampling

Bottom sediments

Bottom sediment samples were collected by Van Veen grab from seven stations (Section I, Fig. 1.2). Three replicate samples were taken at each station. The surface layer of sediments was collected by plastic spoon in pre-cleaned Ziploc plastic bags. Samples were frozen after collection, then freeze-dried in the shore laboratory and transported to Russia for further analysis.

Mussels

Mussels (about 30 at each site) were collected from rocks and concrete piles during low tide at seven stations (Section I, Fig. 1.3). At all stations, mussels *Mytilus trossolus* were found. At station I-6, oysters *Crassostrea gigas* were also found. In the shore laboratory, soft tissues were removed, weighed, placed in pre-cleaned plastic containers and stored frozen. Then samples were freeze-dried and transported to Russia for further analysis.

Fish

Fish were collected by bottom trawl at 5 stations (Section I, Fig. 1.4). Fish muscle samples were taken from 5 individuals (English sole) at each trawling station and kept in pre-cleaned plastic bags on ice aboard the research vessel and then frozen in the shore laboratory. After freeze-drying, samples were transported to Russia for further analysis.

Analysis

In Vladivostok (Russia), samples of bottom sediments, mussel and fish tissues were homogenized and distributed for analysis in three laboratories:

- Pacific Research Centre of Fisheries and Oceanography (TINRO-Centre);
- Pacific Geographical Institute, Far East Branch, Russian Academy of Sciences (PGI FEB RAS);
- Pacific Oceanological Institute, Far East Branch, Russian Academy of Sciences (POI FEB RAS).

Analytical methods used at the TINRO-Centre are briefly described below.

Bottom sediments

After homogenization, about 0.4 g of dry sample was placed in a 50 ml Teflon beaker, $HClO_4$, HNO_3 and HF were added, the beaker was closed and heated to 50°C for 24 hours. Then HNO_3 and HF were added again and the beaker content was dried at 80°C. After that, 1 ml of concentrated HNO_3 and deionised water were added up to final volume of 20 ml. Concentrations of trace metals (Al, Fe, Co, Cr, Cu, Mn, Ni and Zn) were determined using the flame atomic absorption spectrophotometer NIPPON JARREL ASH, model AA-885, with D_2O background correction. For Al analysis, N_2O-acetylene mixture was used, for other metals – acetylene-air mixture. Contents of Cd and Pb were determined using a graphite furnace on atomic absorption spectrophotometer

HITACHI 170-70, with Zeeman background correction. Detection limits (ppm) were as follows: Al and Fe – 2, Cd – 0.0002, Cr – 0.02, Cu – 0.005, Pb – 0.04, Zn – 0.02.

Mussels

After homogenization, 1-3 g of dry sample were soaked in a Teflon beaker with concentrated HNO_3 (10 ml) for 24 hours, then the acid solution was heated to 120°C for 3 hours. After filtration, trace metal contents (Al, Fe, Co, Cr, Cu, Mn, Ni, Zn) were determined using the flame atomic absorption spectrophotometer NIPPON JARREL ASH, model AA-885. For Al analysis, N_2O-acetylene mixture was used, for other metals – acetylene-air mixture. Contents of Cd and Pb were determined using a graphite furnace on atomic absorption spectrophotometer HITACHI 170-70, with Zeeman background correction.

Fish

After homogenization, 1-3 g of dry sample were soaked in a Teflon beaker with concentrated HNO_3 (10 ml) for 24 hours, then the acid solution was heated to 120°C for 3 hours. After filtration, trace metal contents (Al, Fe, Co, Cr, Cu, Mn, Ni, Zn) were determined using the flame atomic absorption spectrophotometer NIPPON JARREL ASH, model AA-885. For Al analysis, N_2O-acetylene mixture was used, for other metals – acetylene-air mixture. Contents of Cd and Pb were determined using a graphite furnace on atomic absorption spectrophotometer HITACHI 170-70, with Zeeman background correction.

Preliminary results and discussion

Metals in bottom sediments

Data on trace metal contents in bottom sediments are presented in the data section of this report. The results obtained in PGI and POI are in reasonable agreement with the TINRO-Centre data. According to the Fe content (from 2.3 to 4.4%), bottom sediment characteristics at sampling sites were quite different. Concentrations of total copper at all stations except B-50 (Howe Sound, reference site) were higher than 34 ppm (ERL, Long *et al*. 1995). Maximum concentration, 333 ppm, was observed at station B-3A (Sulfur Dock/Copper Ore Dock). On the contrary, contents of cadmium at all stations except B-3A were below ERL value, 1.2 ppm. Concentrations of Pb and Zn exceeded those criteria (46.7 ppm and 150 ppm respectively) at stations B-3A, B-38 (Port Moody, refinery) and B-41B (Port Moody, Ioco). For all these metals, maximum contents were observed at station B-3A (Sulfur Dock/Copper Ore Dock).

A large amount of data on trace metal contents in bottom sediments of Vancouver Harbour have been obtained by Canadian researchers (e.g., Goyette and Boyd 1989; Boyd *et al*. 1998). Data from these two reports for Cd, Cu, Pb and Zn are given in Table 1 along with the results from the PICES MEQ Practical Workshop. A similar comparison for the most polluted (in 1999) station B-3A is shown in Table 2. In both cases a decreasing trend in trace metal concentrations is evident.

Table 1. Trace metals in bottom sediments of Vancouver Harbour in 1985-87, 95 and 99 (ppm, dry weight).

Year	Cd	Cu	Pb	Zn	Reference
1985–1987	<0.3–10.2	48–9760	17–15420	88–2267	Goyette and Boyd, 1989
1995	0.1–3.6	31–1008	17–123	50–800	Boyd et al., 1998
1999	0.3–1.2	11–333	4–76	35–407	This work

Table 2. Trace metals in bottom sediments of Vancouver Harbour at station B-3A (ppm, dry weight).

Year	Cd	Cu	Pb	Zn	Reference
1985–1987	7.4	1200*	250*	1300*	Goyette and Boyd, 1989
1995	3.6	1008	123	800	Boyd et al., 1998
1999	1.2	333	76	407	This work

*approximate value from diagram

Metals in mussels

Data on trace metal contents in mussels *Mytilus trossolus* are presented in the data section of this report. The results obtained in PGI and POI are in reasonable agreement with the TINRO-Centre data. Concentrations of Al, Fe, Cd, Cu and Pb were maximum at station I-2A (Sulfur Dock/Copper Dock). Highest zinc content was registered at station I-3A (Longsdale Quay). Metal concentrations in soft tissues of mussels at other stations were comparable with values from reference stations (I-1, PEI, and I-7, Howe Sound).

A large amount of data on trace metal contents in mussels has been collected within US NOAA NS&T Program (e.g., O'Connor 1998). Data from this paper for Cd, Cu, Pb and Zn are given in Table 3 along with the results of the PICES MEQ Practical Workshop. It is necessary to take into account that NS&T sampling stations are situated outside the "hot spots". Therefore, contaminated sites in Vancouver Harbour (stations I-2A and I-3A) should not be considered as exceptionally polluted.

Metals in fish tissues

Data on trace metal contents in fish tissues (English sole, muscle) are presented in the data section of this report. Concentrations of Al, Cd and Cu were maximum at station T-48 (Cates Park, Indian Arm). Highest zinc content was registered at station T-38 (Port Moody, refinery) and maximum lead content at station T-11B (Longsdale Quay). Even the highest concentrations of copper, zinc and other metals in fish muscle were comparable with values from reference stations (T-49, PEI, and T-50, Howe Sound).

A large amount of data on trace metal contents in fish tissues have been collected by Canadian researchers (Goyette and Boyd 1989). Data from this report for Cd, Cu, Pb and Zn are given in Table 4 along with the results of the PICES MEQ Workshop. As in the case of bottom sediments, the decreasing trend in trace metal contents can be seen.

Conclusions

According to the results on trace metal contents in bottom sediments, station B-3A (Sulfur Dock/Copper Ore Dock) is the most polluted (among those sampled in May 1999). Comparison with data obtained in 1985-1987 and in 1995 revealed a decreasing trend in trace metal concentrations. To characterize temporal trends more precisely, analysis of dated sediment cores might be necessary.

Maximum contents of most metals (except Zn) in soft tissues of mussels were observed at station I-2A (Sulfur Dock/Copper Ore Dock). The highest concentration of zinc was determined at the Longsdale Quay (station I-3A).

In the case of trace metals in fish muscle, even the highest concentrations were comparable with values from reference sites. Contents of trace metals in 1999 were lower than in 1985–1986.

Table 3. Trace metal contents in mussels from Vancouver Harbour in 1986-1996 and 1999 (ppm, dry weight).

Year	Cd	Cu	Pb	Zn	Reference
1986–1996	2.0–3.2	7.2–10.0	0.6–1.1	104–143	O'Connor, 1998
1999	1.7–5.9	6.1–60.8	1.0–218.7	112–325	This work

Table 4. Trace metal contents in muscle of fish from Vancouver Harbour in 1985–1986 and 1999 (ppm, dry weight).

Year	Cd	Cu	Pb	Zn	Reference
1985–1986	0.04–0.51	0.4–4.6	0.08–1.59	5.1–39.8	Goyette and Boyd, 1989
1999	0.02–0.04	1.2–1.5	0.23–0.62	16.0–23.7	This work

References

Boyd, J., Baumann, J., Hutton, K., Bertold, S., and B. Moore. 1998. Sediment quality in Burrard Inlet using various chemical and biological benchmarks. Burrard Inlet Environmental Action Program (BIEAP), November 1998.

Goyette, D., and J. Boyd. 1989. Distribution and environmental impact of selected benthic contaminants in Vancouver Harbour, British Columbia, 1985-1987. Environment Canada Regional Program Report: 89-02.

Long, E.R., MacDonald, D.D., Smith, S.L., and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19: 81–97.

O'Connor, T.P. 1998. Mussel Watch results from 1986 to 1996. Marine Pollution Bulletin 37: 14–19.

Assessment of chemical contaminant exposure and effects in English sole

Carla STEHR, Mark Myers, Dan Lomax, Richard Boyer, Sylvester Spencer and John Stein
Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 2725 Montlake Blvd. E., Seattle, WA 98112, U.S.A

The Marine Environmental Quality Committee of PICES sponsored a Practical Workshop in Vancouver Harbour, Canada, during the summer of 1999. The goal of the workshop was to exchange information about approaches PICES member countries use to assess the biological impacts from marine pollution. To accomplish this, scientists from PICES member countries worked cooperatively to study the effects of chemical contaminants on marine organisms at several sites in Vancouver Harbour, British Columbia.

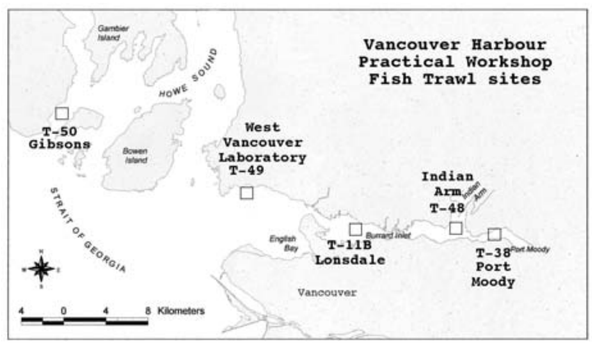


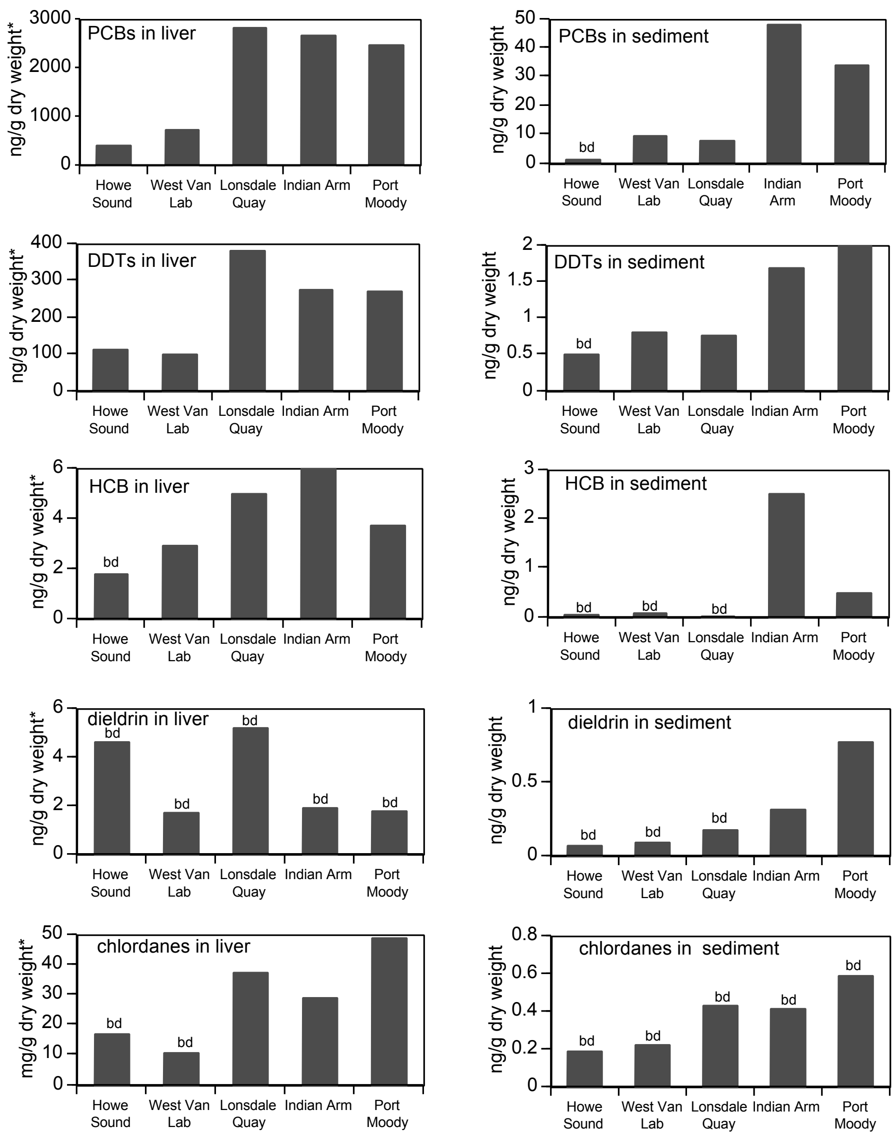
Fig. 1 Location of fish collection sites.

As part of this workshop, the Northwest Fisheries Science Center examined the relationship between liver lesions and chemical contaminant exposure in English sole (*Parophrys vetulus*). English sole is a benthic flatfish used extensively as a sentinel species for contaminant effects in North American west coast marine environments. English sole live in close association with bottom sediments, preying on clams, worms and other benthic invertebrates. This species of fish lives in nearshore environments that are often affected by urban activities, and are therefore at high risk of being exposed to chemical contaminants.

Fish were collected with a bottom trawl from a reference site outside the harbour (Howe Sound), a site near the entrance to the harbour (West Vancouver Lab), and three industrial sites (Lonsdale Quay, Indian Arm and Port Moody) within Vancouver Harbour (Fig. 1). Samples of fish liver, fish bile and sediment were collected, preserved, and returned to the laboratory for analyses. Liver and bile were collected from 30 fish at each site. A portion of the liver was preserved in Dietrichs fixative for histopathology. Paraffin sections were prepared and examined microscopically for non-infectious, toxicopathic lesions. Liver was also collected for chlorinated hydrocarbon analyses. Three composites of liver were analyzed. Each composite contained equal weights of liver from five fish. Bile from 10 individual fish was analyzed at each sampling site. Bile was analyzed for metabolites of aromatic hydrocarbons using HPLC as described by Krahn *et al*. (1986). A Van Veen grab was used to collect sediment from each site.

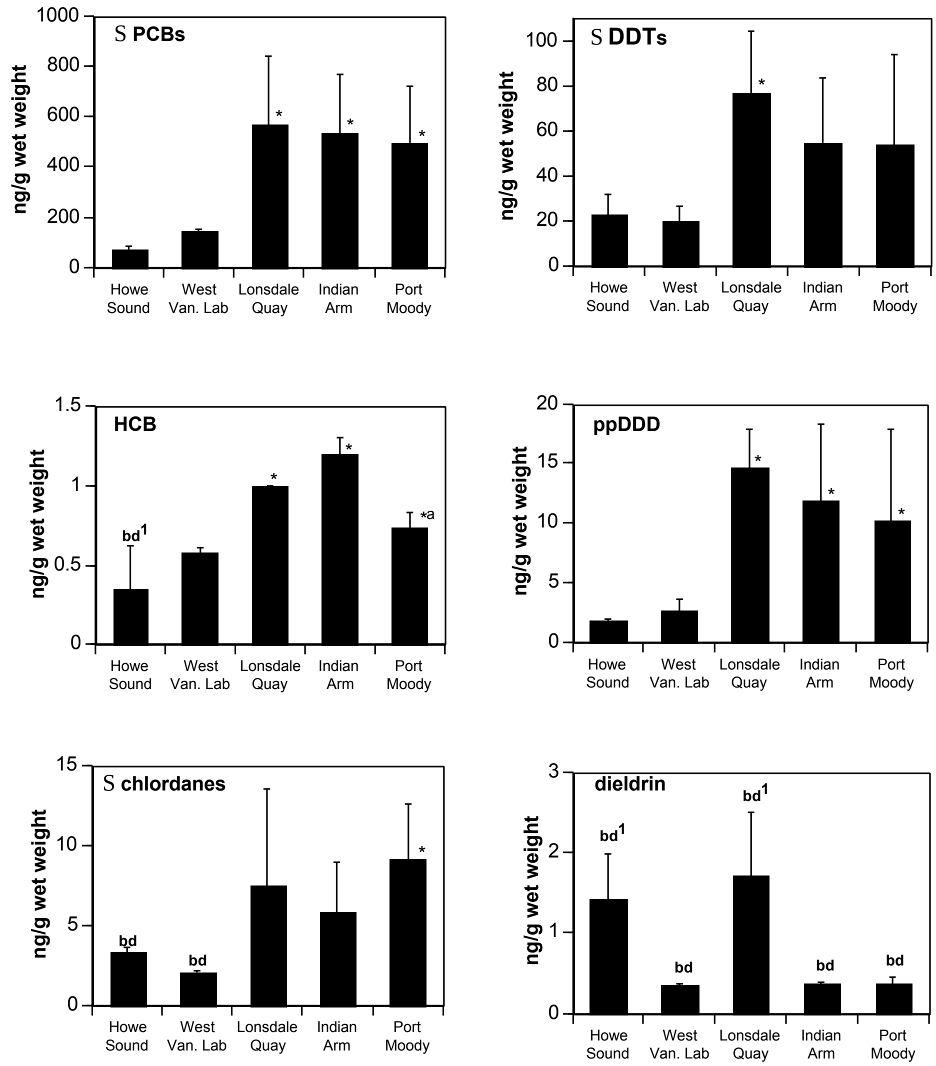
After fishing operations were completed, the center of the trawl area was determined, the anchor was deployed to maintain position, and three grabs of sediment were taken from this area. At sites where no trawling was done, the site location was established by the location of the sediment sample. An equal amount of sediment from each grab was combined to form a sample for each site and analyzed for aromatic hydrocarbons (AHs) and chlorinated hydrocarbons (CHs). Sediment AHs and CHs, and liver CHs were analyzed by gas chromatography/mass spectroscopy as described by Sloan *et al*. (1993).

Sediment concentrations of aromatic hydrocarbons were higher at the three industrialized sites in Vancouver Harbour (Fig. 2). Chlorinated hydrocarbons were higher at Indian Arm and Port Moody, the two industrial sites located farthest inside the Harbour (Fig. 2). Concentrations of PCBs and hexachlorobenzene in English sole liver



* estimated dry weight . Original data is in wet weight, so dry weight was estimated by multiplying wet weight by 5.
bd = below detection limits. Values shown are onehalf of the detection limit

Fig. 2 Comparison of chemical concentrations in English sole and sediment.



Three samples were analyzed for each site. Each sample was a composite of 5 fish.

* indicates a significant difference from the reference sites (Howe Sound and West Vancouver Lab) as shown by the ANOVA statistical analysis.

*[a] Significantly different from Howe Sound, but not West Van Lab

bd = all three samples were below detection limits

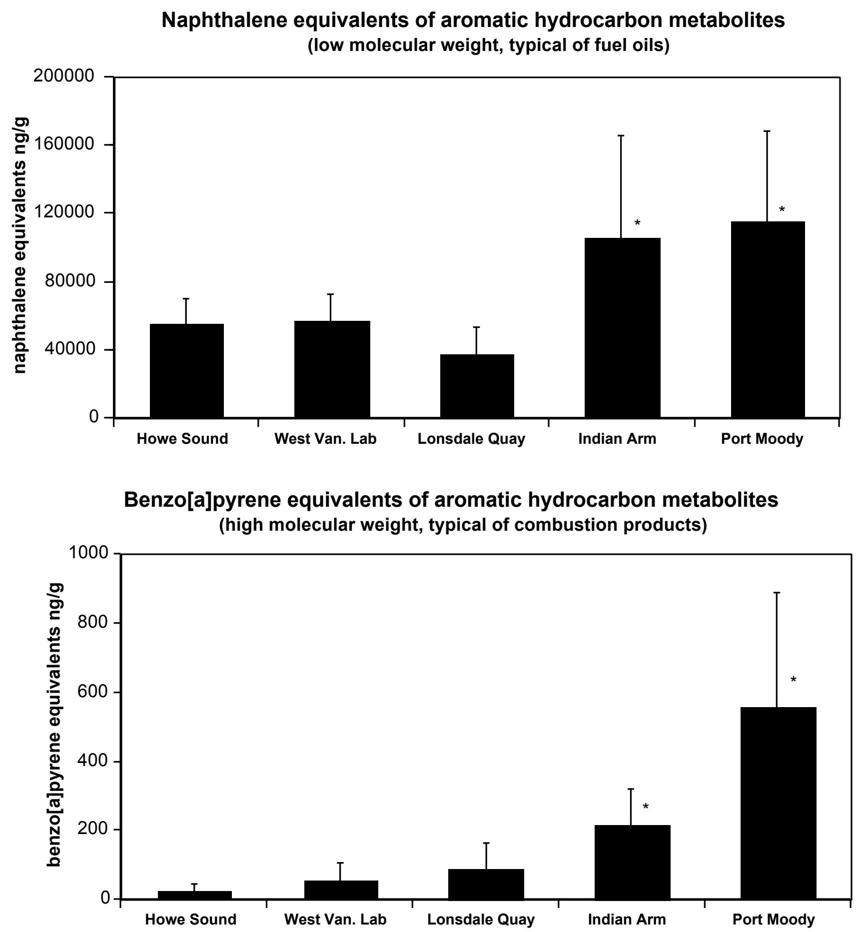
bd[1] = two of the three samples were below detection limits.

The detection limit is different for each sample depending on sample size.

Fig. 3 Chlorinated hydrocarbons in English sole liver.

were significantly higher at all three industrial sites compared to the Howe Sound reference site (Fig. 3). Concentrations of aromatic hydrocarbon metabolites in English sole bile were significantly higher at the Indian Arm and Port Moody sites compared to the reference sites (Fig. 4).

Histopathology of English sole liver was examined as a biological marker of contaminant effects. Fish were examined for toxicopathic liver lesions including proliferative disorders (such as hepatocellular regeneration and cholangiofibrosis), specific degeneration/necrosis (including megalocytic hepatosis and hepatocellular nuclear pleomorphism), preneoplastic conditions (including eosinophilic, basophilic and clear cell foci), and neoplasms (including adenomas and carcinomas). Toxicopathic liver lesions were observed in 20 to 23% of the fish at each of the three industrial sites, while no lesions were observed at either of the reference sites (Fig. 5).



10 samples were analyzed at each site. Each sample was from an individual fish.

* indicates that the aromatic hydrocarbon metabolites at this site are signficantly higher than at the reference sites (Howe Sound and West Vancouver Lab), as shown by ANOVA statistical analysis.

Fig. 4 Aromatic hydrocarbon metabolites (fluorescent aromatic compounds) in bile of English sole.

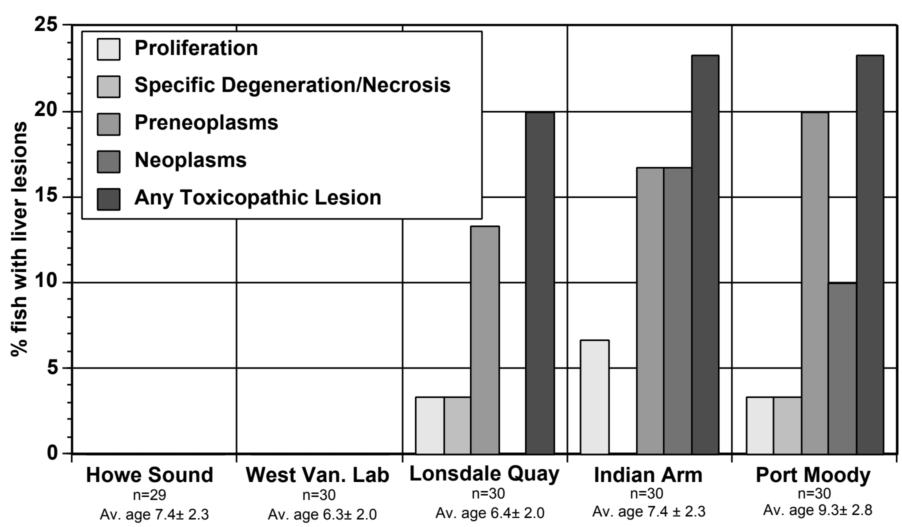


Fig. 5 Liver lesions in English sole.

Fish age data were provided by Colin Levings and colleagues at Fisheries and Oceans Canada in West Vancouver. Otoliths collected from English sole were aged as part of their fish community study that was conducted during the Practical Workshop. The average age of fish was 6 to 7 years at all sites except at Port Moody, where the average age was 9 years. Analysis of variance indicated that the mean age of English sole at Port Moody were significantly older than at other sites. It is important to account for fish age when evaluating prevalences of liver lesions, because the risk of developing these lesions increases with age (Rhodes *et al*. 1987). Therefore, the high prevalence of toxicopathic liver lesions in English sole from Port Moody may be occurring in part because these fish are older than those at the other sites. In other words, the prevalence of liver lesions at Port Moody would probably be somewhat less than 23% if only fish of comparable age were compared with the other Vancouver Harbour sites.

Spearman-Rank correlations showed that the prevalence of toxicopathic liver lesions was significantly associated with low and high molecular weight aromatic hydrocarbons in sediment, and with aromatic compounds fluorescing at Benzo[a]pyrene wavelengths measured in the bile. This is consistent with the hepatocarcinogenicity and hepatotoxicity of high molecular weight polycyclic aromatic hydrocarbons that has been observed in fish, including English sole, from other contaminated sites along the northeastern Pacific coast.

References

Krahn, M.M., Moore, L.K., and W.D. MacLeod, Jr. 1986. Standard analytical procedures of the NOAA National Analytical Facility. Metabolites of aromatic compounds in fish bile. U.S. Dept. Commerce NOAA Tech. Memo. NMFS F/NWC 102, 25 pp.

Myers, M.S., Rhodes, L.D., and B.B. McCain. 1987. Pathologic anatomy and patterns of occurrence of hepatic neoplasms, putative preneoplastic lesions, and other idiopathic hepatic conditions in English sole (*Parophrys vetulus*) from Puget Sound, Washington. JNCI 78(2): 333–363.

Rhodes, L.D., Myers, M.S., Gronlund, W.D., and B.B. McCain. 1987. Epizootic characteristics of hepatic and renal lesions in English sole (*Parophrys vetulus*) from Puget Sound. J. Fish. Biol. 31: 395–407.

Sloan, C.A., Adams, N.G., Pearce, R.W., Brown, D.W., and S.-L. Chan. 1993. Northwest Fisheries Science Center organic analytical procedures. Sampling and analytical methods of the National Status and Trends Program, National Benthic Surveillance and Mussel Watch Projects: 1984–1992. In: Comprehensive Descriptions of Trace Organic Analytical Methods, Vol. IV, p. 182. U.S. Dept. Commerce NOAA Tech. Memo. NOS ORCA 71.

Organochlorine and polyaromatic hydrocarbon residues in English sole, *Pleuronectes vetulus*, at Vancouver Harbour

Seiichi UNO, Jiro Koyama, and Hisashi Yamada
National Research Institute of Fisheries and Environment of Inland Sea, 2-17-5, Maruishi, Ohno, Saeki, Hiroshima 739-0452, Japan

Introduction

The processes for intake of the contaminants by aquatic animals are roughly classified. One is bioconcentration or the intake of dissolved chemicals in water through the gills, and the other is biomagnification through the food web (Herbert 1986). In general, most of the lipophilic compounds such as PCBs and DDTs are accumulated due to biomagnification. Therefore, these chemicals are accumulated at much higher concentrations in the upper trophic level of the food chain (Bentzen *et al*. 1996; Campfens and Mackay 1997; Morrison *et al*. 1997). The lipophilic contaminants could cause negative effects on reproduction and individual health. As a result of regulations by the governments of advanced countries, use of some persistent organochlorine chemicals has declined, and their residual levels in the environment have been decreasing. But these organochlorine chemicals have been detected in wildlife, and contamination has continued at low levels. Benthic fish have been good indicators of coastal pollution in the water column and sediments, although the bioaccumulation patterns of the different chemicals varied substantially among species (Pastor *et al*. 1996).

Usually, soxhlet and ultrasonic extraction methods are used for the extractions of PCBs and polyaromatic hydrocarbons (PAHs) from biological samples. These are fine methods, but they are time consuming and also need complicated preparation, such as hydrolysis of lipids by saponification. In addition, many pesticides are broken down during saponification.

Supercritical fluid extraction (SFE) is performed with carbon dioxide at temperatures and pressures above critical point. The SFE extraction is completed in a shorter time compared to the usual method, and it is possible to simultaneously perform the rough clean-up using alumina and silica. Therefore sample preparation such as the removal of the lipids is expected to be simplified. In addition, SFE is able to extract PCBs, PAHs and organochlorine pesticides simultaneously. Although the application of SFE is increasing for real environmental samples, presently there are only few reports that have examined biological samples from the field (Chester *et al*. 1998).

The PICES Practical Workshop was held from May 24 to June 7, 1999, in Vancouver Harbour, Canada. In this study, English sole, (*Pleuronectes vetulus*), which occupies the upper trophic level in the food chain, were collected from 5 sites within Vancouver Harbour (sampling sites are shown in Section I, Fig. 1.4). English sole tissues were analyzed to determine concentrations of PCBs, organochlorine pesticides and PAHs. SFE was used to extract the contaminants.

Methods

English sole were collected at 5 sites within Vancouver Harbour. Fish were immediately dissected on the ship, and tissues were frozen. Before analysis, the tissue samples were homogenized, and freeze-dried for 24 - 48 hours. The freeze-dried samples were cut into pieces with scissors.

PCBs, PAHs, and organochlorine pesticides in the organs were extracted by SFE using carbon dioxide and a 1% modifier of methanol. The temperature and pressure of SFE were 50°C and 214 bar, respectively (carbon dioxide density, 0.80 g/ml). Before the extraction, the supercritical carbon dioxide was equilibrated in the sample for 10 min, and the extractions were performed for 40 min. The flow rate of supercritical carbon dioxide was 3.0 ml/min. Each sample was put into a stainless steel tube, and 1 g-alumina was packed on the sample. The extracts were adsorbed to a florisil trap which was kept at 65°C. After the extraction, the extracts were eluted first with 3 ml hexane and then with 3 ml acetone. The elutions were combined, the solvent was exchanged to hexane completely, and the hexane solution was concentrated to 1 ml under a nitrogen stream. The concentrated extract was loaded on a florisil column (packed in a Pasteur pipette), washed with 5 ml hexane, eluted with 10 ml hexane, and then with 10 ml - 5% diethyl ether – hexane. Each eluent was concentrated to 0.1 ml under a nitrogen stream and quantified by GC/MS. The analytical assurances were certified by standard reference material 2974 (organics in freeze-dried mussel tissue (*Mytilus edulis*) of the National Institute of Standards and Technology.

Results and discussion

PCBs

Figure 1 shows total PCBs (ΣPCBs) in organs. The concentration distributions were different for muscle, ovaries, testes, and liver among each sampling point. The total PCB concentrations in liver were remarkably high, about 3 - 670 times higher compared to other organs, at all sampling sites. Total PCBs were detected at relatively high levels in organs at sites T-11B, T-38, and T-48.

The ratios of the concentrations were different among the sampling sites, but the order of the concentration was liver > testis > ovarian > muscle.

Seventy PCB congeners were measured. The ratios of distribution for individual PCB congeners in organs were similar. As an example, at site T-11B, the concentration of PCB 153 was highest for all organs (muscle: 0.96 ng/g, ovaries: 1.08 ng/g, testes: 8.92 ng/g, and liver: 27.65 ng/g (Fig. 2)). In addition, the concentrations of PCB 138, 187, 180, 110, and 99 were high in organs. Although fewer congeners were detected in testes than in other organs, the individual concentrations were higher than in muscle and ovary. The concentrations of individual congeners in muscle and ovaries were similar, but these concentrations were 1/20 - 1/400 of that in liver.

PAHs

The concentrations of naphthalene, and 1- and 2-methylnaphthalene were relatively high in all organs. But these chemicals are easily introduced as contaminants during the extraction process, therefore these quantities could be overestimated. In this investigation, because only a small amount of testes were gathered at all sampling sites, naphthalene and methylnaphalene could influence the concentration of total PAHs (ΣPAHs). Except for naphthalene, the concentrations of ΣPAHs in testes and liver were roughly similar at each site. In addition, PAH concentrations in testes and liver were higher than in muscle and ovaries, although the differences were smaller than those found in the case of PCBs. Concentrations of PAHs were lower and less variable among organs than PCBs. This suggested that PAHs were metabolized considerably more than PCBs (Krahn *et al*. 1993) and the parent compounds of PAHs showed less bioaccumulation in lipids than PCBs. The highest concentration of total PAHs in organs was detected at site T-11B. Concentrations of PAH at sites T-50, T-49, T-38, and T-48 were similar, with a slightly higher concentration at site T-50.

Of the individual PAHs measured in fish tissues at the sampling sites (Fig. 3.), phenanthrene was found at the highest concentrations. Furthermore, concen-trations of pyrene, dibenzothiophene, and

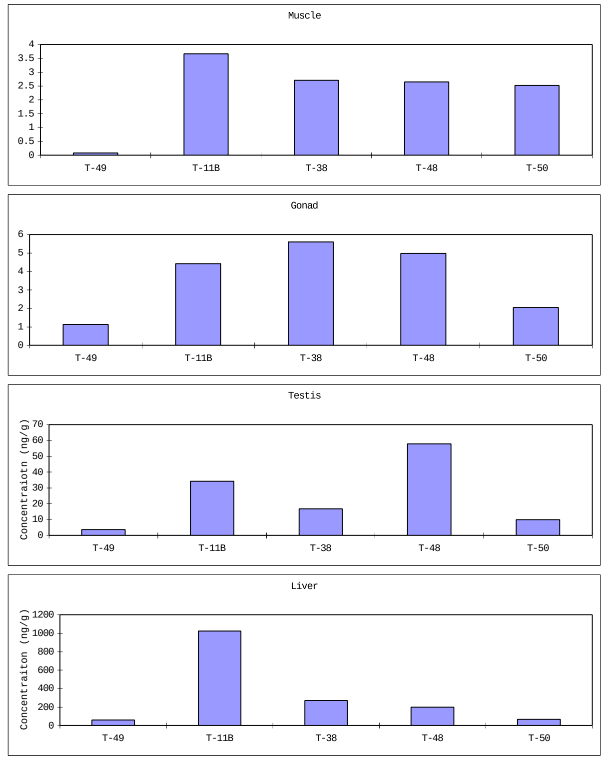


Fig. 1 Concentration of total PCBs in the tissue of English sole from Vancouver Harbour.

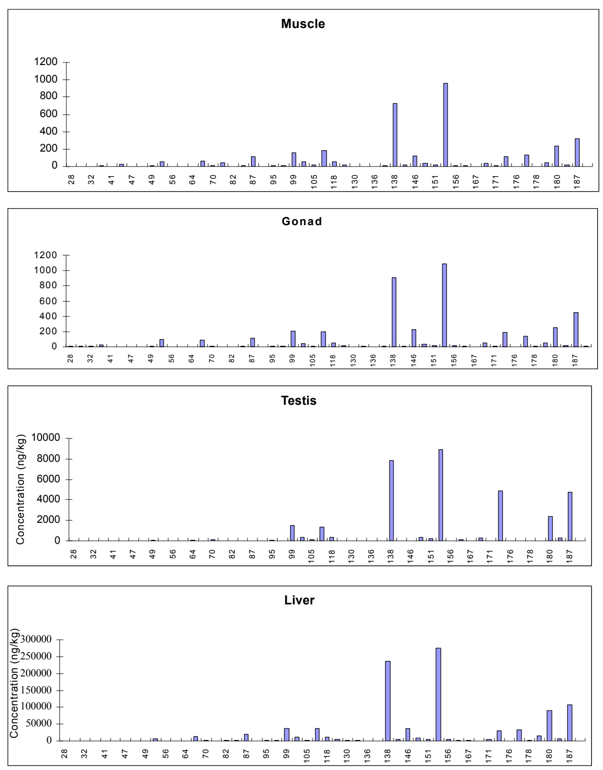


Fig. 2 Concentration of PCB congeners in tissues of English sole at site T-11B.

fluoranthene were slightly elevated. In the mussel investigation portion of the Vancouver Harbour Practical Workshop (see Mussel report, this publication), mussels (*Mytlilus trossulus*) were collected from intertidal sites within Vancouver Harbour and whole body tissue was analyzed for PAHs. The distribution pattern of PAH concentrations in mussels were different from that of fish. Namely, fluoranthene concentrations were higher in mussel than phenanthrene, and concentrations of phenanthrene and pyrene were similar. In addition, dibenzothiophene concentrations were only a small proportion of total PAHs in mussels. These differences may be caused by dissimilar methods of PAH uptake by English sole and mussels.

Organochlorine pesticides

The primary organochlorine pesticides detected in English sole were DDTs (*p,p'*- and *o,p'* -) and its metabolites (*p,p'*-, and *o,p'*-DDDs and DDEs). Other pesticides were found at considerably lower levels. The concentrations of DDTs and its metabolites were highest in liver, and second highest in ovaries. Concentrations of DDTs and its metabolites were higher in liver of fish from sites T-49, T-11B and T-38 (33.36 ng/g, 66.28 ng/g, and 44.36 ng/g, respectively) compared to other organs (Fig. 4). Relatively low concentrations of DDTs were detected in testes, even though PCB and PAH concentrations were high.

The concentration of DDE was higher than DDT and DDD for all organs. Concentrations of DDT metabolites accounted for 40 - 90% of total DDTs (Fig. 5). Concentrations of DDT metabolites in muscle, testis and liver accounted for more than 80% of total DDTs. However, at all sites, DDT concentrations in ovaries were higher than in other organs, and ovaries accumulated parent DDTs at much higher concentrations compared to other organs. The concentration of *o,p*'-DDT was lower in all organs, and it was detected much less frequently than *p,p*'-DDT.

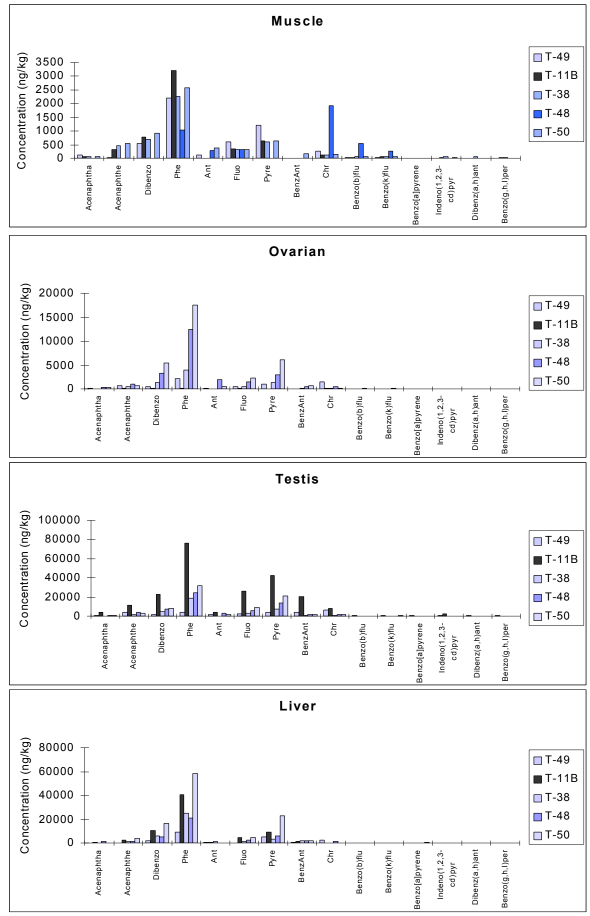


Fig. 3 Concentrations of individual PAHs in tissues of English sole from Vancouver Harbour.

Conclusion

In this study, the contaminant concentrations in muscle, ovaries, testes, and liver of English sole were investigated at Vancouver Harbour, Canada, during the PICES Practical Workshop. The concentrations of PAHs in testes and liver were higher than in muscle and ovaries. The highest concentration of ΣPAHs in organs was detected at site T-11B. Concentrations of PAHs in tissue of English sole from sites T-50, T-49, T-38, and T-48, were similar to each other. Of the individual PAHs measured, phenanthrene was found at the highest concentrations in all tissues. Pyrene, dibenzothiphene, and fluoranthene were also found at detectable levels.

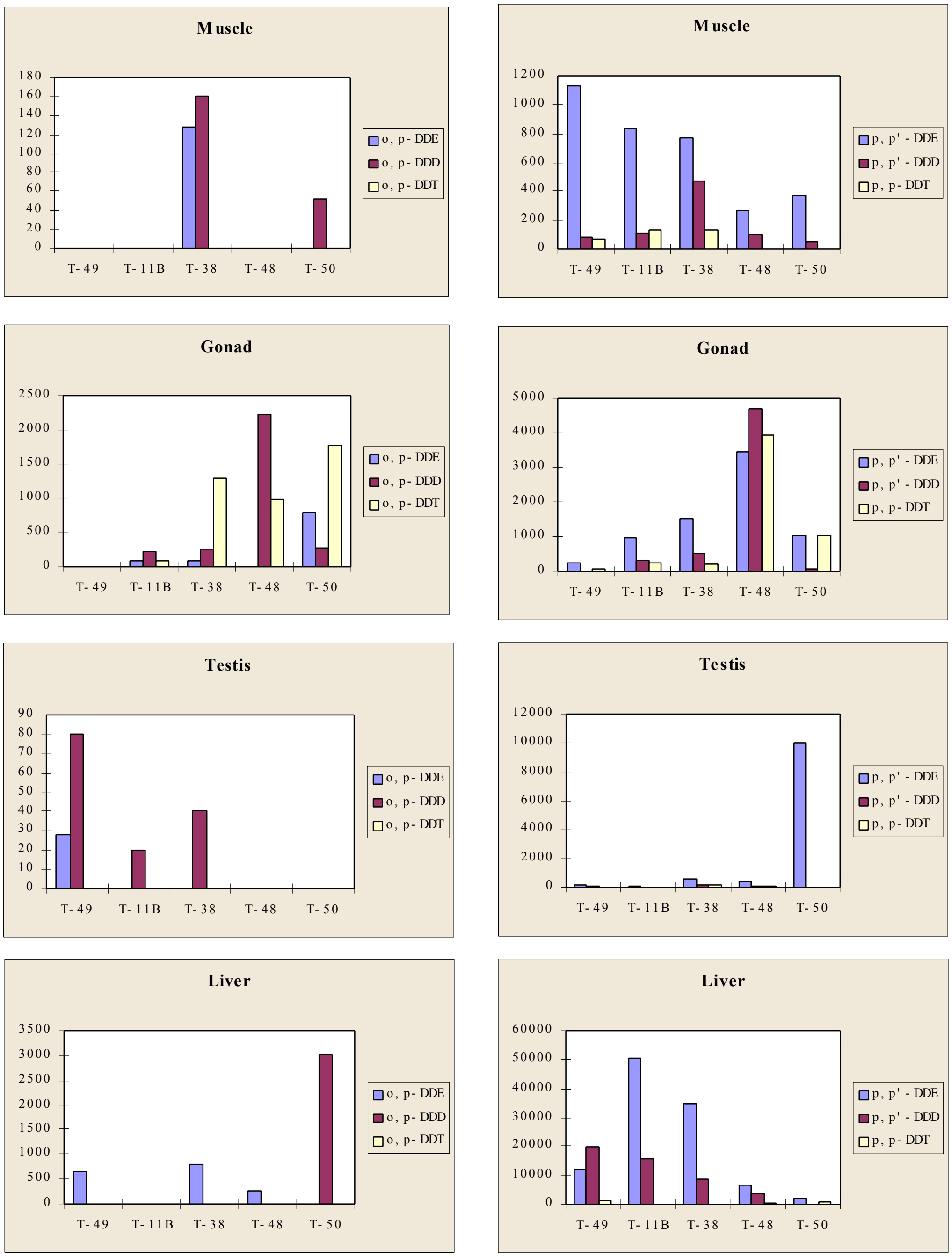


Fig. 4 Concentrations of DDT and its metabolites in tissues of English sole, Vancouver Harbour.

The concentrations of DDT and its metabolites were highest in liver and second highest in ovaries. The concentrations of DDT and its metabolites in liver were relatively high in fish from sites T-49, T-11B and T-38. The concentration of DDE was higher in all organs compared to DDT and DDD. DDT metabolites accounted for 40–90% of total DDT concentrations. However, DDT concentration in ovaries of fish from all sites were higher than in other organs, and ovaries accumulated DDT parent compounds at much higher levels than other organs.

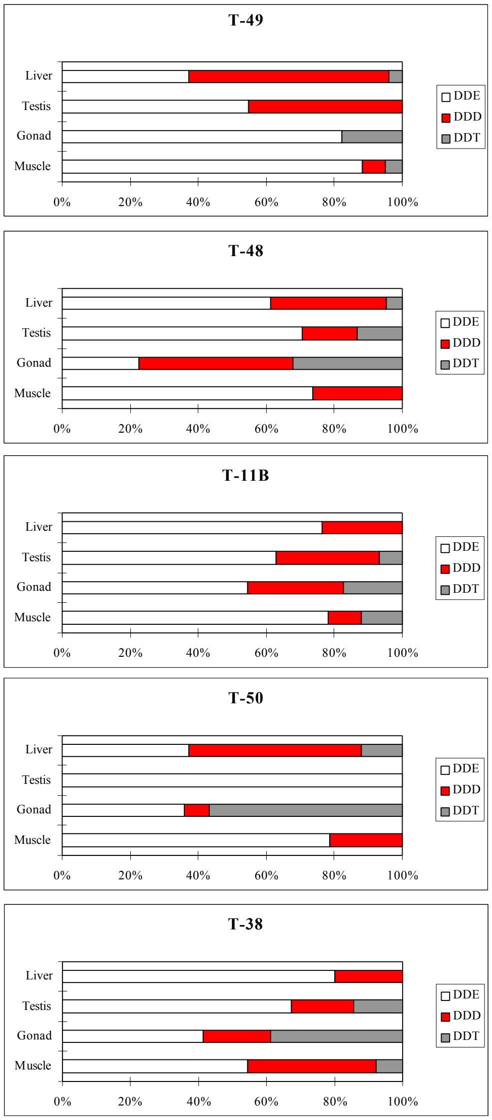


Fig. 5 Concentrations of DDT and its metabolites in tissues of English sole.

References

Bentzen, E., Lean D.R.S., Taylor, W.D., and D. Mackay. 1996. Role of food web structure on lipid and bioaccumulation of organic contaminants, by lake trout (*Salvelinus namaycush*). Can. J. Fish. Aquat. Sci. 53: 2397–2407.

Campfens, J and D. Mackay. 1997. Fugacity-based model of PCB bioaccumulation in complex aquatic food webs. Environ. Sci. Technol. 31: 577–583.

Chester, T.L., Pinkston, J.D., and D.E. Raynie. 1998. Superecritical fluid chromatography and extraction. Anal. Chem. 70: 301R–319R.

Herbert, H.O. 1986. A review of the correlation between physicochemical properties and bioaccumulation. Pest. Sci. 17: 265–276.

Krahn, M.M., Ylitalo, G.M., Buzitis, J., Chan, S., and U. Varanasi. 1993. Rapid high-performance liquid chromatographic methods that screen for aromatic compounds in environmental samples. J. Chromatogra. 642: 15–32.

Morrison, H.A., Gobas, F.A.P.C., Lazar, R., Whittle, D.M., and G.D. Haffner. 1997. Development and verification of a benthic/pelagic food web bioaccumulation model for PCB congeners in Western Lake Erie. Environ. Sci. Technol. 31: 3267–3273.

Pastor, D., Boix, J., Fernández, V., and J. Albaigés. 1996. Bioaccumulation of organo-chlorinated contaminants in three estuarine fish species (*Mullus barbatus*, *Mugil cephalus* and *Dicentrarcus labrax*). Mar. Pollut. Bull. 32: 257–262.

Organochlorine and polyaromatic hydrocarbon residues in bivalves at Vancouver Harbour

Seiichi UNO, Jiro Koyama, and Hisashi Yamada
National Research Institute of Fisheries and Environment of Inland Sea, 2-17-5, Maruishi, Ohno, Saeki, Hiroshima 739-0452, Japan

Introduction

Since bivalves have a wide distribution, extensive populations, filtering habits, and ability to accumulate organic contaminants, analysis of chemicals in the soft tissue of bivalves is useful as an index of contamination in the aquatic environment. In general, invertebrates have low metabolic abilities and the contaminants are accumulated and remain in them for a longer period than in vertebrates. This is especially true for the lipophilic compounds such as organochlorine contaminants (e.g. PCBs and DDT), and polyaromatic hydrocarbons (PAHs) (Connell 1995). These contaminants could cause negative effects for reproduction and individual health. As a result of regulations for the use of some persistent organochlorine chemicals by the governments of advanced countries, residual levels of these chemicals in the environment have declined. But organochlorine chemicals have been detected in wildlife, and contamination has still continued at low levels. Therefore, bivalves have been used by a number of investigators to study the contamination of wildlife (Tanabe *et al*. 1987, Colombo *et al*. 1995, Hofelt and Shea 1997).

Supercritical fluid extraction (SFE) is performed with carbon dioxide under temperatures and pressures above a critical point. The SFE extraction can be completed in a shorter time compared to the usual method, and it is possible to simultaneously perform the rough clean-up using alumina and silica. Therefore sample preparation for GC/MS and HPLC can be simplified. In addition, SFE is able to simultaneously extract PCBs, PAHs and organochlorine pesticides from biological samples. In this decade, the application of SFE is increasing for real environmental samples. However, only few studies of biological samples from the field have been reported so far (Chester *et al*. 1998).

The PICES Practical Workshop was held from May 24 to June 7, 1999, in Vancouver Harbour, Canada. In this study, the contamination levels of PCBs, organochlorine pesticides, and PAHs in mussel, *Mytilus trossulus*, were investigated at West Vancouver Harbour, Canada. Furthermore, 6 species of bivalves were also sampled at a few sampling sites where mussels were collected. Chemical concentrations were also determined in these bivalves and the inter-species differences were examined.

Methods

Mussels were gathered at 9 sampling sites in Vancouver Harbour (these I-sites are shown in Fig. 1). Before analyses, the soft tissue of bivalve samples were shelled, homogenized, frozen at –20°C for a day, and then freeze-dried for 24 - 48 hours. The freeze-dried samples were broken to pieces with scissors.

PCBs, PAHs, and organochlorine pesticides in the bivalves were extracted by SFE using carbon dioxide with a 1% modifier of methanol. The temperature and pressure of SFE were 50°C and 214 bar, respectively (carbon dioxide density, 0.80 g/ml). Before the extraction, the supercritical carbon dioxide was equilibrated in the sample for 10 minutes, and the extractions were performed for 40 minutes. The flow rate of supercritical carbon dioxide was 3.0 ml/min. The sample was put into the stainless steel tube, and 1 g alumina was packed on the sample. The extracts were adsorbed to a florisil trap which was kept at 650°C. After the extraction, the extracts were eluted first with 3 ml hexane, and then with 3 ml acetone. The elutions were combined, the solvent

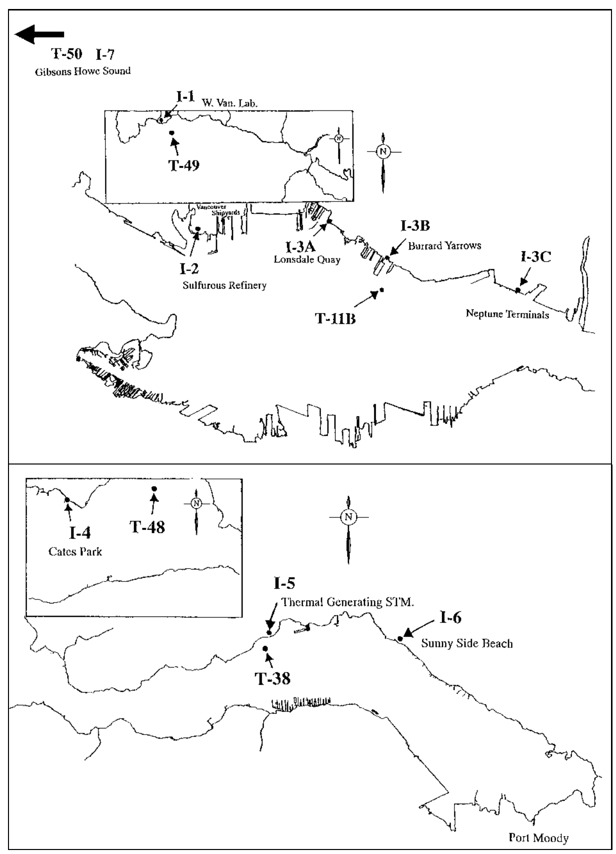


Fig. 1 Sampling sites in Vancouver Harbour.

was exchanged to hexane completely, and the hexane solution was concentrated to 1 ml under a nitrogen stream. The concentrated extract was loaded on a florisil column (packed in a Pasteur pipette), washed with 5 ml hexane, eluted with 10 ml hexane, and then with 10 ml 5% diethyl ether–hexane. Each elutant was concentrated to 0.1 ml under nitrogen stream and quantified by GC/MS. The analytical assurances were certified by standard reference material 2974 (organics in freeze-dried mussel, *Mytilus edulis*, tissue) of the National Institute of Standards and Technology.

Result and discussion

PCBs in mussels

The concentrations of total PCBs (ΣPCBs) detected in mussels at each sampling site were classified roughly into 3 groups, namely, a first group with ΣPCB concentration of about 5 ng/g or more (sites I-3A, I-4, and I-6), a second group with ΣPCB concentration of about 2 ng/g (sites I-3B and I-3C), and a third group with ΣPCB concentration of about 1 ng/g or below (sites I-1, I-2, I-5B and I-7) (Fig. 2).

At the site I-5, the concentration of ΣPCBs was much lower than at the other sampling sites, and low molecular weight congeners (with less than 4 chlorines) made up the highest percentage of total PCBs. At the other sampling sites, 70 – 87% of total PCBs were made up of higher molecular weight congeners with over 5 chlorines. The dominant group of PCB congeners had 6 chlorines, and these accounted for 33 to 55% of total PCBs. The proportions of congeners with 6 and 7 chlorines were relatively higher at sites I-2, I-3A and I-3B (63%, 70% and 64%, respectively) than at other sampling sites (40 - 57 %).

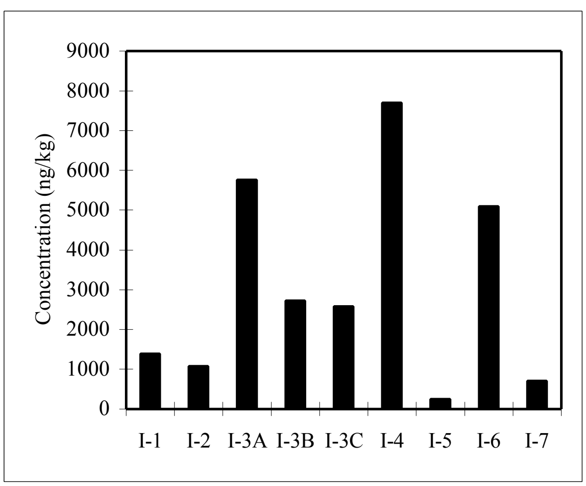


Fig. 2 Concentration of total PCBs in *M. trossulus*.

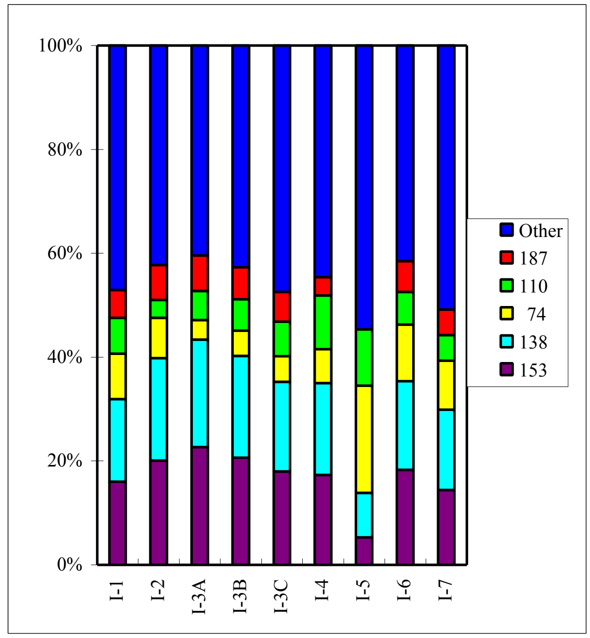


Fig. 3 Rate of PCB congeners in *M. Trossulus.*

For the individual PCB congeners in mussel, PCB 153 and 138 occurred at much higher concentrations than the other congeners. Furthermore, the concentrations of PCB 74, 110, and 187 were also relatively high. The ratios of these five congeners in ΣPCBs were over 50% at all sampling sites, except for site I-5B (45%) (Fig. 3).

Organochlorine pesticides in mussels

In this investigation, there was no common pattern in the distribution of organochlorine pesticides among the sampling sites (Fig. 4). At almost all sampling sites, the concentrations for α-, β-, and γ-HCHs were higher than those of other organochlorine pesticides. Levels of γ-HCH similar to the other HCHs were detected at all sampling sites, although the most common isomers generally found in the environment are α-, β- and γ- (Walker. *et al*. 1999). The concentrations of α-HCH at sites I-1 and I-2 were relatively high (1.5 ng/g and 1.3 ng/g, respectively), although the concentrations of ΣPCBs at both sites were low. The distribution patterns and the concentrations of β- and γ-HCH were similar among all sampling sites. In particular, these concentrations were highest at site I-3C (3.2 ng/g for β-HCH and 3.4 ng/g for γ -HCH, respectively) among all sampling sites, although the concentrations of ΣPCBs were not so high at this site. On the other hand, although concentrations of ΣPCBs were highest at site I-4, concentrations of β- and γ -HCH were low (0.75 and 0.84 ng/g, respectively).

The highest concentrations of p,p'-DDT and its metabolites were detected at site I-4, except for DDD. The concentration of p,p'-DDD was remarkably high (7.7 ng/g). The distribution patterns for p,p'- DDT and metabolites were similar, if DDD at I-3C is excluded.

For heptachlor, it is remarkable that the concentrations were relatively high at sites I-1, I-5B, and I-7, where PCBs levels were low.

PAH in mussels

The maximum concentration of total PAHs (252 ng/g) was detected at site I-4 and the minimum was 53 ng/g at site I-5B. Fluoranthene was detected at highest concentrations at all sampling sites, and those concentrations were 5 - 81 ng/g. Furthermore, the concentrations of phenanthrene, chrysene, and pyrene were relatively high: more than 50% of total PAHs at all sites except for I-5B (Fig. 5).

The benzo[a]pyrene concentration was about 0.2 ng/g at all sampling sites. The concentrations of naphthalene, 1- and 2-methylnaphthalene, biphenyl, fluorene, and acenaphthene (group 1) were similar, and about 1–10 ng/g, at all sampling sites. On the other hand, the concentrations of phenanthrene, anthracene, fluoranthene, pyrene, chrysene, and 1,2-benzoanthracene (group 2) were different among the sites (Fig 6). However, the same compounds were found at all sites, and tended to co-occur with PCBs, although the concentrations of each PAH were quite different. These distributional similarities between PAHs of group 2 and PCBs could exist because PAHs were adsorbed through the food web. Broman *et al*. (1990) did not find biomagnification of PAHs from food in a natural Baltic Sea food chain. But for group 2 all octanol/water coefficients (in logarifmic scale, lgK_{OW}) were above 4 (4.46 for phenanthrene, 4.45 for anthracene, 5.16 for fluoranthene, 4.88 for pyrene, 5.73 for chrysene, and 5.79 for 1,2-benzanthracene (Hansch *et al*. 1995). Spacie *et al*. (1982) estimated that

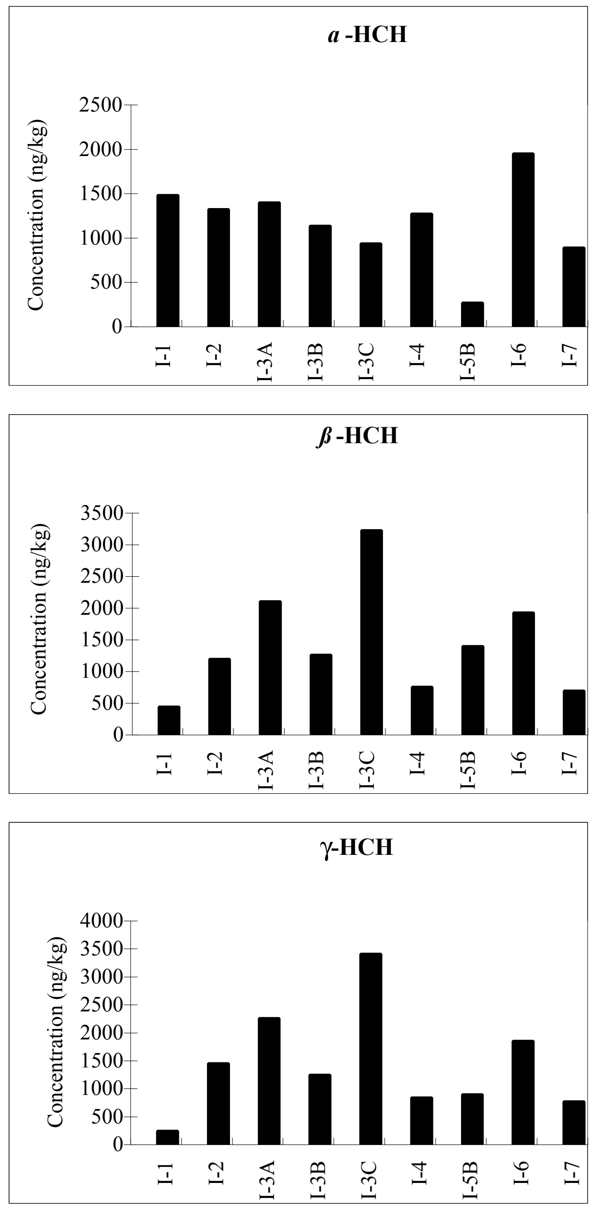
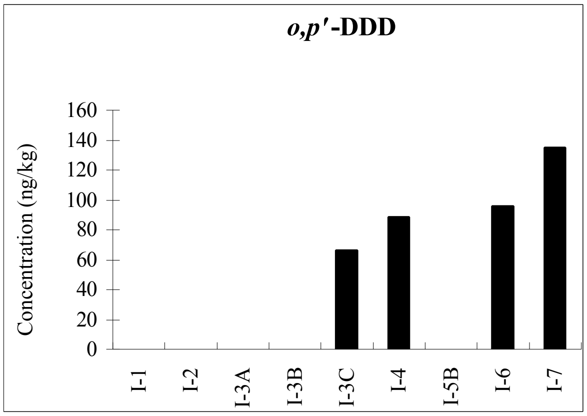
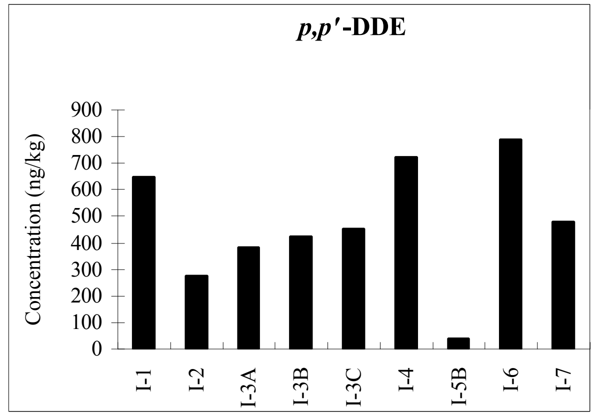
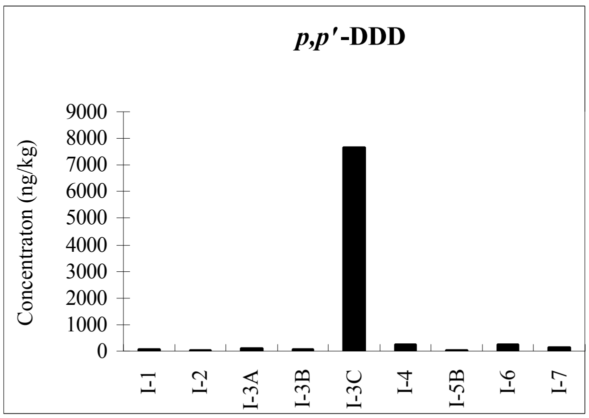
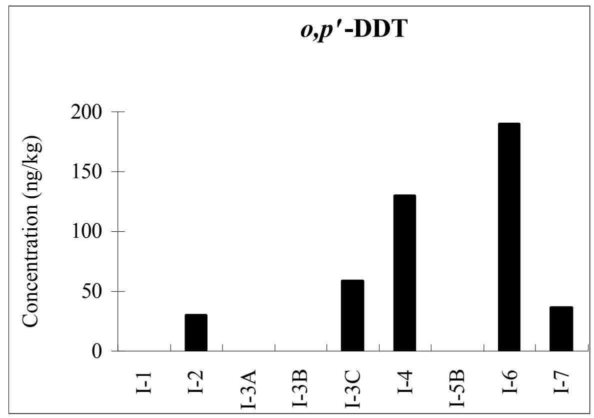


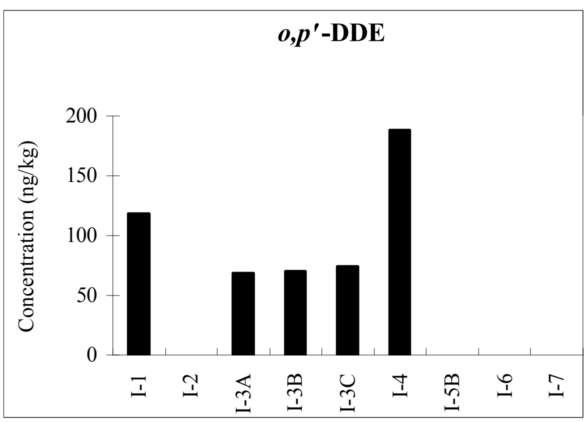
Fig. 4 Concentrations of organochlorine pesticides in *M. trossulus.*

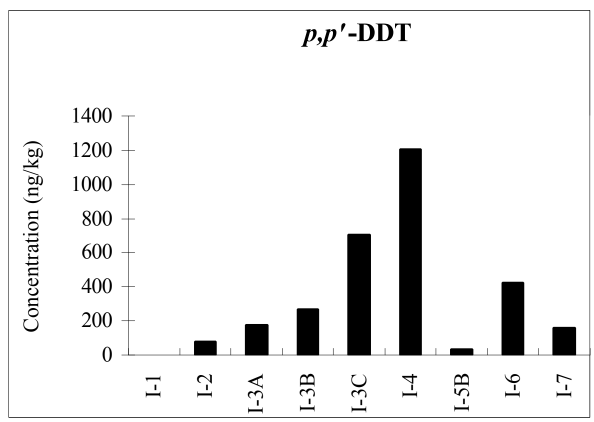


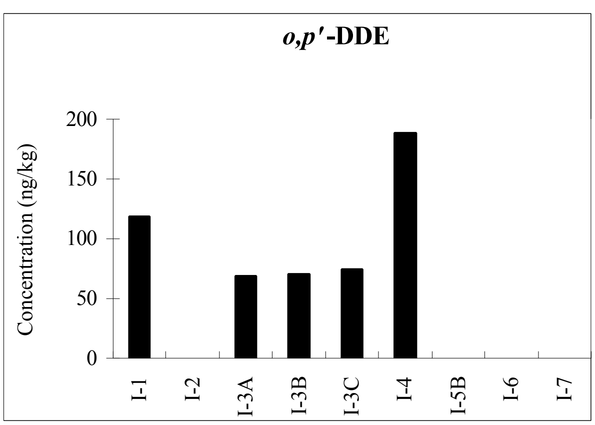












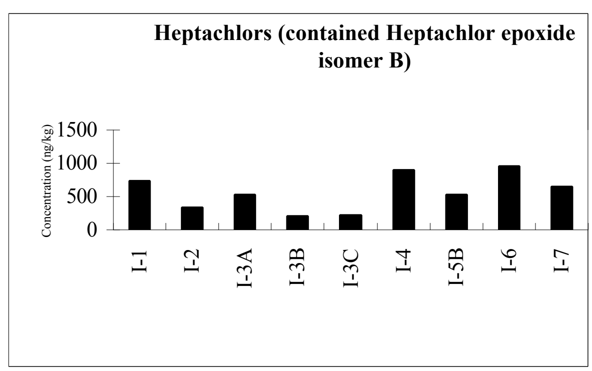


Fig. 4 continued.

the uptake of chemicals with $lgK_{ow} > 5$ through the gill membrane declines gradually. Therefore, a large amount of PAHs in group 2 mussels could be taken up through the food web, although lgK_{ow} for phenanthrene and anthracene is small.

Differences between species

Differences of contaminant concentrations were observed between mussel and other species. As an example, at site I-4, the concentrations of ΣPCBs in Pacific littleneck (*Protothaca staminea*), Nuttall's cockle (*Clinocardium nuttallii*), and Butter clam (*Saxidomus gigantea*) were higher than that in mussel. On the other hand, the concentrations of PAHs in these three species of bivalves were lower than that in mussel. There was no consistent pattern in organochlorine pesticide concentrations among the four species of bivalves.

In this investigation, the concentrations of contaminants in Pacific oyster (*Crassostrea gigas*) were much higher than in other bivalves. For example, the concentration of total PCBs was 30 ng/g in Pacific oyster at site I-6, and that was about 6 times higher than in mussel (4.8 ng/g) from the same site. The concentration of total PAHs in oyster was also about two times higher than that in mussel at this site. Furthermore, all organochlorine pesticides were detected at higher levels in oysters than in mussels (Fig. 7). Results show that Pacific oyster could accumulate more contaminants than mussel.

Conclusions

In this study, the contaminants in mussels and other bivalves were investigated at Vancouver Harbour, Canada, during the PICES Practical Workshop. The highest concentrations of PCBs and PAHs were detected at site I-4 near Cates Park. The distributional patterns of organochlorine pesticide concentrations were individually different. The main congeners of PCBs were IUPAC No. 153, 138, 74, 110, and 187, those of PAHs were phenanthrene, chrysene, and pyrene, and those of organochlorine pesticides were α-, β-, and γ-HCHs.

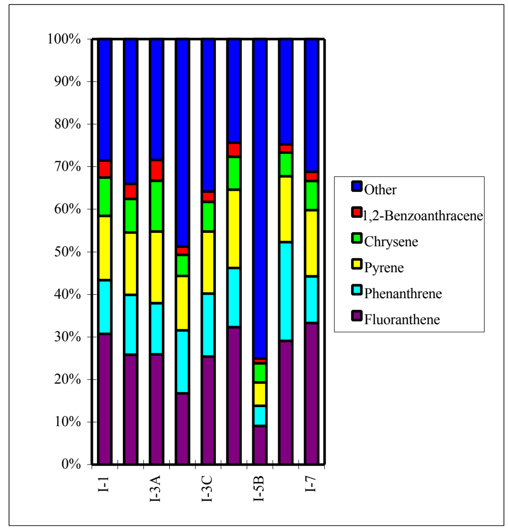


Fig. 5 Rate of PAHs in *M. trossulus* at Vancouver Harbour.

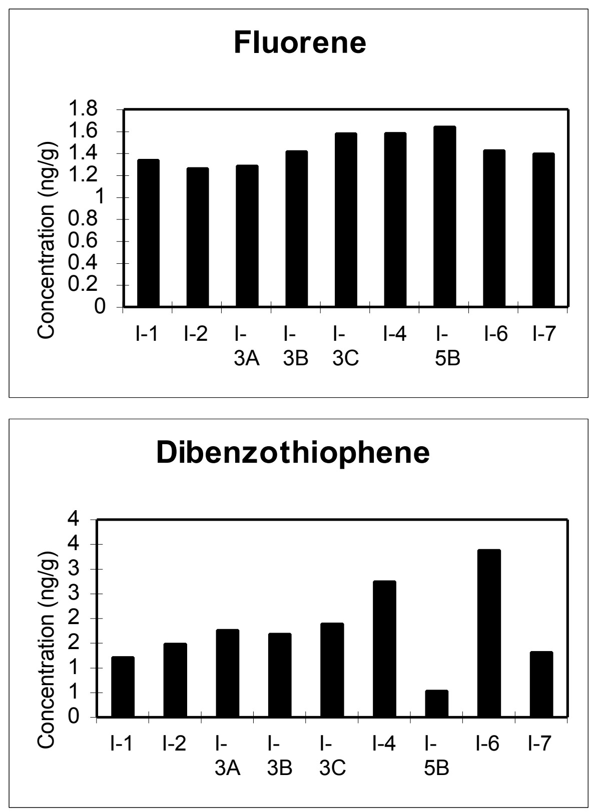


Fig. 6 Concentrations of individual PAHs in *M. trossulus*.

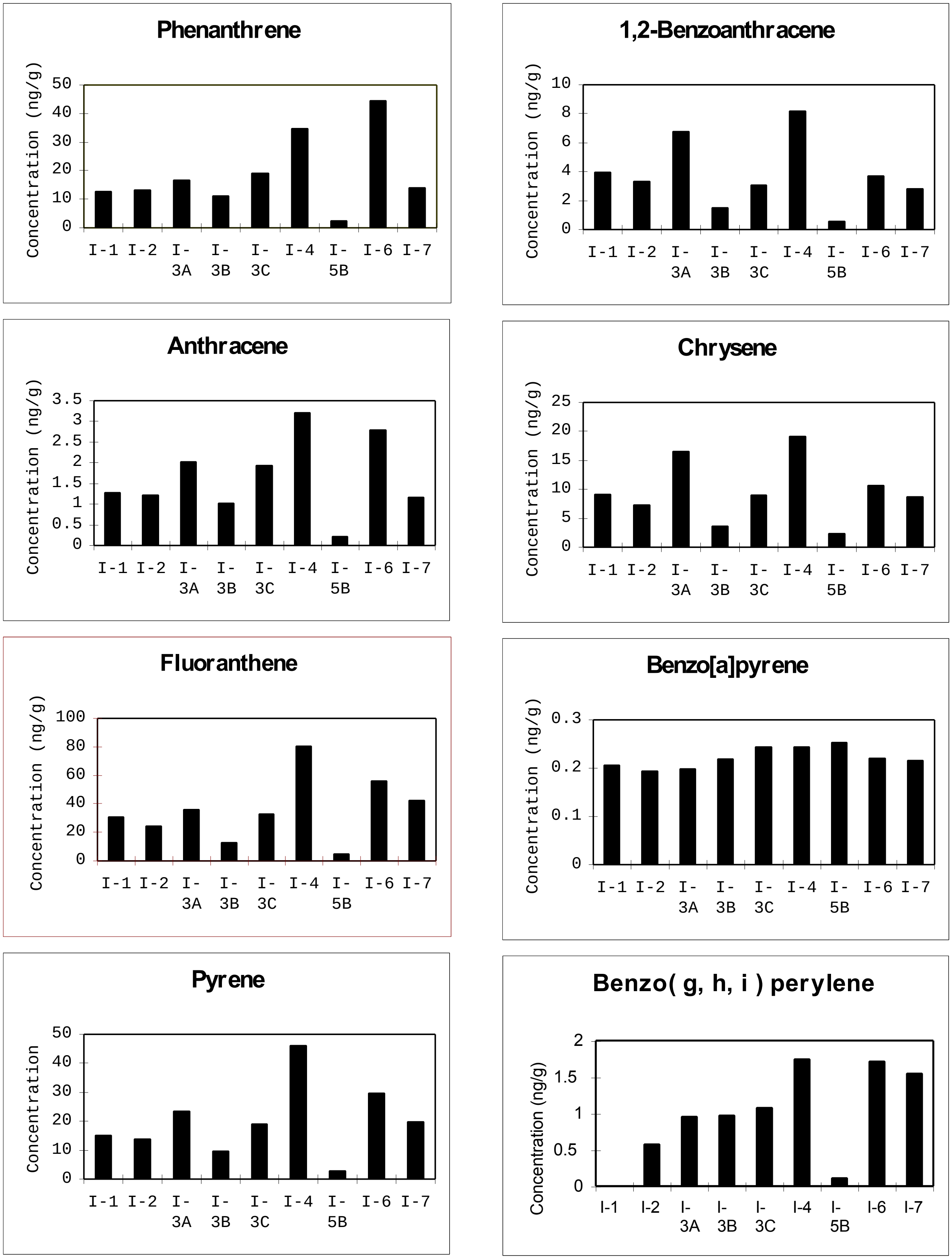


Fig. 6 continued.

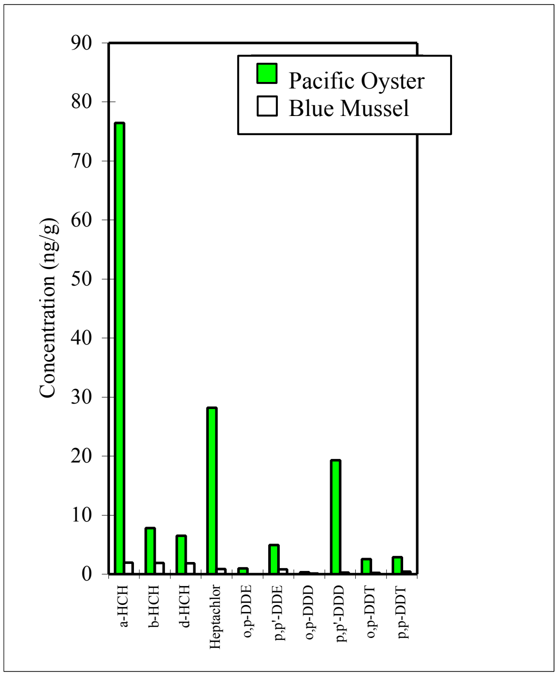


Fig. 7 Concentrations of organochlorine pesticides in the Pacific Oyster (*C. gigas*) and Blue Mussel (*M. trossulus*) at site I-6.

The intakes of phenanthrene, anthracene, fluoranthene, pyrene, chrysene, and 1,2-benzo-anthracene could be through the food web. Since the patterns of distribution among sampling sites were similar with that of ΣPCBs, most of these contaminants were thought to be absorbed from food.

In general, since most of the PCBs and organochlorine pesticides in aquatic animals are accumulated through the food web, these concentrations could be variable seasonally with the dietary quantity (Hühnerfuss *et al*. 1995). Therefore, it is necessary to conduct a few investigations at the same sites for a year to understand these pollution levels.

References

Broman, C., Näff, C., Lundberg, I., and Y. Zebuhr. 1990. An in situ study on the distribution, biotransformation and flux of polycyclic aromatic hydrocarbons in an aquatic food chain (seton-*Mytilus edulis* L.-*Somateria mollisima*) from the Baltic: An ecotoxiclogical perspective. Environ. Toxicol. Chem. 9: 429–442.

Chester, T.L., Pinkston, J.D., and D.E. Raynie. 1998. Supercritical fluid chromatography and extraction. Anal. Chem. 70: 301R–319R.

Colombo, J.C., Bilos, C., Campanaro, M., Rodriguez Presa, M.J., and J.A. Catoggio. 1995. Bioaccumulation of polychlorinated biphenyls and chlorinated pesticides by the asiatic clam *Corbicula fluminea*: Its use as sentinel organism in the Rio de La Plata estuary, Argenina. Environ. Sci. Technol. 29: 914–927.

Connel, D.W. 1995. Prediction of bioconcentration and related lethal and sublethal effects with aquatic organisms. Mar. Pollut. Bull. 31: 201–205.

Hansch, C., Leo, A., and D. Hoekman. Exploring QSAR – Hydrophobic, electronic, and steric constants. American Chemical Society, Washington, DC. 1995.

Hofelt, C.S. and D. Shea. 1997. Accumulation of organochlorine pesticides and PCBs by semipermeable membrane devices and Mytilus edulis in New Bedford Harbour. Envrion. Sci. Technol. 31: 154–159.

Hühnerfuss, H, Pfaffenberger, B., Gehrcke, B., Karbe, L., König, and O. Landgraff. 1995. Stereochemical effects of PCBs in the marine environment: Seasonal variation of coplanar and atropisomeric PCBs in blue mussels (*Mytilus edulis* L.) of the German bight. Mar. Pollut. Bull. 30: 332–340.

Spacie, A., and J.L. Hamelink. 1982. Alternative models for describing the bioconcentration of organics. Environ. Toxicol. Chem. 1: 309–320.

Tanabe, S. Tatsukawa, R., and D.J.H. Phillips. 1987. Mussels as bioindicators of PCBs pollution: A case study on uptake and release of PCB isomers and congeners in green lipped mussels (*Perna viridis*) in Hong Kong waters. Environ. Pollut. 47: 41–62.

Walker, K., Vallero, D.A., and R.G. Lewis. 1999. Factors influencing the distribution of lindane and other hexachlorocyclohexanes in the environment. Environ. Sci. Technol. 33: 4373–4378.

Lipid class and fatty acid composition of mussel, *Mytilus trossulus*, in Vancouver Harbour

Seiichi UNO[1], Yun, Ji Hyun[2], Masaki Kaneniwa[3], Jiro Koyama[1], Hisashi Yamada[1], and Kumiko Ikeda[1]

[1] National Research Institute of Fisheries and Environment of Inland Sea, 2-17-5, Maruishi, Ohno, Saeki, Hiroshima 739-0452, Japan
[2] Pukyung National University, Haeundaegu U 1dong 714-1, Pusan, 612-822, Korea
[3] National Research Institute of Fisheries Science, 2-12-4, Fukuura, Kanazawa, Yokohama, Kanagawa, 236-8684, Japan

Introduction

Lipids are divided broadly into two categories: namely, neutral lipid (NL), which is the stored fat and is mainly composed of triglycerides, and phospholipids (PL) and cholesterol, which are building blocks of membranes. Identification of lipid composition is important for physiological studies. Furthermore, PCBs and other oragano-chlorine contaminants are known to accumulate in tissue, and the information for lipid composition is helpful to explain the mechanism for the accumulation of these chemicals.

Fatty acids are the principal components in lipids. Their diversity in terms of chain length, degree of unsaturation, geometry, and position of the double bonds is responsible for the definitive characteristics of lipids for different organisms (Gutnikov 1995).

The Iatroscan TLC method was used to separate lipids by thin layer chromatography using the hydrogen flame ionization detector (FID). This method was developed by Okumura *et al*. (1975). The next step was done with an adsorbent sintered thin layer chromatographic quartz rod that consisted of silica gel powder fused by fine glass powder as the binding agent and an automatic scanner, which contains a hydrogen-FID for sample detection. The combination of these two steps makes quantitative TLC a rapid and easy method for the routine analysis of lipids separated by regular TLC.

The PICES Practical Workshop was held from May 24 to June 7, 1999, in Vancouver Harbour, Canada. In this study, the lipid and fatty acid composition of mussel, *Mytilus trossulus,* were determined at 7 sites (I-1, I-2, I-3A, I-4, I-5B, I-6, and I-7) in Vancouver Harbour (Fig. 1).

Methods

One hundred mussels of various sizes were gathered at each site. Mussels were shelled, and soft tissues were homogenized. Lipids were extracted from 5 g subsamples using a 30 ml solvent mixture of chloroform-methanol (2:1, v/v) (Blig and Dyer 1959). The chloroform layer, (which contains dissolved lipids) was collected, washed with 0.88% potassium chloride, and removed completely using a rotary-evaporator and a centrifugal-evaporator. Then, the concentration of lipids was adjusted to 100 mg/ml with chloroform. The separation of NL and PL was performed using a Sep-pak Silica washed with 10 ml chloroform. 50 µl of chloroform with extracted lipids was then loaded onto the Sep-pak. The NL was eluted with 8 ml chloroform, and the PL was eluted with 10 ml methanol.

For the determination of the lipidic composition, 0.2 µl of chloroform containing the extracted lipids was spotted onto the base of Chromarods, and developed with hexane-diethylether-acetic acid (70:30:1). After the solution was developed to a certain position, Chromarods were dried at 100ºC, and lipids were analyzed by an Iatroscan. Fatty acids in NL and PL were analyzed according to the methods of the American Oil Chemists' Society (A.O.C.S.) (1991). The extracted lipids were removed using nitrogen gas and a centrifugal evaporator, and saponificated with 0.5 N sodium hydroxide at 100ºC for 5 minutes. Then, the saponificated samples were methylated by 14%

boron trifloride methanol complex methanol solution at 100ºC for 30 minutes. After the methylation, fatty acids were dissolved in Isooctane, and analyzed by GC/MS.

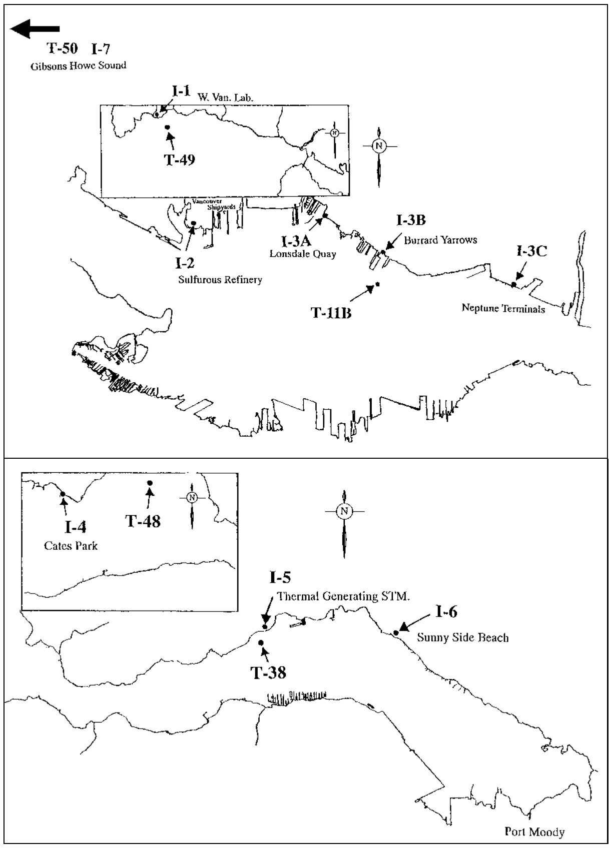
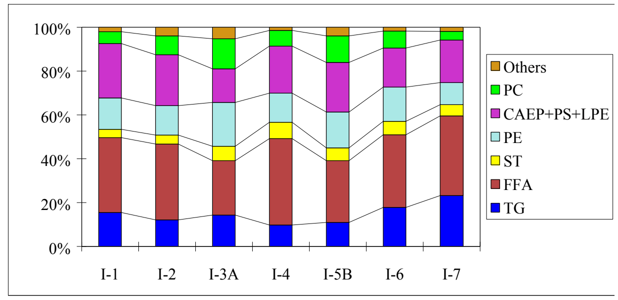


Fig. 1 Sampling sites in Vancouver Harbour.

Results and discussion

Lipid composition in mussels

Results of analysis by the Iatroscan TLC showed that the main lipids in mussels were triglyceride (TG), free fatty acid (FFA), sterol (ST), and phospholipid (PL). The ratios of these compounds to total lipid were 10 - 23% for TG, 24 - 37% for FFA, 4 - 7% for ST, and 36 - 55% for PL (Fig. 2). Furthermore, we analyzed PL using a thin layer chromatograph (TLC) and the Iatroscan TLC. TLC results showed that phospholipid was composed of phosphatidylethanolamine (PE), ceramide 2-aminoethyl phosphate (CAEP), phosphatidylserine (PS), lysophosphatidyl-



TG, Triglyceride; FFA, Free Fatty Acid; ST, Sterol;
PE, Phosphatidylethanolamine;
CAEP, Ceramide 2-aminoethylphosphonate;
LPE, Lysophosphatidylethanolamine;
PS, phosphatidylserine;
PC, Phosphatidylcholine;
Others, Lysophosphatidylcholine+Unknown component

Fig. 2 Lipid composition in *M. trossulu*s (weight % to total lipid).

ethanolamine (LPE), phosphat-idylcholine (PC), lysophosphatidyl-choline (LPC), and others. The individual quantities of CAEP, PS, and LPE could not be determined, because they were not separated completely. The ratios of compositions in the PL were 27 - 37% for PE, 28 - 55% for CAEP+PS+LPE, 11 - 25% for LPC. All components of total lipids are shown in Figure 2.

The depot lipid is mainly TG and the lipid composition changes depending on the nutrient condition. On the other hand, the tissue lipid is mainly PL and its composition does not change. On the basis of these lipidic characteristics, we tried to evaluate the nutrient conditions of mussels at all sampling sites using the TG/PL ratio (Fig. 3). The ratio was highest at site I-7 and the nutrient condition of mussels at this site appeared to be better than at other sites.

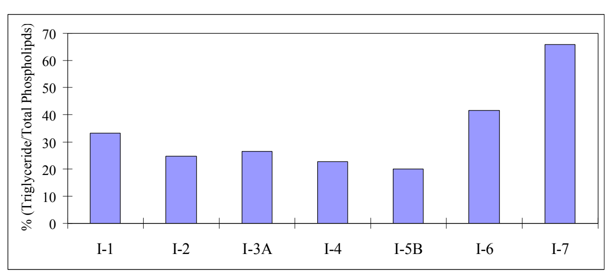


Fig. 3 Tryglyceride to total phospholipids ratio in *M. trossulus*.

It is well known that the oxidation and hydrolysis of lipids in fish and shellfish during frozen storage cause serious deterioration of quality (e.g. Jeong, *et al*. 1990; Shimada and Ogura 1990; Refsgaard *et al*. 1998). Jeong *et al*. (1990) reported that the contents of TG and PC in oyster, *Crassostrea gigas*, decreased during storage at –20°C while the concentration of free fatty acids increased. In this study, the mussel samples were stored at –20°C until analysis. Samples were transported from Canada to Japan on dry ice. Under these circumstances, in our analysis the content of FFA in total lipid could be higher, and content of TG and PC could be lower, than those in live animals. But all samples were kept in the same condition until analysis so that the nutrient condition among the sampling sites might be compared from the TG/PL ratio.

Ota *et al*. (1990) reported that TG was the main component of total lipid (TL) in rainbow trout (91.3%) and other fishes. According to Ozawa *et al*. (1993), the TG content in TL of kokanee salmon's muscle was 65.3% for the dorsal portion, 82.8% for the ventral portion, and 66.7% for the tail. Kawasaki *et al*. (1994) also reported that the TG content in TL in firefly squid's liver was 60.9 - 72.4%. Since the quantity of TG changes considerably with the season, the comparison between mussel and other aquatic animals is difficult. But the TG concentration in mussel was lower than that in fish and squid.

Fatty acid composition

The fatty acid composition was identified for 41 classes by GC/MS. Table 1 shows the fatty acid composition in lipids for those classes that were more than 1% of the total fatty acids. The dominant components of total fatty acids were 16:0, 16:1n-7, 18:1n-7, 20:5n-3, and 22:6n-3. The composition of fatty acids in NL was 41 classes, while that in the PL was 29 classes. Especially, 20:5n-3 and 22:6n-3 contained higher levels of fatty acids and they were 8.8 - 18.8% and 6.4 - 14.5%, respectively. The compositions of 20:4, 20:5, 22:5, and 22:6 are special for aquatic organisms (Koike and Tsuchiya 1988), and these ratios were 20 - 33% in total fatty acids.

Similar levels of 14:0, 16:0, 16:2n-7, 18:0, and 20:5n-3 were found in NL and PL. The contents of 17:0, 18:1n-9, 18:1n-7, 18:3n-3, 18:4n-3, and 20:2n-6 were higher in NL than those in the PL. On the other hand, the contents of 16:1n-7, 20:5n-3, 22:1n-11, and 22:6n-3 were higher in PL than in NL.

Jeng et al. (1990) reported that the percentages of polyenoic acid in PL, NL, and TL for *C. gigas* decreased and the percentage of saturated acids increased during storage at –20°C. In this study, unsaturated fatty acids could be underestimated in comparison with lipid compositions found in live animals.

Conclusion

In this study, the lipid and fatty acid composition in mussel, *M. trossulus*, was determined at Vancouver Harbour, Canada, during the PICES Practical Workshop. The main components of lipid were tryglyceride, free fatty acid, sterol, and phospholipids, which were composed of phosphatidylethanolamine, ceramide 2-amino-ethylphosphonate, phosphatidylserine, lyphosphat-idylethanolamine, phosphatidylcholine, and lysosphatidylcholine. The ratio of triglyceride in total lipid was lower than that in fish.

The dominant components of total fatty acids were 16:0, 16:1n-7, 18:1n-7, 20:5n-3 and 22:6n-3. The composition of fatty acids in neutral lipid and phospholipid was identified for 41 and 29 classes, respectively.

Generally, the fatty acid composition is influenced by feeding, season, water temperature, and depth of the habitat (Hori and Itasaka 1978). In the future, if the plant and animal plankton of food for mussels can be gathered at the sampling sites, the dietary life could be estimated from the fatty acid composition.

The fatty acid and lipid composition might have deteriorated during transportation from Canada to Japan, and during storage until analysis. If more accurate quantitative analysis is needed, lipid determinations will have to be performed as soon as the samples have been gathered.

Table 1. Fatty Acid Components in Total , Neutral, and Phospholipids of *M. trossulus.*

	I-1			I-2			I-3A			I-4			I-5B			I-6			I-7		
Fatty Acid	**TL**	**NL**	**PL**	**TL**	**NL**	**PL**	**TL**	**NL**	**PL**	**TL**	**NL**	**PL**	**TL**	**NL**	**PL**	**TL**	**NL**	**PL**	**TL**	**NL**	**PL**
14:0	3.6	3.7	2.9	2.4	2.4	2.5	1.9	2.0	1.6	3.0	3.2	2.8	3.4	3.5	3.1	2.9	2.8	2.9	5.4	5.7	4.4
16:0	18.9	19.3	15.6	16.0	15.4	17.5	15.9	16.5	15.0	15.5	15.3	15.7	15.7	16.0	15.1	15.9	15.8	16.2	14.9	15.3	13.5
16:1n-7	5.0	4.2	11.2	8.5	8.3	9.2	8.4	9.6	6.4	6.5	4.4	9.4	6.5	3.7	11.3	6.7	5.7	10.3	10.6	9.2	16.0
16:2n-7	1.9	2.2	1.6	1.0	1.4	1.6	0.8	1.2	1.6	0.8	1.3	1.5	1.0	1.5	1.2	1.0	1.2	1.5	1.5	1.9	1.4
17:0	1.9	1.9	-	1.5	1.5	-	1.5	1.5	-	1.4	1.4	-	1.3	1.3	-	1.5	1.5	-	1.6	1.6	-
18:0	2.8	2.8	2.8	2.8	2.7	3.1	3.1	3.0	3.1	2.6	2.5	2.8	2.5	2.4	2.7	2.7	2.7	2.7	2.2	2.2	2.3
18:1n-9	3.1	3.2	2.0	2.3	2.9	0.6	2.6	3.2	1.5	2.3	2.8	1.8	3.0	3.5	2.0	2.7	3.0	1.9	2.6	2.9	1.5
18:1n-7	5.9	6.2	3.7	4.3	4.7	3.3	4.8	5.8	3.1	4.6	5.3	3.6	4.8	5.4	3.9	5.1	5.4	3.7	6.2	6.9	3.4
18:2n-6	2.2	2.3	1.3	1.4	1.6	1.0	1.6	1.9	1.0	2.1	2.5	1.6	2.6	3.1	1.7	2.4	2.6	1.8	2.0	2.2	1.2
18:3n-3	3.0	3.3	-	1.9	2.1	-	1.3	2.0	-	2.5	3.1	-	3.4	3.4	-	2.2	2.9	-	1.6	1.6	-
18:4n-3	7.1	7.7	3.0	4.3	5.0	2.6	3.7	4.7	1.9	5.1	6.6	3.0	4.8	7.6	3.3	5.3	6.1	2.4	1.4	1.8	1.8
20:1n-11	0.8	0.7	1.7	1.0	0.9	1.4	1.5	1.6	1.3	1.1	0.9	1.3	1.1	0.9	1.5	1.2	0.9	2.1	0.9	0.7	1.5
20:1n-9	1.5	1.2	3.1	4.2	4.7	3.0	5.2	6.1	3.6	3.3	3.4	3.3	3.5	3.8	2.9	4.3	4.7	3.0	3.3	3.6	2.3
20:1n-7	4.2	4.4	2.2	3.0	3.3	2.3	2.6	2.8	2.4	3.1	3.5	2.6	3.0	3.4	2.3	3.5	3.8	2.4	2.9	3.2	1.8
20:2*	3.4	3.5	2.7	1.7	1.3	2.9	3.2	2.4	4.7	1.9	1.2	3.0	1.9	1.2	3.1	1.7	1.1	3.8	1.5	0.8	3.9
20:2*	1.1	1.1	1.2	0.7	0.7	0.9	1.2	0.9	1.6	1.0	0.9	1.2	0.7	0.7	0.8	0.9	0.8	1.0	0.9	0.7	1.5
20:2n-6	1.2	1.2	0.8	1.0	1.0	0.7	0.9	1.0	0.7	1.1	1.2	0.9	1.3	1.4	1.2	1.2	1.3	1.0	0.7	0.8	0.5
20:4n-6	2.0	2.1	1.5	1.9	2.0	1.6	3.4	3.8	2.6	2.0	2.1	1.8	1.7	1.8	1.4	2.4	2.6	1.7	2.5	2.7	2.1
20:5n-3	8.8	7.2	20.7	15.3	13.0	21.4	11.0	5.4	20.9	17.6	16.9	18.5	16.8	15.1	19.8	14.5	13.6	17.7	18.8	18.6	19.5

References

Blig, E. B., and W.J. Dyer. 1959. A rapid method of total lipid extraction and purification. Can. J. Biochem. Physiol. 37: 911–917.

Gutanikov, G. 1995. Fatty acid profiles of lipid samples. J. Chromatogr. B, 671: 71–89.

Hori, T., and O. Itasaka. 1978. Lipid of shellfish. SEIKAGAKU 50: 331–346 (Japanese).

Joeng, B. Y., Ohshima, T., and C. Koizumi. 1990. Lipid deterioration and its inhibition of Japanese oyster *Crassostrea gigas* during frozen storage. Nippon. Suisan. Gakkaishi 56: 2083–2091.

Kawasaki, K., Ooizumi, T., Hayashi, S., and K. Hayashi. 1994. Lipid class and fatty composition of liver of firefly squid *Watasenia scintillans*. Nippon Suisan Gakkaishi 60: 247–251 (Japanese).

Koike, H., and T. Tsuchiya. 1988. Fatty acid composition of aquatic animals. J. College of Liberal Arts, Saitama Univ. 24: 55–72 (Japanese).

Official and tentative methods of the American Oil Chemists' Society, American Oil Chemists' Society, Champaign, IL, 1969, revised to 1991, Method Ce 1b-89.

Okumura, T., Kadano, T., and A. Iso'o. 1975. Sintered thin-layer chromatography with flame ionization detector scanning. J. Chromatogr. 108: 329–336.

Ota, T., Sasaki, S., Abe, T., and T. Takagi. 1990. Fatty acid compositions of the lipids obtained from commercial salmon products. Nippon Suisan Gakkaishi 56: 323–327.

Ozawa, A., Satake, M., and T. Fujita. 1993. Comparison of muscle lipids between wild and cultured kokanee salmon. Nippon Suisan Gakkaishi 59: 1545–1549 (Japanese).

Refsgaard, H. H. F., Brockhoff, P. B., and B. Jensen. 1998. Sensory and chemical changes in farmed Atlantic salmon (*Salmo salar*) during frozen storage. J. Agric. Food Chem. 46: 3473–3479.

Shimada, K., and N. Ogura. 1990. Lipid changes in sea urchin gonads during storage. J. Food. Sci. 55: 967–971.

CYP1A and related measurements in English sole (*P. vetulus*) from Vancouver Harbour

Kelsey A. MILLER[1], Richard F. Addison[2], and S.M. Bandiera[1]

[1] Faculty of Pharmaceutical Sciences, University of British Columbia, Vancouver, B.C., Canada. V6T 1Z3

[2] Department of Fisheries and Oceans, Institute of Ocean Sciences, Sidney, B.C., Canada. V8L 4B2

Introduction

Vancouver Harbour is a busy seaport and gets a considerable influx of anthropogenic pollutants including metals, PCBs, organochlorine pesticides, and polyaromatic hydrocarbons. English sole (*Pleuronectes vetulus*) are bottom-feeding fish and subject to bioaccumulation of lipophilic hydrocarbon compounds, which contaminate the sediments in the harbour and are linked to toxicity in various marine organisms. English sole is an excellent sentinel species for monitoring marine ecosystem health because they are relatively slow growing, are widely distributed throughout the harbour and adjacent waters, and individual fish have a small home range or forage in a relatively confined area. In addition, English sole is a potential source of human contaminant exposure because it is fished commercially.

Induction of hepatic microsomal cytochrome P450 (CYP) enzymes is a common and characteristic biochemical response to halogenated hydrocarbon exposure that accompanies and often precedes toxicity in all animals examined thus far. CYP is a large and ubiquitous group of hemeproteins found in fish, mammals, birds, plants, and microorganisms that catalyze the oxidative biotransformation of diverse lipophilic xenobiotic and endogenous compounds. Because CYP enzymes play a critical role in the metabolism, bioaccumulation, and potential toxicity of halogenated and nonhalogenated hydrocarbons found in the food chain, levels of individual CYP enzymes are important determinants of susceptibility to environmental contaminant exposure. CYP enzyme induction in fish populations has been suggested as a sensitive biochemical marker of contaminant exposure, and by inference, of marine ecosystem health (Safe 1990; Goksøyr and Förlin 1992; Stegeman *et al*. 1992; Addison 1996; Addison *et al*. 1994; Campbell *et al*. 1996). Induction of the CYP1A subfamily of enzymes can be determined by measurement of associated enzymes activities such as ethoxyreosufin O-deethylase (EROD) and benzo[a]pyrene hydroxylase or by measuring CYP1A protein using immunochemical methods.

The purpose of the present study was to measure EROD activity and CYP1A protein levels in liver tissue of English sole from five sites in and around Vancouver Harbour, and to compare these biochemical parameters with sediment levels of hydrocarbon pollutants measured at these same sites.

Materials and methods

Liver samples

English sole were collected by trawl net during May and June 1999, from five sites in and around Vancouver Harbour. The sites were designated as T-50 (Howe Sound), T-49 (West Vancouver), T-11B (Lonsdale Quay), T-38 (Port Moody), and T-48 (Indian Arm) (see Section I, Fig. 1.4). Thirty fish were collected from each site. Fish were weighed, separated by sex, and a blood sample was taken. Fish were then killed by dissection of the spinal cord, and livers were removed and placed into ice-cold Tris-HCl buffer, pH 7.4. Hepatic microsomes were prepared from 68 male and female fish (at least 10 fish per site), by differential centrifugation. Microsomal pellets were suspended in 0.25 M sucrose and aliquots of the suspension were stored at –75°C until used.

Twenty additional English sole were collected from site T-49 for use as positive and negative controls for the microsomal CYP assays in a controlled exposure experiment. These fish were housed in salt-water aquaria at a temperature of 8°C in the West Vancouver Facility. After acclimation for 5 days, the fish were weighed and 10 fish in one aquarium tank were treated with β-naphthoflavone (β-NF) in corn oil by a single i.p injection at a dosage of 50 mg/kg. Ten fish in a second tank were treated similarly with corn oil (vehicle) only at a dosage of 0.25 ml/100 g body weight. One week after treatment, the fish were killed by dissection of the spinal cord, weighed, and liver microsomes were prepared as described above.

Determination of cytochrome P450 and protein

Total CYP content was determined from the carbon monoxide difference spectrum using the method of Omura and Sato (1964). Protein concentration was measured by the method of Lowry *et al.* (1981).

Enzyme assays

Microsomal EROD activity was measured using a spectrofluorometric assay as described by Burke *et al.*(1985). Each microsomal sample was assayed directly in a fluorescence cuvette incubated at room temperature (22–25°C) using a Shimadzu Model RF-540 fluorometer interfaced with a Shimadzu DR-3 data recorder.

Preparation of antibodies

Antibody against CYP1A was raised in female New Zealand rabbits immunized with a synthetic peptide corresponding to trout CYP1A coupled to keyhole limpet hemocyanin as described previously (Lin *et al*. 1998). This antibody is specific for mammalian CYP1A1 and recognizes a single CYP1A protein in all fish species tested to date.

Immunoblots and densitometric quantitation

Polyacrylamide gel electrophoresis (PAGE) was performed essentially as described by Laemmli (1970). English sole liver microsomal samples were applied to gels at a final concentration of either 2 or 5 pmol total microsomal CYP per lane. Microsomal proteins resolved on SDS-PAGE were transferred electrophoretically to nitrocellulose and probed with antibodies as described by Towbin *et al.* (1979). Blots were incubated with anti-cytochrome P450 1A peptide IgG at a concentration of 10 μg IgG/ml. Bound primary antibody was located using alkaline phosphatase-conjugated goat anti-rabbit IgG secondary antibody. Immunoreactive proteins were detected by reaction with a substrate solution containing 0.01% NBT, 0.05% BCIP, and 0.5 mM $MgCl_2$ in 0.1 M Tris-HCl buffer, pH 9.5. Assay conditions were optimized to ensure that colour development did not proceed beyond the linear response range of the phosphatase reaction. Staining intensities of the bands were quantified with a pdi 420 oe scanning densitometer connected to an IBM-type personal computer using Quantity One® Version 3.0 software (pdi Inc., Huntington Station, NY). The amount of immunoreactive protein was determined from the integral of the optical density of the stained band. Staining intensities of bands on each blot were normalized with a purified rat hepatic CYP1A1 standard that was included on every gel as an internal standard.

Statistical analysis

Data are presented as the mean ± standard error of the mean of values determined from 10-20 fish per trawl site. Correlations between hepatic microsomal EROD activities and CYP1A protein levels were analyzed by simple linear regression. Coefficients of variation (r^2) with a p value <0.05 were considered statistically significant.

Results

Table 1 lists mean values of body and liver weight, and total cytochrome P450 (CYP) content for liver microsomes prepared from fish treated with corn oil and β-naphthoflavone. As can be seen from the data, liver weight was decreased and the total CYP content was increased for fish treated with β-naphthoflavone in comparison with corn oil-treated fish. Table 2 lists mean values of total CYP content for liver microsomes prepared from fish collected from 5 sites. As can be seen from the data, the mean value of total CYP content was variable for fish collected from the different sites.

EROD activity was measured in English sole liver microsomes. Mean values of fish from the five sites, along with mean values of the β-naphthoflavone and corn oil-treated fish, are shown in Figure 1. Treatment with β-naphthoflavone resulted in a large increase in EROD activity (approximately 18-fold) compared with corn oil-treatment. EROD activity was also elevated in fish from sites T-50 and T-38 compared to fish from sites T-49 and T-11B. In fact, the mean EROD activity of fish from site T-50 was approximately 11-fold greater than the mean EROD activity of corn oil-treated fish and 4-fold greater than that of fish from site T-49.

English sole liver microsomes were analyzed on immunoblots probed with antibody generated to a synthetic peptide corresponding to trout CYP1A1. This antibody detected a single protein band in the microsomal preparations, implying that English sole liver contains one protein that is immunochemically related to trout CYP1A1. As seen on the immunoblot in Figure 2, the CYP1A band in microsomal preparations of fish from site T-50 was stained more intensely than the band in fish from site T-49, indicating that there is increased expression of CYP1A protein in fish from site T-50 relative to site T-49.

Table 1. English sole treated with corn oil or β-naphthoflavone.

Parameter	**Corn oil**	**b-NF**
Number of fish	10	10
Age (yr)	n.d.	n.d.
Body weight (g)	132.3 ± 12.3	103.8 ± 14.4
Liver weight (g)	1.49 ± 0.13	0.97 ± 0.10*
Total CYP content (nmol/mg protein)	0.29 ± 0.02	0.54 ± 0.05*
Number of female fish	5	5/6
Number of male fish	5	5/4

Values for body weight, liver weight, and total CYP content are expressed as the mean ± SEM.

* Indicates that the value is significantly different from that of the corn oil-treated group.

Table 2. English sole from five sites in Vancouver Harbour.

Site	Number of fish	Mean age (yr)	Total CYP content (nmol/mg)	Number of male fish	Number of female fish
T-50 (Howe Sound)	14	7.7	$0.46 \pm 0.03^{a,b}$	5	9
T-49 (West Vancouver)	20	6.2	0.29 ± 0.02^{a}	13	6
T-11B (Lonsdale Quay)	10	7.5	0.31 ± 0.04^{b}	4	6
T-38 (Port Moody)	12	10.5	0.37 ± 0.02	2	10
T-48 (Indian Arm)	12	8.1	0.38 ± 0.03	4	8

Values for total CYP content are expressed as the mean ± SEM.
[a] indicates that the value is significantly different for these two groups ($p < 0.001$).
[b] indicates that the value is significantly different for these two groups ($p < 0.05$).

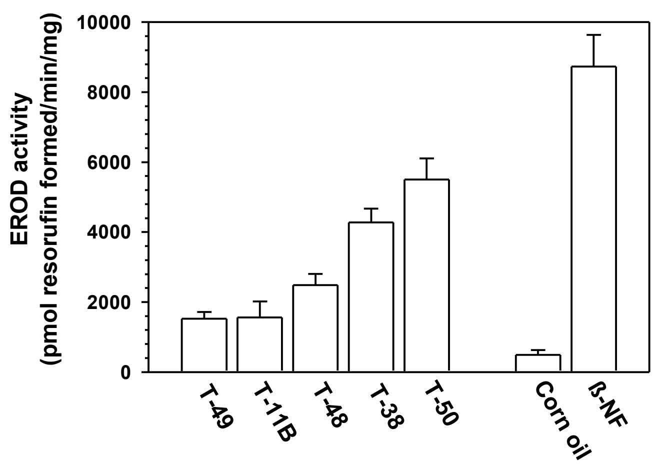


Fig. 1 Hepatic microsomal EROD activity of English sole from Vancouver Harbour.

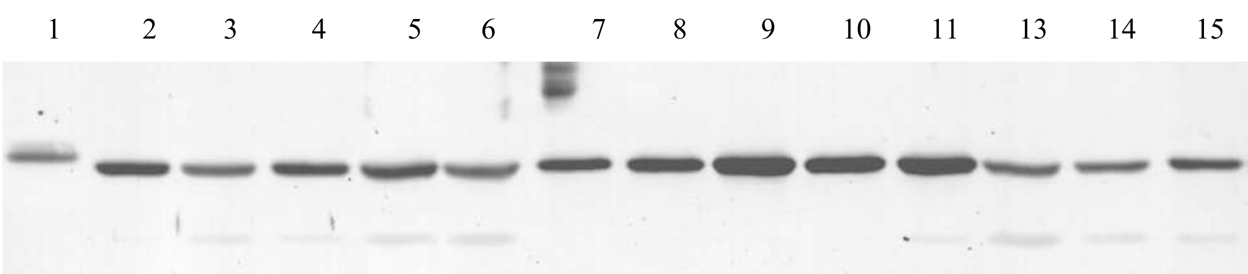


Fig. 2 Representative immunoblot of hepatic microsomes from English sole probed with anti-CYP1A peptide IgG. Samples were applied to the gel at the concentrations indicated. Lane 1 contains purified rat CYP1A1 (1.0 pmol/lane), lane 2 contains liver microsomes from a fish from site T-48 (2 pmol/lane), lanes 3-6 contain liver microsomes from individual fish from site T-49 (5 pmol/lane), lanes 7-11 contain liver microsomes from individual fish from site T-50 (2 pmol/lane), and lanes 13-15 contain liver microsomes from individual fish from site T-49 (5 pmol/lane).

The microsomal CYP1A protein in all 88 English sole was quantified by densitometry and the data are displayed in Figure 3. As was the case with EROD activity, the mean CYP1A protein level was increased after treatment with β-naphtho-flavone (approximately 13-fold) relative to fish treated with corn oil. CYP1A protein levels were elevated in fish from sites T-50, T-38, and T-48 compared to fish from sites T-49 and T-11B. The CYP1A expression livers of fish from site T-50 was approximately equal to that of β-naphtho-flavone-treated fish and was 7-fold greater than that of fish from site T-49.

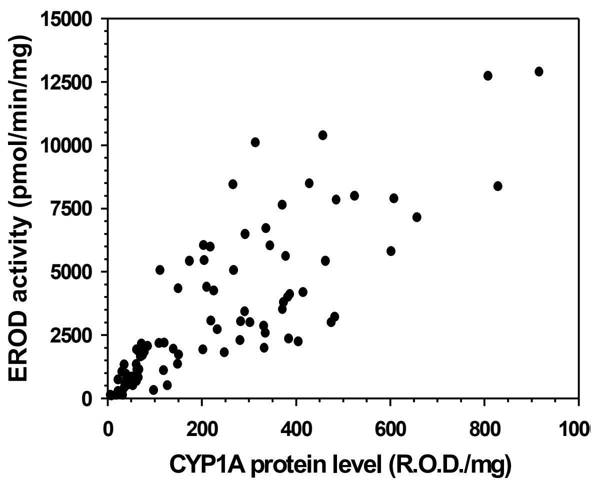


Fig. 3 Hepatic microsomal CYP1A protein levels in English sole from Vancouver Harbour.

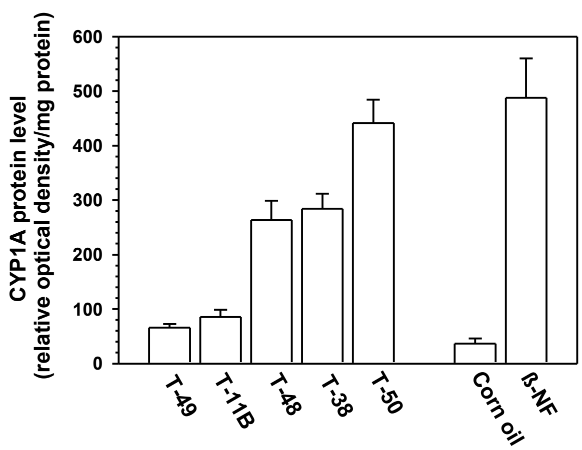


Fig. 4 Correlation between hepatic EROD activity and CYP1A protein levels in English sole samples.

The relationship between CYP1A protein levels and EROD activity for all 88 fish was examined (see Fig. 4). As expected, CYP1A protein levels were found to be highly correlated with EROD activity ($r^2 = 0.66$, $p < 0.05$).

No correlation was found between age of the English sole and CYP1A levels or EROD activity. When fish were segregated according to sex, no correlation was found between sex and EROD activity for fish from most of the sites. The exception was site T-11B, where EROD activity was greater in female than male fish, but the number of male and female fish in this group, as in most of the other groups, was too small for rigorous statistical analysis.

The relationship between CYP1A levels and sediment concentrations of various organochlorine and polyaromatic hydrocarbon compounds was examined. Sediment chemistry data from the PICES Vancouver Harbour Workshop indicated high levels of high molecular weight aromatic compounds (>4000 ng/g dry weight) and high levels of PCBs (>40 ng/g dry weight) at site T-48, with slightly lower levels at site T-38 (4500 and 34 ng/g dry weight, respectively), and even lower levels at site T-49 (2000 and 9.5 ng/g dry weight, respectively). Site T-50 is unusual in that very low or undetectable levels of these compounds were found at this site. Thus, it appears that, except for site T-50, there is a positive correlation between the amount of CYP1A in English sole and total aromatic hydrocarbon and total PCB levels in sediments at these sites.

Discussion

The present study, using English sole liver samples collected from 5 sites in and around Vancouver Harbour demonstrated the following:

1. Hepatic microsomal EROD activity was induced 18-fold by β-naphthoflavone treatment and was 5 to 9 times greater in fish from sites T-38 (Indian Arm), T-48 (Port Moody), and T-50 (Howe Sound) than in corn oil-treated fish.
2. Hepatic CYP1A protein levels were 5 to 6 times greater in fish from sites T-38 (Indian

Arm), T-48 (Port Moody), and T-50 (Howe Sound) than in corn oil-treated fish.
3. Hepatic microsomal EROD activity and CYP1A protein levels were well correlated, supporting the role of CYP1A as the primary catalyst of EROD activity in English sole.
4. A comparison of sediment chemistry data showed that fish with increased CYP1A expression came from sites (T-38 and T-48) containing relatively high levels of polyaromatic hydrocarbon (PAH) and organochlorine compounds, suggesting that CYP1A was induced in English sole by environmental exposure to PAHs and PCBs and related compounds.
5. The sediment data does not explain the high EROD activity and CYP1A protein levels found in fish from site T-50 (Howe Sound). We assume that induction of CYP1A induced in these fish was caused by environmental exposure to effluent from pulp and paper mills nearby (e.g. the Port Mellon mill).
6. Hepatic EROD activity and CYP1A protein levels in English sole are effective indicators of hydrocarbon pollutant levels in the marine environment.

Acknowledgements

We thank the North Pacific Marine Science Organization (PICES) for making this study possible.

References

Addison, R.F. 1996. The use of biological effects monitoring in studies of marine pollution. Environ. Rev. 4: 225–237.

Addison, R.F., Willis, D.E., and M.E. Zinck. 1994. Liver flounder mono-oxygenase induction in winter flounder (*Pseudopleuronectes americanus*) from a gradient of sediment PAH concentrations at Sydney Harbour, Nova Scotia. Marine Environ. Res. 37: 283–296.

Burke, M.D., Thompson, S., Elcombe, C.R., Halpert, J., Haaparanta, T., and R.T. Mayer. 1985. Ethoxy, pentoxy and benzyloxyphenoxazones and homologues: A series of substrates to distinguish between different induced cytochromes P450. Biochem. Pharmacol. 34: 3337–3345.

Campbell, P.M., Kruzynski, G.M., Birtwell, I.K., and R.H. Devlin. 1996. Quantitation of dose-dependent increases in CYP1A1 messenger RNA levels in juvenile chinook salmon exposed to treated bleached-kraft mill effluent using two field sampling techniques. Environ. Toxicol. Chem. 15: 1119–1123.

Goksøyr, A., and L. Förlin. 1992. The cytochrome P450 system in fish, aquatic toxicology and environmental monitoring. Aquat. Toxicol. 22: 287–312.

Laemmli, U.K. 1970. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature 227: 680–685.

Lin, S., Bullock, P.L., Addison, R.F., and S.M. Bandiera. 1998. Detection of cytochrome P4501A in several species using antibody against a synthetic peptide derived from rainbow trout cytochrome P4501A1. Environ. Toxicol. Chem. 17: 439–445.

Lowry, O.H., Rosebrough, N. J., Farr, A.J., and R.J. Randall. 1951. Protein measurement with the Folin phenol reagent. J. Biol. Chem. 193: 265–275.

Omura, T., and R. Sato. 1964. The carbon monoxide-binding pigment of liver microsomes. I. Evidence for its hemeprotein nature. J. Biol. Chem. 239: 2370–2378.

Safe, S.H. 1990. Polychlorinated biphenyls (PCBs), dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs) and related compounds: Environmnental and mechanistic considerations which support the development of toxic equivalency factors (TEFs). CRC Crit. Rev. Toxicol. 21: 51–88.

Stegeman, J.J., Brouwer, M., Di Giulio, R., Forlin, L., Fowler, B.A., Sanders, B.M., and P.A. Van Veld. 1992. Molecular responses to environmental contamination: Enzyme and protein systems as indicators of chemical exposure and effect. *In* Biomarkers: Biochemical, Physiological and Histological Markers of Anthropogenic Stress. *Edited by* R.J. Huggett, R.A. Kimerle, P.M. Mehrle, Jr., and H.L. Bergman. pp. 235–335, Lewis Publish.,Chelsea, MI.

Towbin, H., Staehlin and J. Gordon. 1979. Electrophoretic transfer of proteins from polyacrylamide gels to nitrocellulose sheets: procedures and some applications. Proc. Natl. Acad. Sci. USA 76: 4350–4354.

Contamination of organotin compounds and imposex in molluscs from Vancouver, Canada

Toshihiro HORIGUCHI[1], Seiichi Uno[2], Makoto Shimizu[3], Hiroaki Shiraishi[1] and Masatoshi Morita[1]

[1] National Institute for Environmental Studies, Tsukuba, Ibaraki, 305-0053, Japan

[2] National Research Institute of Fisheries and Environment of Inland Sea, Ohno-cho, Hiroshima, 739-0452, Japan

[3] University of Tokyo, Bunkyo-ku, Tokyo, 113-8657, Japan

Introduction

Organotin compounds, such as tributyltin (TBT) and triphenyltin (TPhT), have been used worldwide in antifouling paints for ships and fishing nets since the mid-1960s, and have caused imposex in neogastropods and mesogastropods in the world (Goldberg 1986; Horiguchi 2000). Imposex is defined as a superimposition of male sexual organs (penis and vas deferens) on female gastropods, and may bring about reproductive failure at severely affected stages (Smith 1971; Gibbs and Bryan 1986; Gibbs *et al*. 1987, 1988, 1990). Imposex is thought to be endocrine disruption induced by TBT and TPhT in gastropods (Matthiessen and Gibbs 1998).

The use of TBT has been banned in antifouling paints for ships smaller than 25 m in length in many developed countries, such as European countries and the United States, since the 1980s (Stewart 1996). In Japan, the production, import and use of organotins (TBT and TPhT) have been regulated by law and administrative guidance since 1990, resulting in no production in 1997 (Horiguchi 2000). TBT-based antifouling paints, however, have still been used in developing countries, such as Asian countries, and also for most vessels larger than 25 m in length (Stewart 1996; Horiguchi 2000). The worldwide ban of TBT is being discussed by the Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) (Horiguchi, 2000).

A PICES Practical Workshop was held from May 24 to June 7, 1999, in Vancouver, Canada. The aim of this study is to know the tissue concentrations of organotin (butyltin and phenyltin) compounds in molluscs (gastropods and bivalves) from Vancouver, the imposex symptoms in gastropods around Vancouver, and to assess the present status on organotin contamination in Vancouver.

Materials and methods

Molluscan specimens (gastropods and bivalves) were collected at 15 sites near Vancouver and Victoria during the Workshop. After sampling them, raw or frozen gastropod specimens were used for imposex identification: sex determination and imposex identification were anatomically done (Gibbs *et al*. 1987). The degree of imposex was expressed as incidence (frequency) (%), Relative Penis Length (RPL) Index (%), Relative Penis Size (RPS) Index (%) and Vas Deferens Sequence (VDS) Index through the measurement of penis length and observation of the development of vas deferens (Gibbs *et al*. 1987; Horiguchi *et al*. 1994).

Chemical analysis of organotin (butyltin and phenyltin) compounds in tissues of both gastropod and bivalve specimens were conducted by the methods described in Horiguchi *et al*. (1994). Briefly, tissues were extracted with 0.1% tropolone/benzene and 1N HBr/ethanol by ultrasonication, derivatized with propylmagnesium bromide, cleaned by silica gel column chromatography and quantified by gas chromatography with a flame photometric detection (GC-FPD). The detection limit of the instrument was 50 pg, and certified reference material of Japanese sea bass, *Lateolabrax japonicus*, for TBT and TPhT analysis (prepared by the National Institute for Environmental Studies; NIES CRM No. 11) was used for quality assurance and quality control. The analytical conditions are described in more detail in Horiguchi *et al*. (1994).

Results and discussion

No neogastropod specimens (e.g. *Nucella lima*) were collected at sites in Vancouver in this study. No neogastropod specimens were collected either in the survey around Vancouver in 1994 (Tester *et al*. 1996). Neogastropods, such as *Nucella*, however, were observed around Vancouver in the 1970s (Levings, personal communication). It is possible that neogastropod populations have been wiped out by some biological and/or environmental factors in Vancouver since the 1980s.

Results on imposex survey in the file dogwinkle, *Nucella lima*, and the frilled dogwinkle, *Nucella lamellosa*, from Ogden Point, Clover Point and Ten-mile Point in Victoria, and from Mission Point in Wilson Creek (see Section I, Fig. 1.5) are shown in Table 1. Slightly affected imposex was observed in populations of both the file dogwinkle and frilled dogwinkle (3.3 - 19.0, 0.004 - 0.7 and 1.1 - 2.9 for RPL, RPS and VDS Indices in the file dogwinkle and 8.2 – 23.1, 0.1 – 1.2 and 1.0 for RPL, RPS and VDS Indices in the frilled dogwinkle, respectively) although the incidences of imposex were high (71-100% and 100% in populations of the file dogwinkle and the frilled dogwinkle, respectively).

Butyltin concentrations in tissue of both the file dogwinkle and frilled dogwinkle are shown in Figure 1. Phenyltin compounds were not detected in both the file dogwinkle and frilled dogwinkle. Regarding TBT, 2.4 – 14.4 ng/g wet wt. and 6.5 – 22.0 ng/g wet wt. were detected in the file dogwinkle and frilled dogwinkle, respectively. Total butyltin concentrations in tissue (sum of TBT and its metabolites, monobutyltin (MBT) and dibutyltin (DBT)) of the file dogwinkle and frilled dogwinkle were 7.3 – 28.8 ng/g wet wt. and 10.8 – 44.0 ng/g wet wt., respectively.

Table 1. Imposex in the File Dogwinkle (*Nucella lima*) and the Frilled Dogwinkle (*Nucella lamellosa*) from Victoria (Ogden Pt., Clover Pt. and Ten-Mile Pt.) and Wilson Creek (Mission Pt.).

Imposex in the File Dogwinkle (*Nucella lima*)			
	Ogden Pt.	**Clover Pt.**	**Ten-Mile Pt.**
Frequency(%)	100	72	71
RPL Index (%)	19.0	11.8	3.3
RPS Index (%)	0.7	0.2	0.004
VDS Index (%)	2.9	2.1	1.1

Imposex in the Frilled Dogwinkle (*Nucella lamellosa*)		
	Ten-Mile Pt.	**Mission Pt.**
Frequency(%)	100	100
RPL Index (%)	8.2	23.1
RPS Index (%)	0.1	1.2
VDS Index (%)	1.0	1.0

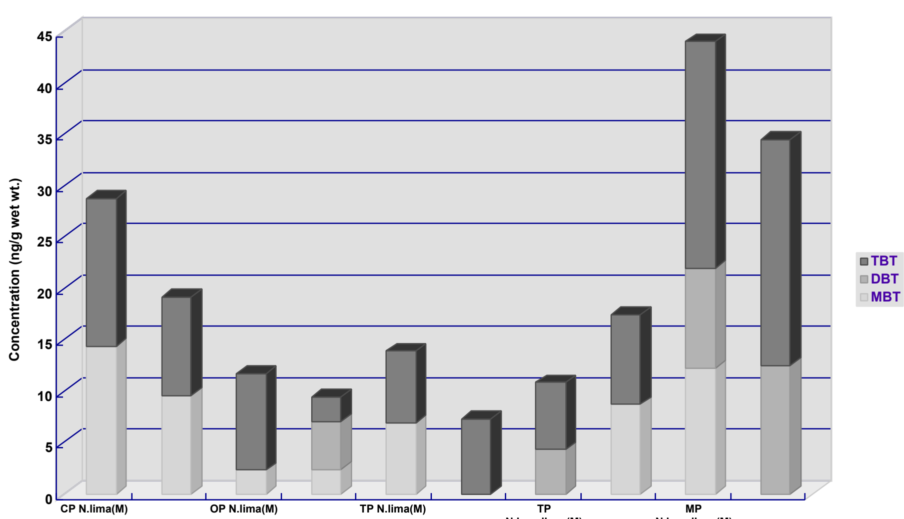


Fig. 1 Tissue concentrations of butyltin in the dogwinkle.

Comparison of these analytical values with reported concentrations of TBT and/or butyltin compounds in tissues of organisms shows that TBT and/or butyltin concentrations detected in the dogwinkles from the sites of Victoria and Wilson Creek were relatively low (Belfroid *et al*. 2000; Environmental Agency of Japan 1999; Tanabe *et al*. 1998; Takahashi *et al*. 1997). As imposex seems to have been extensively caused by relatively low contamination levels of TBT in dogwinkle populations surveyed in this study, it is suggested that dogwinkles may be sensitive to TBT and that imposex may be induced even at a low environmental concentration of TBT in dogwinkles. Under laboratory experimental conditions, imposex was induced at 64 ng/l of average exposure concentration of TBT for 120 days in the file dogwinkle, and bioconcentration factor of TBT was estimated to be approximately 2200 (Stickle *et al*. 1990).

Biological monitoring using the foolish mussel, *Mytilus trossulus*, was also carried out to determine the present status on organotin contamination in Vancouver. Results on chemical analysis of organotin compounds in tissues of the foolish mussel specimens are shown in Figure 2. Phenyltin compounds were not detected in the foolish mussel specimens either. Butyltin compounds were detected in foolish mussel specimens from all of sites surveyed, including a reference site (I-7), with a maximum concentration of 173.2 ng/g wet wt. (I-4). TBT was the most predominant among butyltin compounds detected in the foolish mussel, except for the specimens from I-3-A station: DBT was the most predominant among butyltin species detected in the foolish mussel from I-3-A, possibly suggesting some sources of the contamination of DBT near I-3-A because DBT has been used in PVC stabilizer.

Concentrations of TBT detected in tissues of the foolish mussel from Vancouver in this study were relatively high, compared with those of TBT in marine organisms reported in recent publications, although they were below the tolerable average residue level of Canada (Belfroid *et al*. 2000; Environmental Agency of Japan 1999; Takahashi *et al*. 1997). TBT concentrations in sediment core samples collected from Vancouver Harbour

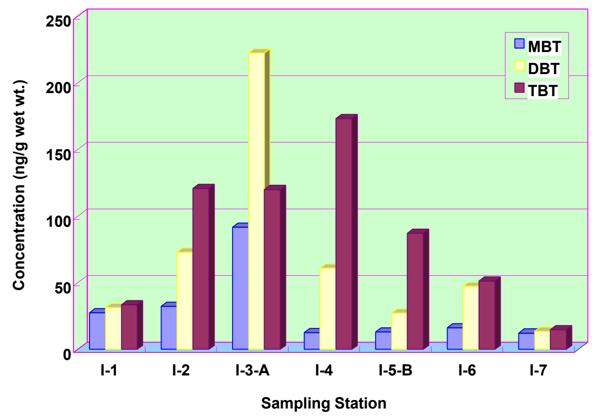


Fig. 2 Tissue concentrations of butyltins in the foolish mussel from Vancouver Harbour (May-June 1999).

(Burrard Inlet) do not show the temporal declining but still high (Thompson 1997). It could result from a continuous use of TBT in antifouling paints for vessels larger than 25 m in length, and a persistence of TBT in bottom sediments. TBT contamination was therefore confirmed to have still continued in Vancouver. Based on the results mentioned above, it is strongly believed that one of the causal factors having wiped out neogastropod populations in Vancouver is TBT from antifouling paints.

A remarkable difference of TBT accumulation in tissue was observed among the bivalve species (Fig. 3). The highest concentration of TBT was detected in the horse clam, *Tresus capax* (2229.9 ng/g wet wt.). Although bioconcentration factor of TBT and/or bioavailability of TBT through contaminated sediment are unknown in the horse clam, remarkably high concentration of TBT in tissue may have caused some adverse effects in the horse clam because some chronic toxicities have been observed in bivalves by exposure to low concentrations of TBT (Alzieu and Heral 1984; Thain and Waldock 1986; Bryan *et al*. 1987; Lawler and Aldrich 1987; Salazar and Champ 1988). Further study is necessary to examine possible adverse effects in the horse clam. Regarding the ratio of butyltin species in tissue, TBT was the most predominant in almost all bivalve specimens surveyed, suggesting low metabolic rate of TBT in these bivalve species. Phenyltin compounds were not detected in bivalves other than the foolish mussel either.

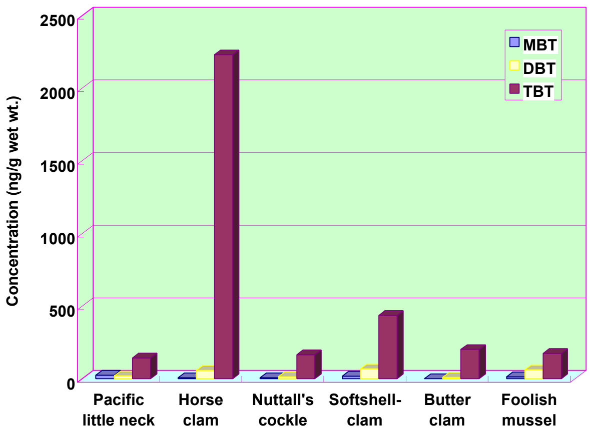


Fig. 3 Tissue concentrations of butyltins in bivalves at station I-4 in Vancouver Harbour (May 30, 1999).

The highest TBT concentration in tissue was consistently observed in the Pacific oyster, *Crassostrea gigas*, among the marine invertebrates collected in every intertidal zone of 3 sites of Japan (Horiguchi et al., unpublished data). As TBT concentrations in tissue were also consistently higher in the Pacific oyster than in the foolish mussel in this study, the Pacific oyster could be useful for biological monitoring of TBT contamination.

References

Alzieu, C. and M. Heral. 1984. *In* Ecotoxicological Testing for the Marine Environment. *Edited by* G. Persoone et al., Vol.2, State Univ. Ghent and Inst. Mar. Scient. Res., Bredence, Belgium, pp. 187–196.

Belfroid, A.C. et al. 2000. Mar. Pollut. Bull. 40: 226–232.

Bryan, G.W. et al. 1987. J. Mar. Biol. Ass. U.K. 67: 525–544.

Environmental Agency of Japan. 1999. *In* Chemicals in the Environment. *Edited. by* Environmental Health and Safety Division, Environmental Agency of Japan, pp. 239–260. (in Japanese)

Gibbs, P.E. and G.W. Bryan. 1986. J. Mar. Biol. Ass. U.K. 66: 767–777.

Gibbs, P.E. et al. 1987. J. Mar. Biol. Ass. U.K. 67: 507–523.

Gibbs, P.E. et al. 1988. J. Mar. Biol. Ass. U.K. 68: 715–731.

Gibbs, P.E. et al. 1990. J. Mar. Biol. Ass. U.K. 70: 639–656.

Goldberg, E.D. 1986. Environment 28: 17-20, 42–44.

Horiguchi, T. et al. 1994. J. Mar. Biol. Ass. U.K. 74: 651–669.

Horiguchi, T. 2000. *In* Problems of Endocrine Disruptors in Fisheries Environment. *Edited by* S. Kawai and J. Koyama. Koseisha-Koseikaku, Tokyo, pp.54–72. (in Japanese)

Lawler, I.F. and J.C. Aldrich. 1987. Mar. Pollut. Bull. 18: 274-278.

Matthiessen, P. and P.E. Gibbs. 1998. Environ. Toxicol. Chem. 17: 37–43.

Salazar, M.H. and M.A. Champ. 1988. Oceans '88: 1497–1506.

Smith, B.S. 1971. Proc. Malacol. Soc. Lond. 39: 377–378.

Stewart, C. 1996. *In* Tributytltin: Case study of an environmental contaminant. *Edited by* S.J. de Mora. Cambridge Univ. Press, pp.264–297.

Stickle, W.B. et al. 1990. J. Exp. Mar. Biol. Ecol. 143: 165–180.

Takahashi, S. et al. 1997. Environ. Sci. Technol. 31: 3103–3109.

Tanabe, S. et al. 1998. Environ. Sci. Technol. 32: 193–198.

Tester, M. et al. 1996. Environ. Toxicol. Chem. **15**, 560–567.

Thain, J.E. and M.J. Waldock. 1986. Wat. Sci. Tech. 18: 193–202.

Thompson, J.A.J. 1997. A Report prepared for the Dept. of Fisheries and Oceans, Institute of Ocean Sciences, 19 pp.

Changes in benthic communities along a presumed pollution gradient in Vancouver Harbour

Jong-Geel JE[1], Tatyana Belan[2], Colin D. Levings[3] and Bon Joo Koo[1]

[1] Korea Ocean Research and Development Institute (KORDI), Korea
[2] Far Eastern Regional Hydrometeorological Research Institute (FERHRI), Russia
[3] West Vancouver Laboratory, Science Branch, Fisheries and Oceans Canada, Canada

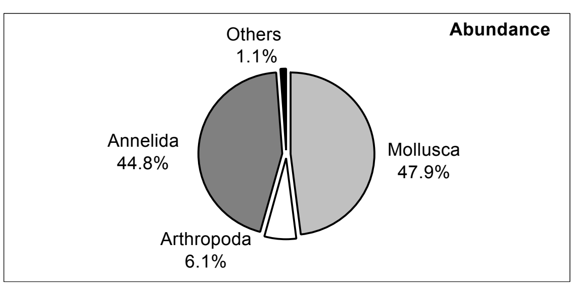
Objectives of this work during the MEQ Practical Workshop were to assess degree of pollution in Vancouver Harbour by analyzing macrobenthic community structure, and examine the potential usefulness of higher-level taxa of macrobenthos in detecting degree of pollution.

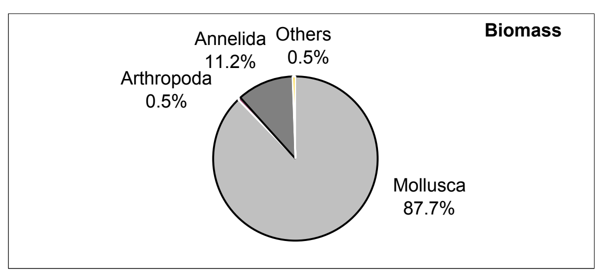
Samples for benthic community studies were collected with a Van Veen grab at 7 stations on a presumed pollution gradient from the head of Vancouver Harbour through to Howe Sound (see Section I, Fig. 1.2). 5 replicate grab samples were taken at each site. Sediments were immediately passed through a 0.5 mm sieve. Benthic organisms were removed from the sieve, and preliminary sorting of fauna was carried out in the West Vancouver Laboratory, Fisheries and Oceans Canada. Samples were preserved and transported to Russia and Korea for further analysis.

Detailed identification of polychaetes was completed at the Far Eastern Regional Hydrometeorological Institute (Vladivostok), ophiuroids, nemertineans, crustaceans, sipunculans and others at the Institute of Marine Biology (Vladivostok), and molluscs at the Korean Ocean Research and Development Institute (Seoul). The data were then combined for community analyses using a station by species matrix.

The sediments were analyzed for grain size at KORDI using standard sieving and settling tube technique. It was shown that all stations are characterized by mud, except the Howe Sound station that is dominated by sand. 171 species were identified in the sorted 8 faunal groups. The stations were divided into 3 groups by species and abundance similarity: 2 stations in Port Moody Arm, 4 stations in the Inner and Outer Harbours, and 1 station in Howe Sound.

Some preliminary results on faunal composition (Fig. 1-3, Table 1), along with interpretation of changes relative to the data on contaminants in the sediments found by other researchers (Fig. 4) are presented in this report.





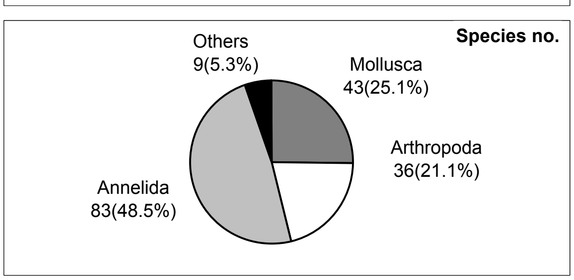


Fig. 1 The faunal group composition of macrobenthos occurring in Vancouver Harbour: mean density = 957 individuals/m^2 (top left); mean biomass = 114.2 g per m^2 wet weight (top right); 171 species in 8 Phyla (bottom left).

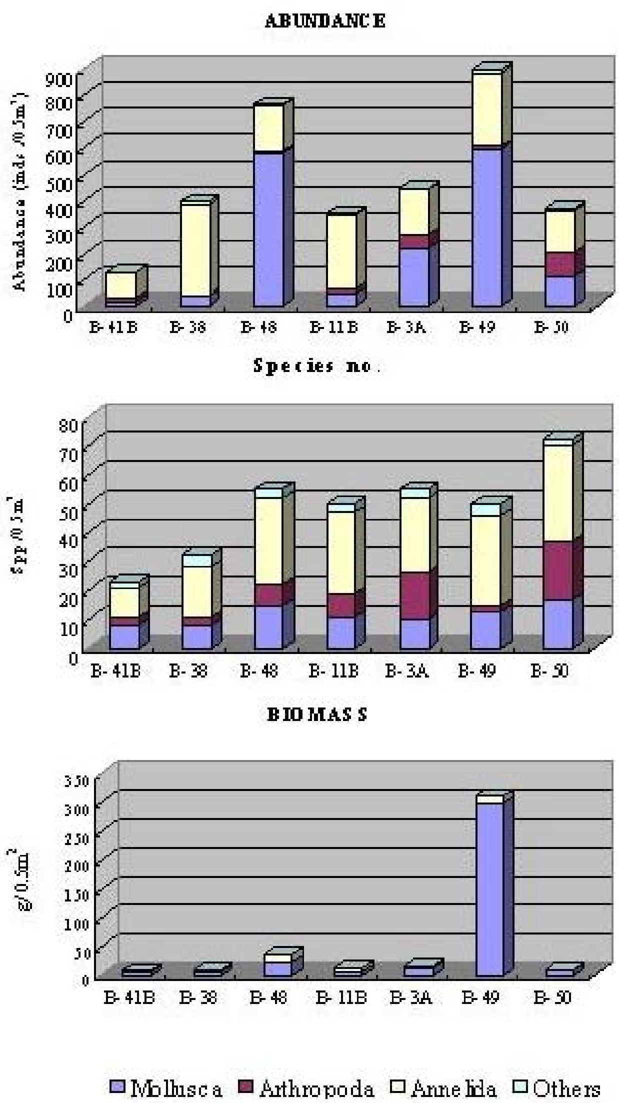


Fig. 2 The abundance (top left), biomass (top right) and species number (bottom left) of macrobenthos occurring in Vancouver Harbour.

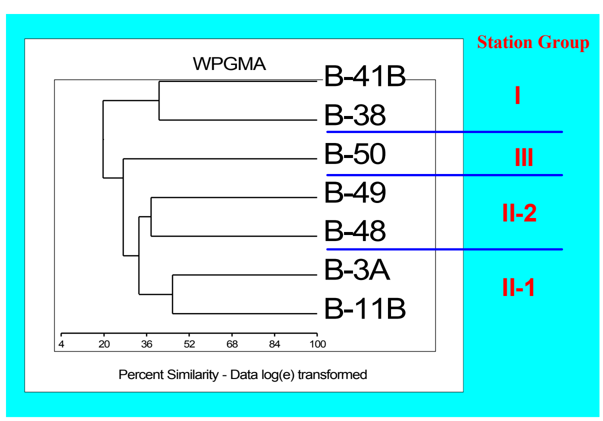


Fig. 3 A dendrogram from the cluster analysis using the abundance of macrobenthos occurring in study areas near Vancouver Harbour by percent similarity and weighted pair group average linkage.

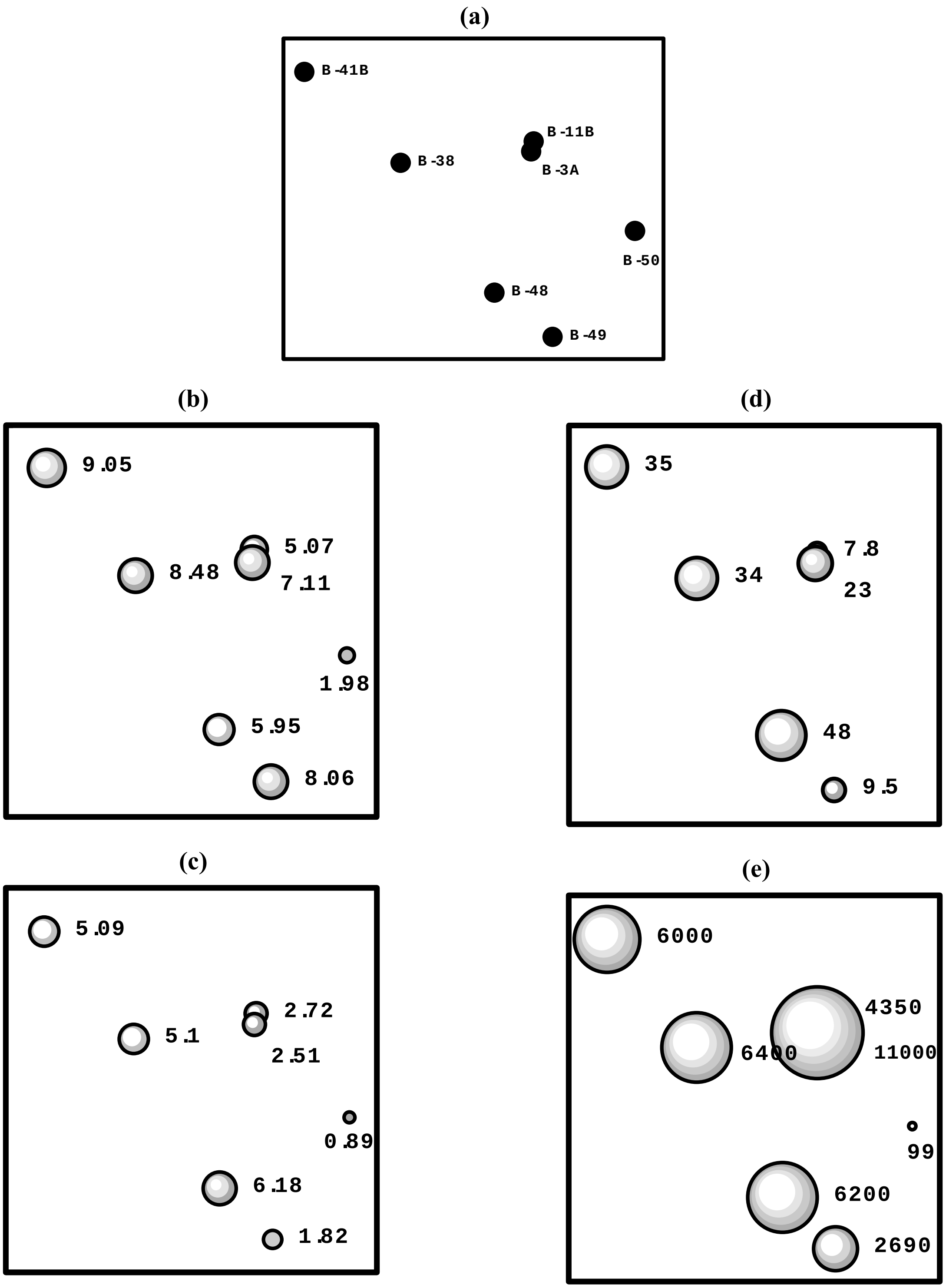


Fig. 4 MDS ordination of Bray-Curtis similarities from 4th-root transformed species abundance data at 7 stations (a); same MDS but with superimposed circles of increasing size with increasing concentration of Mz (b), organochlorine pesticides (c) polychlorinated biphenyls (d), and polycyclic aromatic hydrocarbons (e). Units for (c)-(e) are ng/g dry weight.

Table 1. Ecological parameters and dominant species in each station group.

	STATION GROUP			
PARAMETERS	I	II-1	II-2	III
Number of station (n)	2	2	2	1
Number of species	45	77	84	72
Mean no. of species (Spp./0.5m^2)	27.5	52.5	52.5	72
Mean density (Inds./m^2)	526.0	798.0	1658.0	732
ECOLOGICAL INDICES				
Species diversity (H')	2.06	2.87	2.28	3.51
Eveness (J)	0.63	0.73	0.58	0.82
DOMINANT SPECIES (INDS./M^2)				
Tharyx multifilis (P)	<u>235</u>	1	-	-
Nephtys cornuta franciscanum (P)	<u>81</u>	16	8	-
Spionidae indet.1 (P)	<u>45</u>	-	14	2
Lumbrineris luti (P)	<u>36</u>	<u>81</u>	57	<u>56</u>
Axinopsida serricata (M)	21	<u>104</u>	<u>717</u>	<u>96</u>
Transenella tantilla (M)	-	<u>89</u>	-	2
Ophelina acuminata (P)	-	<u>122</u>	13	-
Bivalvia indet.5 (M)	1	1	<u>161</u>	-
Macoma calcarea (M)	3	-	<u>143</u>	-
Nucula tenuis (M)	1	-	23	<u>52</u>
Tellina capenteri (M)	-	-	-	<u>26</u>
Pinnixa rathbunae (C)	5	-	-	<u>62</u>
Tanaidacea indet. (C)	-	-	-	<u>42</u>
Chaetozone setosa (P)	-	4	5	<u>30</u>
Glycera sp. (P)	1	-	6	<u>32</u>
Nephtys firruginea (P)	1	16	61	<u>30</u>
Scoloplos armiger (P)	-	3	1	<u>30</u>

1) Underline numbers are the mean density of dominant species in each station group;
2) P: polychaetes; M: molusks; C: crustaceans;
3) “-“: not occured.

Fish communities and life history attributes of English sole (*Pleuronectes vetulus*) in Vancouver Harbour

Colin D. LEVINGS and Stacey Ong
West Vancouver Laboratory, Science Branch, Fisheries and Oceans Canada, Canada

Introduction

The species composition of fish communities has been proposed as a key variable to assess the biological integrity of estuarine ecosystems (Deegan *et al*. 1997), and is also used as a monitoring variable to detect changes in coastal water quality. In this paper, we report on the spatial changes and relative abundance of demersal or bottom dwelling fish in Vancouver Harbour, and evaluate the usefulness of the data for evaluation of environmental quality in the context of the PICES Practical Workshop. There are some data available on fish communities in Vancouver Harbour collected several decades or years ago (Levings 1973; Goyette and Thomas 1987, Goyette and Boyd 1989, Washington Dept of Fish and Wildlife 1995), enabling comparisons over the longer term. The English sole (*Pleuronectes vetulus*) was identified as a dominant demersal species in the earlier work. Because the physiological and health status of English sole was studied extensively by other investigators in the Workshop, basic data on length, weight, age and growth, and feeding were also obtained.

Methods

Field sampling

A small otter trawl (mesh size in body/wing 38 mm, 3.2 mm in codend, width of opening estimated 4.9 m) was towed by the NOAA vessel *Harold W. Streeter* at 5 stations, on a presumed pollution gradient from inner to outer Vancouver Harbour (see Section I, Fig 1.4; Table 1). Each station was sampled between 3 and 7 times. The net was towed between 5 and 10 minutes, and sampled an estimated area of between 1,643 to 8,570 m^2 in each trawl.

Table 1. Basic data on trawl stations in Vancouver Harbour* indicates one additional trawl completed but results discarded because of gear problems.

Site name	Station name	Number of trawls	Depth range (m)
Port Moody	T-38	3	11-14
Indian Arm	T-48	3	26-30
Lonsdale Quay	T-11B	4	24-26
West Vancouver Lab*	T-49	6	30-45
Gibsons-Howe Sound*	T-50	3	55-73

The catch from each trawl was sorted by species, then enumerated by species and weight. The larger invertebrates such as Dungeness crab (*Cancer magister),* tanner crab (*Chionocetes tanneri),* anemone (*Metridium* spp) and a few species of bivalve molluscs were also enumerated and weighed. The total length of each English sole in the catch was measured to the nearest millimetre. Data on weight, stomach content, and age were obtained for English sole specimens autopsied by Stehr et al. (this report) for physiological condition and histopathology. The minimum size for the latter studies was 25 cm, the approximate length of sexual maturity for this species. After autopsy, the stomach was removed from each fish and preserved in 3.7% formalin. For ageing, the right otolith was removed and placed in a glycerol-thymol mixture.

Laboratory methods

Stomach contents of a random sample of 10 English sole stomachs were examined in the laboratory. A Wild M-5 Stereomicroscope was used to enumerate organisms, which were identified to the major group level. Ages were determined by the Fish Aging Unit, DFO Science Branch, Pacific Biological Station, Nanaimo. Condition factor was computed using Fulton's K where $K = wt/l^3 \times 10^5$.

Results

Fish community data

The mean number of fish species obtained in the trawls ranged from 11 (se 0.5) at station T-38 to 12.2 (se 0.2) at T-49. However based on the total number of species caught in the trawls at a particular site, the fish community at Station T-11B was most diverse (19 species), with the other stations as follows: T-38, 12 species; T-48, 16 species; T-49, 17 species; and T-50, 17 species. Mean biomass ranged from 0.65 kg·100 m^{-2} (se 0.1) at T-38 to 0.15 kg·100 m^{-2} (se 0.1) at T-11B, and number of individuals from 350 100 m^{-2} (se 50)·to 100·100 m^{-2} (102) at the latter 2 stations.

15 fish species accounted for at least 1% of the catch in the trawls at particular stations (Table 2). Flatfish (Pleuronectidae and Bothidae) were the dominant species, especially English sole (*Pleuronectes vetulus*), Starry flounder (*Platichthys stellatus*), Flathead sole (*Hippoglossoides elassodon*), Dover sole (*Microstomus pacificus*), Rex sole (*Errex zachirus*), slender sole (*Lyopsetta exilis*) and Rock sole (*Pleuronectes bilineatus*). Flatfish were the dominant taxa at the inner harbour station (T-38), accounting for more than 50% of the fish caught there. Other dominant species were the Pacific tomcod (*Microgadus proximus*) and the blackbelly eelpout (*Lycodopsis pacifica*). Species composition at the five sites differed significantly ($p<0.05$) after testing with χ^2.

Table 2. Percentage data for abundance of fish species accounting for at least 1% of catch (numerical data) at any of the five stations sampled in Vancouver Harbour. Percentages computed using only fish data.

Species/Station	T-38	T-48	T-11B	T-49	T-50
Longfin smelt	1.7	3.1	1.2	0.0	0.0
Herring	2.8	1.6	5.5	<1.0	0.0
Longnose skate	0.0	0.0	<1.0	0.0	0.0
Spiny dogfish	0.0	0.0	0.0	0.0	<1.0
Pacific hake	0.0	0.0	0.0	0.0	35.5
Walleye pollock	0.0	<1.0	0.0	0.0	0.0
Pacific tomcod	8.6	10.3	10.5	1.1	9.2
Shiner seaperch	4.1	1.0	1.0	<1.0	<1.0
Copper rockfish	0.0	0.0	0.0	0.0	<1.0
Tadpole sculpin	0.0	0.0	0.0	0.0	<1.0
Roughback sculpin	0.0	1.0	1.9	<1.0	0.0
Buffalo sculpin	0.0	0.0	<1.0	0.0	0.0
Staghorn sculpin	3.3	1.7	<1.0	<1.0	0.0
Sturgeon poacher	0.0	<1.0	1.0	<1.0	7.1
Midshipman	4.3	1.6	0.0	<1.0	<1.0
Whitespot greenling	0.0	<1.0	<1.0	0.0	0.0
Blackbelly eelpout	0.0	6.6	2.1	38.2	3.1
Flathead sole	1.0	14.7	1.0	14.1	1.6
Dover sole	13.1	0.0	0.0	1.3	<1.0
English sole	49.6	56.1	56.8	14.9	35.9
Rock sole	0.0	<1.0	6.2	1.5	<1.0
Slender sole	0.0	0.0	2.9	8.8	3.3
Starry flounder	9.6	1.0	4.5	5.7	0.0
Butter sole	0.0	0.0	<1.0	0.0	0.0
Rex sole	0.0	0.0	0.0	10.2	1.2
Sand sole	1.1	<1.0	2.6	1.3	0.0
Speckled sandab	0.0	0.0	0.0	0.0	<1.0
Pacific sandab	1.0	0.0	2.1	1.0	1.0

English sole life history features

Abundance

Mean abundance of English sole varied between the stations, ranging from about 6 fish·100 m^{-2} (se 1) at station T-38 to <1·100 m^{-2} (se 1) at station T-49. Biomass showed the same pattern, ranging from about 0.35 kg·100 m^{-2} (se 0.05) at station T-38 to 0.05 kg·100 m^{-2} (se 0.7) at station T-49. Abundance and biomass at station T-38 was significantly higher ($p<0.05$) compared to the other stations.

Length, sex ratio, and age

Mean English sole length was 291 mm (se 4.6) at Station T-38, 270 mm (se 4.7) at T-48, 242 mm (se 4.6) at T-11b, 254 mm (se 3.9) at T-49, and 240 mm (se 4.8) at T-50. As judged by ANOVA, lengths were significantly different between stations (Table 3, $p<0.05$), with the largest fish at Station T-38. Mean lengths at Station T-38 were statistically significant ($p<0.05$) when tested against all other stations. Comparisons among the other stations were variable.

Sex ratio

Female English sole were more common (chi - square, $P<0.05$) in the inner harbour stations (T-50, T-48, and T-11B) relative to the outer harbour stations (Table 4).

Age and growth

Age of the English sole ranged from 2 - 15 years (Fig. 2) and mean age over all stations and sexes was 7.3 y. Mean age at the various stations were 9.3 y at T-38, 7.4 y at T-48, 6.4 y at T-11B, 6.3 y at T-49, and 7.4 y at T-50. The percentage accounted for the various age groups was significantly ($p<0.05$) different over all the stations, as judged by chi-square. More older fish were found in the inner harbour stations. The only 14 and 15 y fish in the survey were caught at station T-38.

Table 3. Statistical comparisons of mean lengths of English sole at the five stations.

Station	T-50	T-48	T-11B	T-38	T-49
T-50	-	-	-		
T-48	<0.05	-	-		
T-11B	ns	<0.05	-		
T-38	<0.05	<0.05	<0.05	-	
T-49	ns	ns	ns	<0.05	-

Table 4. Percentage of male and female English sole at the five stations.

Site/sex	T-38	T-48	T-11B	T-49	T-50
Percent Female	75	86	76	45	44
Percent Male	25	14	24	55	56
Number of Fish	28	28	30	42	27

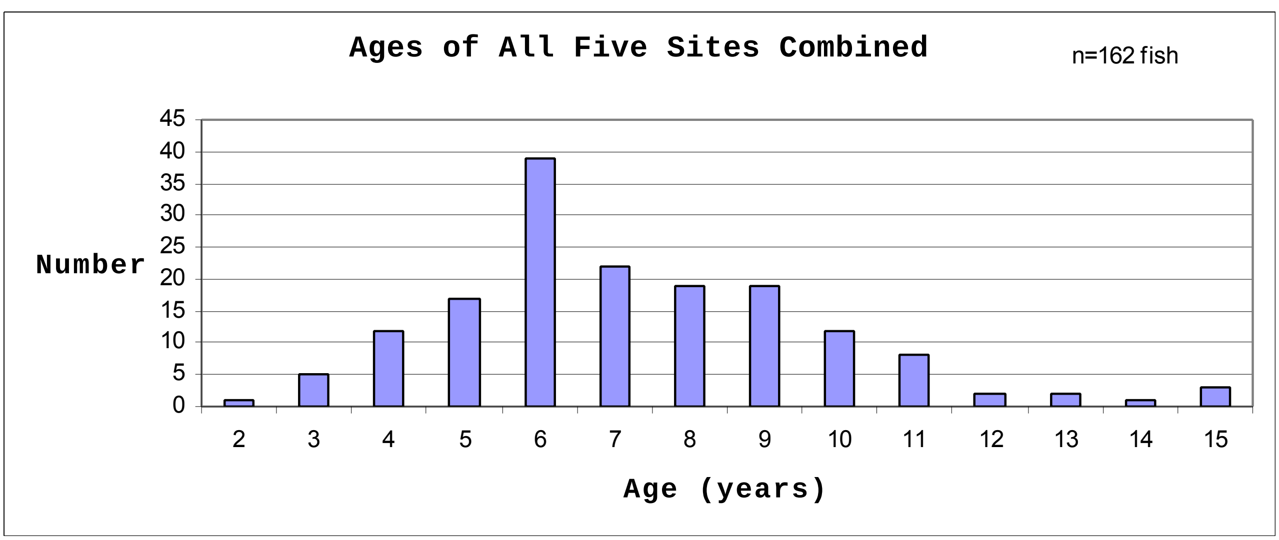


Fig. 2 Age distribution of English sole from all sample stations combined.

English sole growth was estimated by the slope of the regression line between age (x) and length (y). Using combined data for both males and females, English sole grew fastest at station T-11B (y=9.35x + 182.25), followed by T-38 (y=3.31x + 265.77), T-48 (y=3.05x + 248.11), T-50 (y=1.92x + 225.92), and T-49 (y=1.69x + 243.30).

Condition factor

Condition factor was lower for male and female English sole at Stations T-38 and T-50 ($K < 0.787$) relative to the other three stations ($K > 0.808$) (Table 5).

Table 5. Fulton's condition factor (K, se, and number of fish) for female and male English sole.

Station	Female English sole	Male English sole
T-38	0.787, 0.01, 21	0.726, 0.02, 7
T-48	0.821, 0.02, 24	0.808, 0.04, 4
T-11B	0.853, 0.01, 23	0.838, 0.02, 7
T-49	0.827, 0.02, 19	0.844, 0.01, 23
T-50	0.758, 0.02, 12	0.716, 0.02, 15

Feeding habits

In ranked order, annelid worms, bivalve molluscs, foraminifera, amphipods, and unidentified crustaceans were the dominant organisms in English sole stomachs at all stations except T-38. At the latter station, annelid worms were the dominant taxa. The mean number of organisms per stomach ranged from about $48 \cdot fish^{-1}$ (se 10) at Station T-38 to $22 \cdot fish^{-1}$ (se 9) at Station 11-B.

References

Washington Department of Fish and Wildlife. 1996. Puget Sound/Georgia Basin 1995 Transboundary Survey: analytical results for a Georgia Basin bottomfish survey. Final Report, July 23 1996.

Levings, C.D. 1973. Sediments and abundance of *Lycodopsis pacifica* (Pisces, Zoarcidae) near Point Grey, B.C., with catch data for associated demersal fish. Fish. Res. Bd. Canada Tech. Rep. No. 393. 32 pp.

Deegan, L.A., Finn, J.T., Ayvazian, S.G., Ryder-Kieffer, C.A., and J. Buonaccorsi. 1997. Development and validation of an Estuarine Biotic Integrity Index. Estuaries 20: 601–617.

Goyette, D., and M. Thomas. 1987. Vancouver harbour benthic environmental quality studies May 1985 to September 1986. Relative species abundance and distribution - trawl catch. Environment Canada, Regional Data Report 87-03. 62 pp.

Marine environmental quality assessment using polychaete taxocene characteristics in Vancouver Harbour

Tatiana A. BELAN
Far Eastern Regional Hydrometeorological Research Institute (FERHRI), 24 Fontannaya St., Vladivostok 690600, Russia

Introduction

An International Practical Workshop on biological effects of pollutants, organised by the Marine Quality Committee of PICES, took place from May 24 to June 7, 1999, in Vancouver, British Columbia, Canada. Specialists from all PICES member countries participated in the sampling and analysing of the data obtained to detect biological consequences of contaminants in the marine environment.

To evaluate marine environment quality, a set of chemical and biological properties was used. Biological properties included the characteristics of polychaete taxocene. Polychaetes are one of the most important groups of marine benthic animals. This group is characterised by high species richness and diversity as well as high biomass and density (up to 80% of total benthos abundance). In addition, polychaetes have a high level of tolerance to adverse effects – both to pollution and natural perturbation (Bryan and

Gibbs 1987; Burd and Brinkhurst 1990; Levings et al. 1985; Rygg 1985a, b). Thus, the state of polychaete taxocenes indicates the state of marine bottom communities as a whole. So, for marine environmental quality assessment we used characteristics of polychaete taxocene and sediment chemistry data.

Materials and methods

Sampling design

Benthic samples were collected in Vancouver Harbour in May-June of 1999 (see Section I, Fig. 1.2). 7 sites were sampled: one in Howe Sound (B-50), one in Outer Harbour (B-49), two in Inner Harbour (B-3A, B-11B), one in Indian Arm (B-48), two in Port Moody (B-38, B-41B). 5 replicate sediment samples were taken at each site with a Van-Veen grab (0.11 m^2) to analyse a set of chemical and biological properties.

Sample processing

The sediments were washed by seawater through a 1-mm sieve, and residues including macrobenthos were preserved with a 4% buffered formaldehyde solution. In the laboratory, benthic organisms were sorted from the sediment to major taxa. All individuals were identified to species level, but some organisms could only be identified to higher taxa. Wet weight of macrofauna was determined: organisms were blotted and air-dried for approximately one minute prior to weighing (Bilyard and Becker 1987).

Data analysis

The software package PRIMER (Plymouth Routines In Multivariate Ecological Research), developed at the Plymouth Marine Laboratory was used for data analysis (Clarke and Green 1988, IOC 1983, UNEP 1995, UNESCO 1988). Univariate measures included Margalef richness index (R), Shannon-Wiener diversity index (H), Pielou evenness index (e), Simpson domination index (Si), total polychaetes biomass (B), abundance (N), and number of polychaetes species (S). Ecological indices were calculated as:

$$H = -\sum p_i \times (\log_2 p_i),$$
$$e = H/\log_2 S$$
$$R = (S-1)/\log_2 N;$$
$$Si = \sum (p_i)^2$$

where p_i is the proportion of abundance i-th species from total abundance of polychaetes; S is total number of polychaetes species.

Multivariate techniques included ordination of benthic samples by Multi-Dimensional Scaling (MDS) and their classification by clustering. Clustering was done by a hierarchical agglomerative method which employs group-average linking of Bray-Curtis similarities, after the 4th root transformation. Species biomass data, excluding those with count less than 2% of total polychaete biomass, were used. Ordination of polychaete taxocene parameters and environment factors was by Principal Component Analysis (PCA).

Results and discussion

In total, 82 polychaete species were found. The biomass matrix consisted of 82 species at 7 sites, and was subjected to ordination and cluster-analysis. Results of ordination are shown in Figures 1. MDS technique detected 4 groups of stations according to dissimilarity of species composition. The reliability of this diagram was tested by value of stress coefficient. Low values

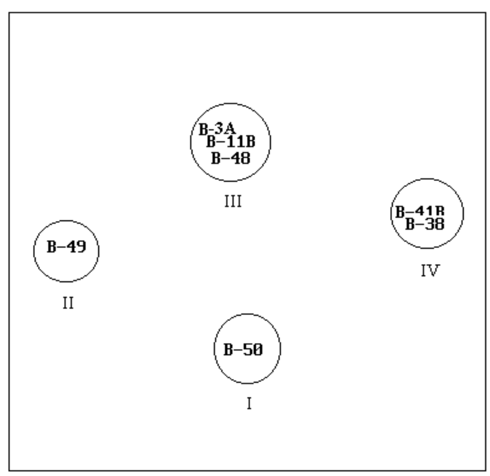


Fig. 1 Polychaete fauna. MDS ordination of Bray-Curtis similarities from vv-transformed species biomass data from 7 sites. MDS stress = 0.01.

of this coefficient (0.01–0.05) indicate excellent correspondence and reliability. Thus these groups of stations have different species compositions.

Cluster-analysis confirmed the result of ordination, and detected the same 4 groups of stations as well, shown in Figures 2 and 3. The first diagram shows the results for 5 replicates, while the second diagram demonstrates the results of average biomass for 7 sites.

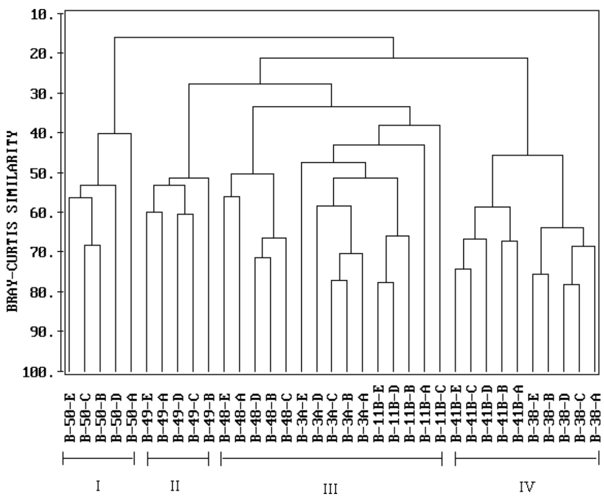


Fig. 2 Polychaete fauna. Dendrogram for hierarchical clustering fop 5 replicates from each of 7 sites, using group-average linking of Bray-Curtis similarities calculated on √√-transformed biomass data.

The lowest Bray-Curtis sites similarity (15%) is observed between Site B-50 and the other sites. This may be explained by the natural environmental factors: depth and sediment type. Site B-50 is located at the deepest part of the research area – at a depth of 50 m on fine sands. While the other sites are disposed at the silty sediments with depths from 10 to 29 m, except for Site B-49**,** which is located at a depth of 49 m. Low Bray-Curtis species similarity (about 20%) is observed between Group IV (Sites B-38 and B-41B) and the others groups. But these differences probably have been caused by anthropogenic factors: sediment pollution and influence of H_2S.

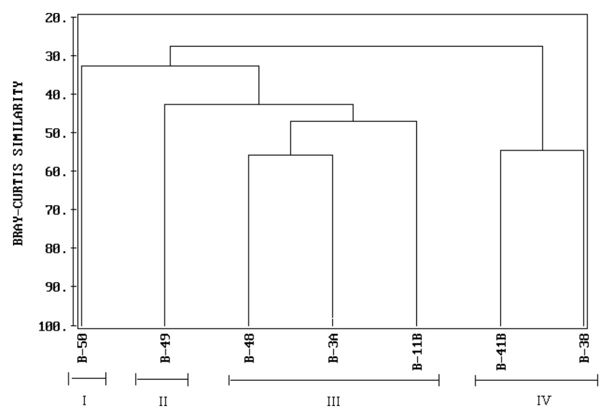


Fig. 3 Polychaete fauna. Dendrogram for 7 sites.

Table 1. Pollutant concentrations adverse affects on marine benthic invertebrates.

Pollutants	**ERL – Effect range-low**[1]	**ERM –Effect range-medium**[2]	**Observed concentrations**	**Sites**[3,4]
Cd (ppm)	0.676–1.2	4.21–9.6	0.2–1.2	B-3A
Cr	52.3–81.0	160–370	25.0–68.3	***B-41B***
Cu	18.7–34.0	108–270	10.8–172.5	B-38
Pb	30.2–46.7	112–218	4.0–75.8	B-3A, B-41B, B-38
Ni	15.9–20.9	42.8–51.6	11.3–34.0	***B-49***
Zn (ppm)	124–150	271–410	35.0–406.7	B-3A
∑DDTs (ppb)	1.58	46.10	0–2.50	B-41B
∑LACs	552	3160	70–2200	B-3A
∑HACs	1700	9600	29–8800	B-3A
∑PCBs (ppb)	22.7	180	0–48	B-48

1 ERL-results in initial, reversible changes in benthic community.
2 ERM-results in reduction of benthos abundance and species richness in bottom community, and 50% mortality in toxicology experiments (Boyd *et al*. 1998; Long *et al*. 1995).
3 Shaded fields indicate stations with pollutant content, corresponding to ERM concentrations.
4 Bold and italic show stations with pollutant content, corresponding to ERL concentrations.

Table 1 demonstrates the range of pollutant concentrations in bottom sediments that negatively affects marine benthos. These values were obtained by American and Canadian scientists (Boyd *et al*. 1998, Long *et al*. 1995). Pollution loads at the level of effects in initial reversible changes in benthic communities (range-low concentrations results), and at the level of effects in reduction of benthos abundance and species richness in communities, and 50% mortality in toxicological experiments (range-medium concentrations results). As shown in Table 2, these concentrations of trace metals, DDTs, PCBs, LACs and HACs were found at 5 stations.

The PCA of sediment chemistry data (concentrations of 22 pollutants in bottom sediments) detected 4 groups of stations, shown in Figure 4. Group II (sites B-38 and B-41B) is characterized by maximal and increasing concentrations of organic contaminant in bottom sediments. Site B-3A has maximal concentrations of trace metals. Low pollutant content was recorded at site B-50. Group III (sites B-11B, B-48, and B-49) is characterized by intermediate position. In this diagram Group II (sites B-38 and B-41B) disposes separately from the other sites, as it was shown in Figure 1. So we can propose that strong species dissimilarity of Sites B-38 and B-41B compared with other sites may be evidence of pollutant impact.

The PCA of polychaete taxocene characteristics, including number of species and ecological indices, has also indicated 4 groups (Fig. 5). Group I and II (sites B-38 and B-41B) have lowest values of number of species, as well as indices of diversity and richness. Site B-38 has maximal values of domination index. Domination of tolerant pollution species *Tharyx multifilis* and low density of sensitive-pollution species (*Scoloplos armiger, Laonice cirrata*) were detected at these stations. Sites of Group IV (B-50, B-49, B-48, and B-11B) are characterized by the highest values of the number of species, and maximal richness and diversity of polychaetes. Site B-3A is very close to Group IV.

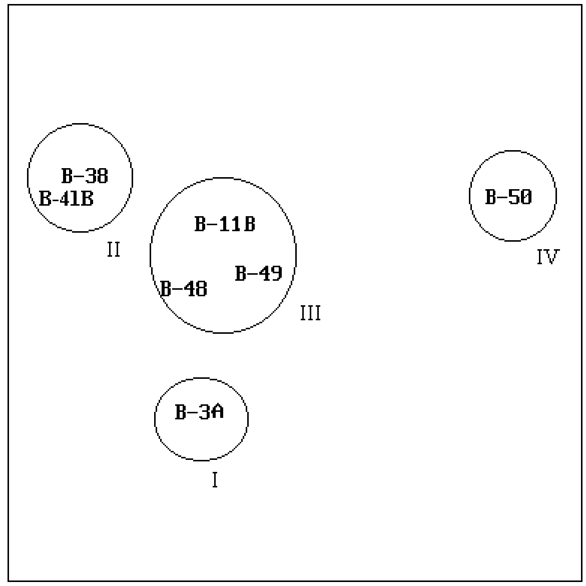


Fig. 4 PCA ordination of sediment chemistry data. Concentration of 22 pollutants in bottom sediments after transformation (√) and normalization for 7 sites (% variance explained = 77%).

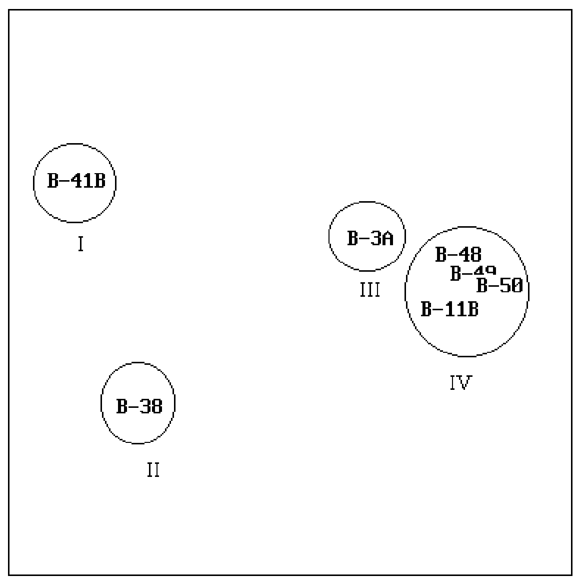


Fig. 5 PCA ordination of 5 characteristics of polychaete taxocene variables after transformation (log *x*) and normalization for 7 sites (% variance explained = 99.6%).

Thus, sediment quality assessment indicates:

- Severe adverse effect at sites B-38 and B-41B**;**
- Sites B-48, B-49 and B-11B are characterized by low and moderate adverse effects;
- Site B-3A, judging by ecological indices and species structure has an intermediate position between severe and moderate adverse effects.

References

Bilyard, G.R., and S. Becker. 1987. Recommended protocols for sampling and analyzing subtidal benthic macroinvertebrate assemblages in Puget Sound. US EPA Washington. Contract No. 68-01-6938. 30 pp.

Boyd, J., Baumann, J., Hutton, K., Bertold, S., and B. Moore. 1998. Sediment Quality in Burrard Inlet Using Various Chemical and Biological Benchmarkers. Burrard Inlet Environmental Action Program. Burnaby, B.C., 37 pp.

Bryan, G.W., and P.E. Gibbs. 1987. Polychaetes as indicators of heavy-metal availability in marine deposits. Oceanic Processes in Marine Pollution. Malabar, Publ. Co. 1: 194–200.

Burd, B.J., and R.O. Brinkhust. 1990. Vancouver Harbour and Burrard Inlet Benthic Infaunal Sampling Program, October 1987. Canadian Technical Report of Hydrography and Ocean Sciences 122. 49 pp.

Clarke, K.R., and R.N. Green. 1988. Statistical design and analysis for a 'biological effects' study. Mar. Ecol. Prog. Ser. 46: 213–226.

IOC Workshop on the biological effects of pollutants. IOC Workshop Report No 53. Oslo, Norway, 1983. 53 pp.

Levings, C.D., Anderson, E.P., and G.W. O'Connell. 1985. Biological effects of dredged-material disposal in Alberni Inlet. Wastes in the Ocean. Malabar, Publ. 6. 131–155.

Long, E.R., MacDonald, D.D., Smith, S.L., and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environ. Management 19: 81–97.

Rygg, B. 1985a. Effects of sediment copper on benthic fauna. Mar. Ecol. Prog. Ser. 25: 83–89.

Rygg, B. 1985b. Distribution of species along pollution-induced diversity gradients in benthic communities in Norwegian Fjords. Mar. Pollut. Bull. 16: 469–474.

UNEP. 1995. Statistical analysis and interpretation of marine community data. Reference Methods for Marine Pollution Studies. UNEP No. 64.

UNESCO. 1988 Second IOC Workshop on the Biological Effects of Pollutants. Bermuda, 10 Sept.-2 Oct. 1988. IOC, UNESCO, Paris, 30 p.

Harmful algae survey in Vancouver Harbour

Tian YAN, Mingjiang Zhou, Jun Li, Rencheng Yu, Zhijun Tan and Fengyun Wang
Institute of Oceanology, Chinese Academy of Sciences, Qingdao, People's Republic of China. 266071

Introduction

As part of the work conducted during the Practical Workshop sponsored by the Marine Environmental Quality Committee of the North Pacific Marine Science Organization (PICES), a harmful algae survey was carried out, including shellfish PSP distribution, ARTOX test and cyst distribution. Samples were collected during May 23 to June 8, 1999, at 9 stations in Vancouver Harbour (Fig. 1).

Material and methods

Shellfish sample collection

Shellfish samples collected for algal toxin analysis at each station are shown in Table 1. About 500g of whole mussels *Mytilus trossuous* were collected at each intertidal sampling site. Clam samples were also obtained from some interdital beaches (*Ruditapes philippinarium*, *Venerupis staninea*) and from benthic trawling (*Clinocardium nuttallii*, *Yoldia sp*.). Samples were weighed and processed immediately after collection, and then frozen for later lyophilizing. After lyophilization, samples were weighed and then stored in the laboratory before analysis.

Mouse bioassay

The AOAC mouse bioassay method (AOAC 1990) for PSP was used in the investigation. Mice (strain ICR) were purchased from the Medical Inspection Institute of Qingdao. A dry sample (0.5g) was extracted with 3 ml 0.1N HCl, ultra-sonicated for 8 × 10 seconds, then centrifuged at 10,000 rpm for 10 minutes. 1 ml of supernant was used for mouse injection, and 1 ml 0.1N HCl was used as control. Purified STX at concentrations of 0.147 μg/ml and 0.294 μg/ml of STX (purchased from the National Research Council, Canada) were also tested. Symptoms exhibited by mice after injection were observed, and lethal time was recorded.

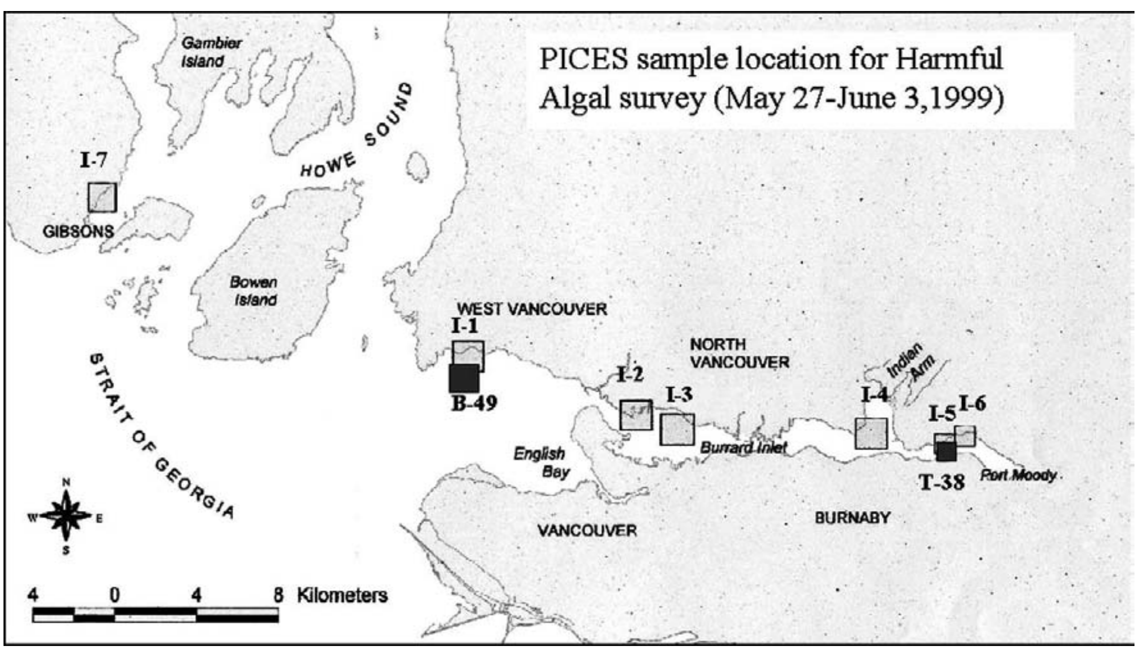


Fig. 1 Sampling sites in Vancouver Harbour.

Table 1. Shellfish sample number, collection station and collection time.

Sample No.	Site Time	I1 0527	B49 0527	I3A 0528	I5B 0529	I6 0529	T38 0529	I4 0530	I2A 0601	I7 0602
	Mytilus trossulos	1, 2		4, 5	6, 7	8, 9		14, 15	18, 19	20, 21
Intertital	*Ruditapes philippinarium*					10				
	Venerupis staninea							16, 17		
Benthic	*Clinocardium nuttallii*		3				11,12			
	Yoldia sp.						13			

Artemia Toxicity Test (ARTOX)

Several species of macroalgae were collected at each intertidal sampling site. Attached microalgal cells were scraped from macroalgae and concentrated for testing.

Artemia cysts were obtained from the *Artemia* Center in Belgium and kept at a low temperature (about 4°C) during transportation and storage. Hatching was initiated 2 days before experiments in Petri-dishes. 10 *Artemia* larvae at the second or third instar stage were transferred under a dissection microscope to 4 wells of the 6 × 4-well plates. Each well contained 1 ml of test algal culture. Each group consisted of three replicate wells and one rinsing well which was used to minimize dilution of the test solution during shrimp transfer. The *Artemia* were observed during the exposure at several-hour intervals and surviving *Artemia* were counted after 24 hours of incubation in the darkness. Seawater was used as a control in the *Artemia* test. Quality control tests were carried out using potassium dichromate $K_2Cr_2O_7$ as the positive control toxin according to the standardized protocol of the method.

Replicate sediment core samples were collected near sites I-7, I-3 and I-6 (Fig. 1). The surficial sediment of each core was incubated using phytoplankton growth medium and optimal light conditions for approximately 3 weeks. Sub-samples were collected every few days and preserved in Lugol's Solution. These samples will be analyzed for phytoplankton abundance and composition. The germination of potentially harmful phytoplankton will be documented.

Results

PSP analysis in shellfish samples

Wet and dry weight of shellfish samples collected from each station are shown in Table 2. Table 3 includes only intertidal samples. Only mussel samples were found to contain PSP. PSP was not determined in other shellfish samples, not even in shellfish collected from the sites which were very close to the site where PSP has been detected in mussel samples such as *Venerupis staninea* from site I-4 and *Clinocardium nuttallii* from site I-1. Table 4 shows that the PSP concentrations in mussels were all lower than eqv. STX 20 μg/100g ww, which is below the common limit of eqv. STX 80μg / 100g ww.

The results indicated that PSP was found only in mussels, and only in English Bay and Burrard Inlet, but not in Port Moody and Gibsons. The concentrations showed a decreasing trend from the West Vancouver to the east of Vancouver Harbour (Fig. 2).

Table 2. Wet and dry weight of shellfish collected.

Sample No.	Wet W.(g)	Dry W. (g)	W:D	Sample No.	Wet W. (g)	Dry W. (g)	W:D
1*	94.1	16.0	5.9	12	29.6	4.2	7.0
2*	83.4	14.5	5.8	13	5.3	0.9	5.9
3	20.5	3.0	6.8	14*	117.1	8.9	6.2
4*	103.6	17.5	5.9	15*	97.3	17.2	5.7
5*	89.5	14.8	6.0	16	98.3	16.1	6.1
6*	101.4	22.2	4.5	17	93.7	16	5.9
7*	106.5	26.0	4.0	18*	97.3	14.9	6.5
8*	78.3	16.5	4.7	19*	98.0	15.2	6.4
9*	76.5	15.7	4.9	20*	81.9	16.9	4.8
10	90.1	17.2	5.2	21*	56.7	11.3	5.0
11	117.7	18.9	8.1				

*mussel sample

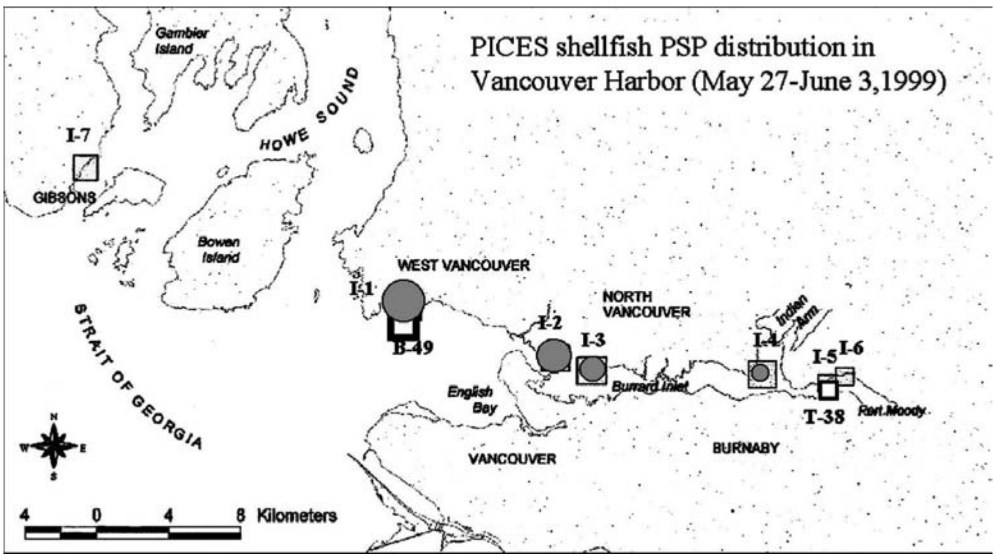


Fig. 2 Distribution of PSP in shellfish collected May 27-June 3, 1999, in Vancouver Harbour. The size of the dots indicates the concentration of PSP.

Table 3. Average lethal time of mouse injected with shellfish sample extraction.

Sample No.	Average lethal time (h)	Sample No.	Average lethal time (h)
1*	12	12	–
2*	1.5	13	–
3	–	14*	+(>24)
4*	12	15*	+(>24)
5*	24	16	–
6*	–	17	–
7*	–	18*	+(>24)
8*	–	19*	1.1
9*	–	20*	–
10	–	21*	–
11	–	Control	–

*mussel sample

Table 4. Determination of PSP concentration in shellfish samples using purified STX.

Sample	Average lethal time	PSP in extraction (eqv. STX μg/ml)	PSP in mussel (eqv. STX μg/100g ww)
STX 0.294μg /ml	9.5 min		
I 1 mussel	l 6.5h	0.15-0.2	15-20
I 2A mussel	12h	0.15-0.2	15-20
STX 0.147μg /ml	15h		
I 3A mussel	18h	<0.15	<15
I 4 mussel	+ >24h	<0.15	<15

+(>24h): showed classical PSP symptoms, such as paralyzed legs, slow but deep respiratory, twitching, trembling head, but survived after 24h.

Table 5. *Artemia* test results of samples from each station.

	Site Date	I 1 5.27	I 3A 5.28	I 5B 5.29	I 6 5.29	I 4 0530	I 2A 0601	I 7 0602
Artemia		–	+	–	–	–	–	–

+: swimming behavior of *Artemia* was inhibited and 24h LC50 of *Artemia* was about 50%.

Artemia test

Positive results of the sample from Longsdale Quay I-3A (Table 5) indicated that toxic algae such as *Heterosigma* or DSP producer *Prorocentrum lima* might be present in the water (Demaret *et al*. 1995). However, no toxicity was found from re-samples collected 4 days later.

Discussion

PSP contents and toxin profile will be further studied using HPLC. Cyst distribution work undertaken by T. Sutherland will be submitted once finished.

References

AOAC. 1990. Paralytic Shellfish Poison. Biological method. Final action[M]. *In* Official methods of analysis. *Edited by* K. Hellrich. 15th Edition. sec 959.08. Association of Official Methods of Analytical Chemists. Arlington. Virginia. USA. pp. 881–882.

Demaret A., Sohet, K., and G. Houvenaghel. 1995. Effects of toxic Dinoflagellates on the feeding and mortality of *Artemia franciscana* larvae[M]. *In* Harmful marine algal blooms. *Edited by* P. Lassns, G. Arzul, D.E. Erardle, P. Gentien, and C. Marciallou. Lavoisier, Paris. pp. 427–432.

Section IV – Comprehensive Data Tables

Table 1

Trawl and sediment collection locations for the PICES Vancouver Harbour Practical Workshop.

Investigators: Mr. Dan Lomax, Ms. Carla Stehr. Dr. Colin Levings

Date	Site	Site Name	Trawl #	Start Latitude Degrees	Start Latitude minutes	End Latitude Degrees	End Latitude minutes	Start Longitude Degrees	Start Longitude minutes	End Longitude Degrees	End Longitude minutes	Start Depth (feet)	Wire Out (meters)	End Depth (feet)	Duration (minutes)	Start Time	Notes	Tide	Area trawled (square meters)
5/27/99	T49	West Vancouver Lab	1	49	20.146	49	20.194	123	13.712	123	14.017	100	100	103	10	1017		slack	3734
5/27/99	T49	West Vancouver Lab	2	49	20.000	49	20.102	123	13.595	123	14.002	150	150	145	10	1054	cod-end opened	slack	5184
5/27/99	T49	West Vancouver Lab	3	49	19.932	49	20.056	123	13.353	123	14.051	150	150	145	8	1120		slack	8570
5/27/99	T49	West Vancouver Lab	4	49	20.125	49	20.212	123	13.474	123	14.040	100	100	110	10	1640		slack	6889
5/27/99	T49	West Vancouver Lab	5	49	20.125	49	20.232	123	13.480	123	14.084	100	100	110	10	1513		slack	7385
5/28/99	T11B	Lonsdale Quay	6	49	18.176	49	18.271	123	4.733	123	5.214	80	80	82	10	1115		flood	5960
5/28/99	T11B	Lonsdale Quay	7	49	18.118	49	18.241	123	4.577	123	5.107	80	80	80	10	1143		flood	6637
5/28/99	T11B	Lonsdale Quay	8	49	18.112	49	18.239	123	4.672	123	5.142	80	80	80	10	1211		flood	6010
5/29/99	T38	Port Moody	9	49	17.780	49	17.736	122	53.115	122	53.555	38	40	46	10	1034		ebb	5257
5/29/99	T38	Port Moody	10	49	17.830	49	17.760	122	53.230	122	53.490	37	40	45	5	1135		ebb	3321
5/29/99	T38	Port Moody	11	49	17.800	49	17.752	122	53.290	122	53.471	37	40	43	5	1215		slack	2308
5/30/99	T48	Indian Arm	12	49	18.013	49	18.130	122	56.811	122	56.620	87	100	100	5	1005		ebb	3154
5/30/99	T48	Indian Arm	13	49	17.970	49	18.175	122	56.810	122	56.420	85	100	101	10	1030		ebb	5930
5/30/99	T48	Indian Arm	14	49	17.945	49	18.165	122	56.780	122	56.390	85	100	101	10	1102		ebb	6140
6/1/99	T11B	Lonsdale Quay	15	49	18.180	49	18.120	123	5.032	123	4.620	85	85	80	10	1015		flood	5035
6/2/99	T50	Gibsons Howe Sound	16	49	24.370	49	24.300	123	29.660	123	29.740	225	250	240	7	1111		ebb	1643
6/2/99	T50	Gibsons Howe Sound	17	49	24.369	49	24.632	123	29.662	123	29.368	225	250	235	10	1142		ebb	5838
6/2/99	T50	Gibsons Howe Sound	18	49	24.428	49	24.603	123	29.673	123	29.488	180	190	200	5	1220	broke off net	ebb	3942
6/2/99	T50	Gibsons Howe Sound	19	49	24.498	49	24.671	123	29.541	123	29.254	230	240	240	8	1305		ebb	4650
6/3/99	T49	West Vancouver Lab	20	49	20.152	49	20.240	123	13.598	123	14.180	100	100	100	10	936		flood	7072
6/3/99	T49	West Vancouver Lab	21	49	20.239	49	20.190	123	13.991	123	13.602	100	100	100	7	1014		flood	4709
5/28/99	B49	West Vancouver Lab	sediment	49	20.128			123	13.946										
5/29/99	B11B	Lonsdale Quay	sediment	49	18.185			123	4.902										
5/30/99	B38	Port Moody	sediment	49	17.755			122	53.312										
5/30/99	B41B	IOCO	sediment	49	17.946			122	52.683										
5/31/99	B48	Indian Arm	sediment	49	18.046			122	56.630										
6/2/99	B3A	Sulfur Dock	sediment	49	18.550			123	6.720										
6/3/99	B50	Gibsons	sediment	49	24.582			123	29.612										

Table 2

Intertidal site locations for Vancouver Harbour Practical Workshop.

Investigator: Dr. Toshihiro Horiguchi

Site Name	Site Number	Date Collected	Comments
West Vancouver Lab	I1	5/27/99	
Sulfur Dock	I2	6/1/99	Site I2A same as site I2
Lonsdale	I3A	5/28/99	Lonsdale Quay
Burrard Narrows	I3B	5/28/99	At Dry Dock near I-3A
Neptune Terminals	I3C	5/28/99	at pilings of Neptune Terminal
Indian Arm (Cates Park east)	I4A	5/30/99	east side of pier located in Cates Park, same as site I-4
Indian Arm (Cates Park west)	I4B	5/30/99	west side of Pier located in Cates Park
IOCO	I5A	5/29/99	no molluscs collected
IOCO	I5B	5/29/99	at pilings of a pier near an oil refinery, also called site I-5
Port Moody	I6	5/29/99	
Gibsons (Howe Sound)	I7	6/2/99	
Mission Point (Schelt)		6/2/99	Gastropods collected for imposex study
Ogden Point (Victoria)		5/31/99	Gastropods collected for imposex study
Clover Point (Victoria)		5/31/99	Gastropods collected for imposex study
Ten Mile Point (Victoria)		5/31/99	Gastropods collected for imposex study

Table 3

Sediment Grain Size.

Investigators: Dr. Jong Jeel Je, Dr. Colin Levings

Site	Core Number	Depth In Core*	Gravel	Sand	Silt	Clay	Sediment Type**	mm	MZ(Phi)	Standard Deviation	Skewness	Kurtosis
B3A	5	1		10.45	48.33	41.23	sM	0.0039	7.53	2.73	-0.02	2.11
B3A	5	2		7.12	45.55	47.33	M	0.0039	7.95	2.77	-0.20	2.16
B3A	5	3	1.07	12.08	41.34	45.50	(g)sM	0.0039	7.58	3.13	-0.50	2.78
B3A	5	4	21.24	11.23	31.80	35.72	sM	0.0156	5.50	4.95	-0.44	1.90
B3A	5	5	1.37	16.63	37.96	44.03	(g)sM	0.0078	7.38	3.32	-0.36	2.35
B3A	5	6		22.76	32.41	44.83	sM	0.0078	7.44	3.36	-0.08	1.59
B3A	5	7	0.67	33.22	33.56	32.55	(g)sM	0.0156	6.37	3.42	0.19	1.88
B11	5	1		55.81	20.62	23.57	mS	0.0031	5.28	3.40	0.83	2.18
B11	5	2		57.89	20.06	22.05	mS	0.0031	5.15	3.29	0.90	2.36
B11	5	3		58.28	21.27	20.45	mS	0.0031	4.99	3.24	0.95	2.49
B11	5	4		59.33	18.81	21.85	mS	0.0031	5.08	3.35	0.94	2.39
B11	5	5		61.45	17.45	21.09	mS	0.0031	4.97	3.34	1.01	2.51
B11	5	6		62.74	18.40	18.86	mS	0.0031	4.82	3.19	1.09	2.77
B11	5	7		57.40	19.88	22.72	mS	0.0031	5.17	3.32	0.85	2.28
B38	1	1		2.97	40.25	56.78	M	0.0020	8.83	2.49	-0.26	1.75
B38	1	2		3.36	51.54	45.10	M	0.0039	7.86	2.57	0.07	1.89
B38	1	3		3.78	40.76	55.46	M	0.0020	8.64	2.49	-0.23	1.85
B38	1	4		2.86	44.13	53.02	M	0.0020	8.52	2.44	-0.10	1.82
B38	1	5		3.58	44.18	52.24	M	0.0020	8.49	2.44	-0.09	1.85
B38	1	6		3.56	45.06	51.38	M	0.0020	8.43	2.40	-0.04	1.88
B38	1	7		2.63	43.34	54.03	M	0.0020	8.57	2.41	-0.10	1.82
B41B	1	1		3.32	35.22	61.46	M	0.0020	8.92	2.33	-0.35	2.10
B41B	1	2		2.75	34.12	63.14	M	0.0020	9.03	2.30	-0.38	2.10
B41B	1	3		3.50	33.57	62.94	M	0.0020	9.02	2.37	-0.43	2.11
B41B	1	4		3.09	33.51	63.40	M	0.0020	9.11	2.37	-0.46	2.05
B41B	1	5		3.09	35.05	61.86	M	0.0020	8.96	2.37	-0.38	2.05
B41B	1	6		2.47	32.72	64.81	M	0.0020	9.14	2.32	-0.46	2.08
B41B	1	7		2.33	33.46	64.20	M	0.0020	9.14	2.29	-0.41	2.02
B48	1	1		40.81	30.92	28.27	sM	0.0016	6.14	3.21	0.66	1.93
B48	1	2		40.55	30.25	29.20	sM	0.0016	6.22	3.25	0.61	1.85
B48	1	3		43.38	29.71	26.91	sM	0.0016	5.99	3.18	0.71	2.02
B48	1	4		46.19	28.81	25.00	sM	0.0016	5.78	3.20	0.79	2.17
B48	1	5		39.45	35.66	24.89	sM	0.0016	5.94	3.01	0.72	2.21
B48	1	6		39.29	35.57	25.14	sM	0.0016	5.93	3.00	0.76	2.22
B48	1	7		46.06	31.78	22.16	sM	0.0016	5.64	3.01	0.91	2.49
B49	1	1		7.25	46.81	45.93	M	0.0039	7.95	2.64	0.01	1.82
B49	1	2		7.47	45.64	46.89	M	0.0039	8.07	2.64	-0.06	1.90
B49	1	3		7.63	49.05	43.32	M	0.0039	7.90	2.57	0.05	1.99
B49	1	4		11.11	43.64	45.25	sM	0.0039	7.91	2.85	-0.13	1.92
B49	1	5		2.72	48.19	49.09	M	0.0039	8.30	2.48	-0.03	1.91
B49	1	6		7.77	43.52	48.70	M	0.0039	8.24	2.76	-0.11	1.68
B50	4	1		96.80	3.20		S	0.2500	1.97	0.95	0.53	3.27
B50	4	2		97.43	2.57		S	0.2500	1.97	0.92	0.52	3.36
B50	4	3		96.87	3.13		S	0.2500	2.07	0.94	0.47	3.06
B50	4	4		97.06	2.94		S	0.2500	1.96	0.94	0.51	3.38
B50	4	5		97.24	2.76		S	0.2500	1.93	0.94	0.58	3.34
B50	4	6		97.30	2.70		S	0.2500	1.97	0.90	0.57	3.50
B50	4	7		97.29	2.71		S	0.2500	1.99	0.93	0.50	3.28

sM = Sandy mud; M = Mud; (g)sM = sandy mud with gravel; mS = muddy sand; S = Sand.

* each number represents 1 cm of sediment in the core. For instance, 1 = sediment from surface to 1 cm in depth, 2 = sediment 1-2 cm deep, 3= sediment 2-3 cm deep, etc.

**sediment type according to Folk, R.L., 1974. The Petrology of sedimentary rocks. Austin, Tex., USA, Hemphill Publishing, Co. 182p.

Table 4

Total organic carbon in sediment.

Investigator: Ms. Carla Stehr (analyses done by Columbia Analytical Services, Inc.)

Site	Matrix	Basis	Units	Result
B49	Sediment	Dry	PERCENT	2.04
B41B	Sediment	Dry	PERCENT	4.36
B3A	Sediment	Dry	PERCENT	3.96
B50	Sediment	Dry	PERCENT	0.20
B11B	Sediment	Dry	PERCENT	1.99
B38	Sediment	Dry	PERCENT	3.69
B48	Sediment	Dry	PERCENT	2.69
Method Blank	Sediment	Dry	PERCENT	ND

ND= not detected

One composite sample was analyzed for each site. Three sediment grabs were collected at each site, and equal amounts of sediment from each grab were combined for the composite sample.

Table 5

Polycyclic aromatic hydrocarbons in sediment from Vancouver Harbour (ng/g, dry weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

Site	B3-A	B41-B	T11-B	T38	T48	T49	T50
Location	Sulfur Dock	Pt. Moody IOCO	Lonsdale Quay	Port Moody	Indian Arm	West Van Lab	Howe Sound
Dry Weight (%)	44.5%	24.0%	43.7%	28.4%	42.8%	42.0%	78.9%
naphthalene	200	260	64	440	200	62	bd
2-methylnaphthalene	110	170	94	150	120	61	bd
1-methylnaphthalene	66	95	51	82	65	43	bd
biphenyl	48	77	27	73	42	20	bd
2,5-dimethylnaphthalene	71	130	71	110	89	42	bd
acenaphthylene	19	56	10	120	39	12	bd
acenaphthene	170	37	41	37	43	20	bd
2,3,5-trimethylnaphthalene	26	43	17	39	20	25	bd
fluorene	150	88	53	74	69	42	bd
dibenzothiophene	45	29	18	27	23	12	68
phenanathrene	810	430	350	530	500	240	2.1
anthracene	360	140	90	140	110	62	bd
1-methylphenanathrene	94	75	59	76	75	43	bd
fluoranthene	1900	690	550	820	1000	340	8.6
pyrene	1700	970	550	1000	920	350	6
benz[a]anthracene	780	250	280	250	290	170	2
chrysene + triphenylene	1100	480	330	370	480	230	3.9
benzo[b]fluoranthene	710	410	300	360	460	170	2.3
benzo[j+k]fluoranthene	630	310	260	310	350	150	1.8
benzo[e]pyrene	490	350	230	320	330	140	1.7
benzo[a]pyrene	600	300	300	300	350	170	1.6
perylene	170	150	110	130	110	81	1.6
indeno[1,2,3-c,d]pyrene	340	220	210	230	240	110	bd
dibenz[a,h]anthacene	64	46	43	41	52	23	bd
benzo[g,h,i]perylene	340	270	210	290	260	130	bd
LMWAH	2200	1600	950	1900	1400	690	70
HMWAH	8800	4400	3400	4500	4800	2000	29

Table 5

Polycyclic aromatic hydrocarbons in sediment from Vancouver Harbour (ng/g, dry weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

bd = below detection limits. Dectection limits vary depending on the analyte and sample weight. If detection limits are needed, please contact Carla Stehr at carla.m.stehr@noaa.gov

LMWAH = Low molecular weight aromatic hydrocarbons = naphthalene + 2-methylnaphthalene +1-methylnaphthalene + biphenyl + 2,6-dimethylnaphthalene + acenaphthylene + acenaphthene + 2,3,5-trimethylnaphthalene + fluorene + dibenzothlophene + phenanthrene + anthracene + 1-methylphenanthrene.

HMWAH = high molecular weight aromatic hydrocarbons = fluoranthene + pyrene + benz[a]anthracene + chrysene + triphenylene + benzo[b]fluoranthene + benzo[j]fluoranthene + benzo[k]fluoranthene + benzo[e]pyrene + benzo[a]pyrene + perylene + indeno[1,2,3-cd]pyrene + dibenz[a,h]anthracene + dibenz[a,c]anthracene + benzo[ghl]perylene.

Chrysene is not resolved from triphenylene using our gas chromatographic procedure. In addition, the compounds have very similar mass spectra, therefore we report their combined concentrations as Chrysene. Benzo[k]fluoranthene is not resolved from benzo[j]fluoranthene using our gas chromatographic procedure. In addition, the compounds have very similar mass spectra, therefore we report their combined concentrations as Benzo[k]fluoranthene. Dibenz[a,h]anthracene is not resolved from dibenz[a,c]anthracene using our gas chromatographic procedure. In addition, the compounds have very similar mass spectra, therefore we report their combined concentrations as Dibenz[a,h]anthracene.

Each value represents the data from the analysis of one sample. Three grabs were made at each site. Equal amounts of sediment from each grab were combined into a single sample (composite) and analyzed.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/mass spectrometry using scan mode.

all analytes are reported as if two figures are significant

Table 6

Quality assurance data for polycyclic aromatic hydrocarbons in sediment (ng/g dry weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

Sample #	100-1998	100-1999	100-2000	100-2006	100-2007	100-2008
SampleType	SRM 1941a	SRM 1941a	Method Blank	SRM 1941a	SRM 1941a	Method Blank
Sample Weight (g)	2.81	2.16	10.35	2.07	2.45	10.43
Dry Wt (%)	49.7	49.7	36.8	50.0	50.2	48.5
naphthalene	1100	1100	bd	1100	1100	bd
2-methylnaphthalene	360	360	bd	350	360	bd
1-methylnaphthalene	200	200	bd	200	200	bd
biphenyl	100	100	bd	110	110	bd
2,5-dimethylnaphthalene	180	170	bd	180	180	bd
acenaphthylene	59	53	bd	56	60	bd
acenaphthene	53	45	bd	43	50	bd
2,3,5-trimethylnaphthalene	72	91	bd	58	74	bd
fluorene	97	98	bd	94	110	bd
dibenzothiophene	55	54	bd	54	56	bd
phenanathrene	640	620	bd	600	620	bd
anthracene	220	220	bd	230	220	bd
1-methylphenanathrene	120	120	bd	110	110	bd
fluoranthene	1300	1300	bd	1200	1200	bd
pyrene	1100	1000	bd	980	1000	bd
benz[a]anthracene	570	530	bd	510	540	bd
chrysene + triphenylene	760	730	bd	720	750	bd
benzo[b]fluoranthene	920	870	bd	880	930	bd
benzo[j+k]fluoranthene	780	740	bd	720	720	bd
benzo[e]pyrene	700	630	bd	680	680	bd
benzo[a]pyrene	700	650	bd	650	680	bd
perylene	450	440	bd	440	450	bd
indeno[1,2,3-c,d]pyrene	610	540	bd	570	590	bd
dibenz[a,h]anthacene	110	100	bd	120	120	bd
benzo[g,h,i]perylene	620	600	bd	570	620	bd
LMWAHs	3300	3200	bd	3200	3200	bd
HMWAHs	8500	8100	bd	8000	8300	bd

nd = below detection limits. Detection limits vary depending on the analyte and sample weight. If detection limit data is needed, please contact Carla Stehr at carla.m.stehr@noaa.gov.

LMWAH = Low molecular weight aromatic hydrocarbons = naphthalene + 2-methylnaphthalene +1-methylnaphthalene + biphenyl + 2,6-dimethylnaphthalene + acenaphthylene + acenaphthene + 2,3,5-trimethylnaphthalene + fluorene + dibenzothlophene + phenanthrene + anthracene + 1-methylphenanthrene.

HMWAH = high molecular weight aromatic hydrocarbons = fluoranthene + pyrene + benz[a]anthracene + chrysene + triphenylene + benzo[b]fluoranthene +benzo[j]fluoranthene + benzo[k]fluoranthene + benzo[e]pyrene + benzo[a]pyrene + perylene + indeno[1,2,3-cd]pyrene + dibenz[a,h]anthracene + dibenz[a,c]anthracene + benzo[ghl]perylene.

Chrysene is not resolved from triphenylene using our gas chromatographic procedure. In addition, the compounds have very similar mass spectra, therefore we report their combined concentrations as Chrysene. Benzo[k]fluoranthene is not resolved from benzo[j]fluoranthene using our gas chromatographic procedure. In addition, the compounds have very similar mass spectra, therefore we report their combined concentrations as Benzo[k]fluoranthene. Dibenz[a,h]anthracene is not resolved from dibenz[a,c]anthracene using our gas chromatographic procedure. In addition, the compounds have very similar mass spectra, therefore we report their combined concentrations as Dibenz[a,h]anthracene

Table 6

Quality assurance data for polycyclic aromatic hydrocarbons in sediment (ng/g dry weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

The sample weight used to calculate concentrations for the method blank is the mean sample weight calculated for the field samples in the same set.

The concentrations of naphthalene, 2-methylnaphthalene, and 1-methylnaphthalene were calculated using naphthalene-d8 as the surrogate standard; biphenyl, 2,6-dimethynaphthalene, acenaphthylene, acenaphthene, 2,3,6-trimethylnaphthalene, fluorene, dibenzothiophene, phenanthrene, anthracene, 1-methylphenanthrene, fluoranthene and pyrene were calculated using acenaphthene-d10 as the surrogate standard; benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[a]pyrene, perylene, indenopyrene, dibenz[g,h,i]perylene were calculated using benzo[a]pyrene-d12 as the surrogate standard.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/mass spectrometry using scan mode.

All analytes are reported as if two figures are significant.

Table 7

PCB (chlorobiphenyl) congeners in sediment from Vancouver Harbour (ng/g dry weight).

Investigators: Ms. Jennie Bolton and Ms. Carla Stehr

Site	B3-A	B41-B	T11-B	T38	T48	T49	T50
Location	Sulfur Dock	Port Moody IOCO	Lonsdale Quay	Port Moody	Indian Arm	West Van Lab.	Gibsons Howe Sound
Congener #							
28	0.48	0.96	bd	bd	1.5	0.56	bd
44	bd	bd	bd	bd	0.74	0.44	bd
52	bd	bd	bd	2.1	4.7	bd	bd
66	0.62	0.73	bd	bd	0.96	bd	bd
101	1.6	1.5	bd	1.9	2.7	0.37	bd
105	0.31	0.52	bd	bd	0.51	bd	bd
118	0.36	1.2	0.48	1.3	1.4	0.42	bd
128	0.37	0.5	bd	bd	0.54	0.22	bd
138/163/164	1.6	2.8	0.99	3.4	2.8	0.73	bd
153	1.9	3.4	1.3	3	2.4	0.95	bd
170/190	0.63	1	bd	1.1	0.65	0.37	bd
187	1.6	3.2	1.2	4.2	3.8	0.49	bd
195	0.83	0.67	bd	bd	0.65	0.19	bd
206	bd	bd	bd	bd	bd	bd	bd
209	1.4	0.97	bd	bd	0.48	bd	bd
Total PCBs	23	35	7.8	34	48	9.5	bd

bd = below detection limits. Detection limits vary depending on the analyte and sample weight. If detection limit data is needed, please contact Carla Stehr at carla.m.stehr@noaa.gov.

CB Numbers refer to PCB congeners as identified by the IUPAC (International Union of Pure and Applied Chemistry) number.

*PCBs 101 and 90 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "101". PCBs 138,163, and 164 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "138/163/164". PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153". PBCs 170 and 190 are not resolved by our gas chromatographic methods, therefore we report their combined concentrations as "170/190".

The concentrations of analytes were calculated using CB103 as the surrogate standard.

The concentrations reported for "Total PCBs" is an estimate of the total PCB concentration, obtained by taking the sum of the concentrations of 17 selected congeners (CBs 18, 28, 44, 52, 95, 101, 105, 118, 128, 138, 153, 170, 180, 187,195, 206, and 209), and multiplying by 2.

Each value represents the data from the analysis of one sample. Three grabs were made at each site. Equal amounts of sediment from each grab were combined into a single sample (composite) and analyzed.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/electron capture detection.

Table 8

Chlorinated pesticides in sediment from Vancouver Harbour (ng/g, dry weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

Site	B3-A	B41-B	T11-B	T38	T48	T49	T50
Location	Sulfur Dock	Port Moody IOCO	Londsdale Quay	Port Moody	Indian Arm	West Van. Lab	Gibsons Howe Sound
***cis*- chlordane**	0.17	bd	bd	bd	bd	bd	bd
***trans* -chlordane**	bd	bd	bd	bd	0.36	bd	bd
heptachlor	bd	bd	bd	bd	bd	bd	bd
heptachlor epoxid	bd	bd	bd	bd	bd	bd	bd
oxychlordane	bd	bd	bd	bd	bd	bd	bd
***trans* -nonachlor**	0.13	bd	bd	bd	bd	bd	bd
***cis* -nonachlor**	bd	bd	bd	bd	bd	bd	bd
HCB	0.21	0.44	bd	0.51	2.5	0.17	bd
γ-HCH	0.18	0.57	bd	bd	bd	bd	bd
aldrin	bd	bd	bd	bd	bd	bd	bd
dieldrin	bd	0.49	bd	0.77	0.32	bd	bd
mirex	bd	bd	bd	bd	bd	bd	bd
o,p'-DDD	bd	bd	bd	bd	bd	bd	bd
o,p'-DDE	bd	bd	bd	bd	bd	bd	bd
o,p'-DDT	bd	bd	bd	bd	bd	bd	bd
p,p'-DDD	0.76	2	0.76	2	1.3	0.55	bd
p,p'-DDE	0.29	0.52	bd	bd	0.37	0.26	bd
p,p'-DDT	bd	bd	bd	bd	bd	bd	bd

bd = below detection limits. Detection limits vary depending on the analyte and sample weight. If detection limit data is needed, please contact Carla Stehr at carla.m.stehr@noaa.gov.

HCB = hexachlorobenzene; γ-HCH = gamma-hexachlorocyclohexane

Each value represents the data from the analysis of one sample. Three grabs were made at each site.
Equal amounts of sediment from each grab were combined into a single sample (composite) and analyzed.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/electron capture detection.

Table 9

Quality assurance data for chlorinated hydrocarbon analyses of sediment (ng/g dry weight).

Investigators: Ms. Jennie Bolton and Ms. Carla Stehr

Sample	100-1998	100-1999	100-2000	100-2006	100-2007	100-2008
Sample Type	SRM 1941a	SRM 1941a	Method Blank	SRM 1941a	SRM 1941a	Method Blank
Sample wt (g)	2.81	2.16	10.35	2.07	2.45	10.43
Dry wt (g)	49.70	49.73	36.83	49.97	50.19	48.45
CB18	NR	NR	bd	NR	NR	bd
CB28	8.4	9.7	bd	8.4	8.3	bd
CB44	6.5	6.7	1	5.5	5.3	bd
CB52	10	12	bd	11	10	bd
CB66	9.2	10	bd	9.5	9.2	bd
CB101	17	19	bd	17	17	bd
CB105	2	2.5	bd	3.2	3.2	bd
CB118	8.3	9.5	bd	8.1	8.6	bd
CB128	1.7	2	bd	1.9	1.9	bd
CB138	14	16	bd	16	15	bd
CB153	17	19	bd	20	19	bd
CB170	4.2	4.6	bd	4.3	4	bd
CB180	NR	NR	bd	NR	NR	bd
CB187	13	13	bd	14	14	bd
CB195	2.4	2.4	bd	2.7	2.6	bd
CB206	4	4.3	bd	4.6	4.6	bd
CB209	10	11	bd	12	12	bd
PCB Est. total	260	280	2	280	270	0
***cis* -chlordane**	1.8	2.1	bd	2.1	2	bd
***trans* –chlordane**	2.3	2.3	bd	2.4	2.3	bd
oxychlordane	bd	bd	bd	bd	bd	bd
heptachlor	bd	bd	bd	bd	bd	bd
heptachlor epoxide	bd	bd	bd	bd	bd	bd
***cis* -nonachlor**	0.53	0.87	bd	bd	1.1	bd
***trans* -nonachlor**	0.56	0.76	bd	0.91	0.93	bd
hexachlorobenzene	71	75	bd	74	72	bd
lindane (γ-HCH)	1.4	1.4	bd	1.3	1.3	bd
aldrin	bd	bd	1.4	bd	bd	0.96
dieldrin	2.1	2.1	bd	2.1	2.1	bd
mirex	bd	bd	0.29	bd	bd	bd
o,p'-DDD	bd	bd	bd	bd	bd	bd
o,p'-DDE	0.83	0.81	bd	bd	bd	bd
o,p'-DDT	bd	bd	bd	bd	bd	bd
p,p'-DDD	5.7	6.3	bd	6.6	6.7	bd
p,p'-DDE	4.3	4.6	bd	4.4	4.2	bd
p,p'-DDT	bd	bd	bd	bd	bd	bd

SRM = standard reference material

bd = below detection limits. Detection limits vary depending on the analyte and sample weight. If detection limit data is needed, please contact Carla Stehr at Carla.m.stehr@noaa.gov.

NR = the concentrations of these analytes could not be reported, due to an analytical interference.

Table 9

Quality assurance data for chlorinated hydrocarbon analyses of sediment (ng/g dry weight).

Investigators: Ms. Jennie Bolton and Ms. Carla Stehr

CB Numbers refer to PCB congeners as identified by the IUPAC (International Union of Pure and Applied Chemistry) number.

lindane is the same as γ-HCH; γ-HCH =gamma-hexachlordane;

*PCBs 101 and 90 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "101". PCBs 138,163, and 164 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "138". PCBs 153 and 132 are not resolved by our gas chromatographic procedure, therefore we report their combined concentrations as "153". PBCs 170 and 190 are not resolved by our gas chromatographic methods, therefore we report their combined concentrations as "170".

The concentrations of analytes were calculated using CB103 as the surrogate standard.

The concentrations reported for "PCBs Est. Total" is an estimate of the total PCB concentration, obtained by taking the sum of the concentrations of 17 selected congeners (CBs 18, 28, 44, 52, 95, 101, 105, 118, 128, 138, 153, 170, 180, 187, 195, 206, and 209), and multiplying by 2.

The sample weight used to calculate analyte concentrations for method and field blanks is the mean sample weight of all field samples (excluding field blanks) in the same sample set.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/electron capture detection.

Table 10
Metals in sediment (dry weight).
Investigators: Dr. Alexander Tkalin and Dr. Tatiana Lishavskaya

Sample	Site	Al	Cu	Co	Cr	Ni	Cd	Pb	Zn	Mn	Fe	Laboratory
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	
1B49	B49	65000	180.0	13.0	57.5	38.0	0.3	27.5	138	500	4.4	TINRO-Centre
2B49	B49	65000	167.5	13.0	62.5	21.0	0.3	27.5	140	500	4.4	TINRO-Centre
3B49	B49	65000	170.0	13.0	65.0	43.0	0.4	27.5	138	500	4.3	TINRO-Centre
1B11B	B11B	65000	132.5	11.0	42.5	27.5	0.5	30.0	125	500	3.8	TINRO-Centre
2B11B	B11B	65000	125.0	12.5	47.5	29.0	0.5	32.5	130	520	3.9	TINRO-Centre
3B11B	B11B	65000	112.5	12.0	47.5	24.0	0.4	25.0	120	510	3.7	TINRO-Centre
1B38	B 38	62500	127.5	12.5	55.0	30.0	0.8	62.5	165	450	4.1	TINRO-Centre
2B38	B 38	65000	127.5	12.0	57.5	27.0	0.6	65.0	170	450	4.1	TINRO-Centre
3B38	B 38	60000	125.5	11.5	57.5	30.0	0.8	70.0	165	420	4.2	TINRO-Centre
1B41B	B41B	60000	105.0	11.5	65.0	29.5	0.9	70.0	165	450	3.9	TINRO-Centre
2B41B	B41B	57500	105.0	9.5	65.0	30.0	1.2	67.5	165	450	3.7	TINRO-Centre
3B41B	B41B	60000	105.0	10.0	75.0	30.0	1.1	75.0	165	450	4.0	TINRO-Centre
1B3A	B3A	67500	400.0	13.0	50.0	30.0	1.2	77.5	375	560	3.8	TINRO-Centre
2B3A	B3A	70000	300.0	12.0	52.5	31.0	1.1	85.0	420	575	3.8	TINRO-Centre
3B3A	B3A	70000	300.0	12.0	50.0	21.5	1.2	65.0	425	625	3.8	TINRO-Centre
1B48	B48	65000	100.0	9.0	45.0	19.5	0.5	30.0	100	625	3.6	TINRO-Centre
2B48	B48	65000	95.0	9.0	47.5	19.5	0.6	30.0	130	525	3.7	TINRO-Centre
3B48	B48	62500	135.0	10.0	50.0	20.0	0.6	35.0	130	576	3.7	TINRO-Centre
1B50	B50	70000	10.0	7.5	25.0	11.5	0.2	4.0	33	450	2.4	TINRO-Centre
2B50	B50	70000	12.5	7.5	25.0	11.0	0.2	4.0	40	425	2.2	TINRO-Centre
3B50	B50	70000	10.0	7.5	25.0	11.5	0.2	4.0	33	425	2.3	TINRO-Centre
1B49	B49		168.5			49.0		38.1	139	493	4.14	PGI RAS
2B49	B49		162.1			50.5		38.2	133	491	4.15	PGI RAS
3B49	B49		164.8			50.7		38.1	143	481	3.98	PGI RAS
1B11B	B11B		116.7			40.1		33.1	133	502	3.48	PGI RAS
2B11B	B11B		121.5			36.1		39.7	126	503	3.48	PGI RAS
3B11B	B11B		110.7			31.1		39.7	129	488	3.31	PGI RAS
1B38	B38		116.9			43.2		63.1	156	432	3.99	PGI RAS
2B38	B38		118.2			40.1		66.2	159	431	3.97	PGI RAS
3B38	B38		117.4			40.3		69.4	159	431	3.97	PGI RAS
1B41B	B41B		102.4			38.8		66.2	156	403	3.64	PGI RAS
2B41B	B41B		95.5			36.4		69.4	152	386	3.47	PGI RAS
3B41B	B41B		97.3			38.2		69.7	156	388	3.49	PGI RAS
1B3A	B3A		550.1			46.5		83.0	432	529	3.82	PGI RAS
2B3A	B3A		533.5			41.1		92.8	398	511	3.60	PGI RAS
3B3A	B3A		533.5			41.1		92.0	432	529	3.82	PGI RAS
1B48	B48		92.7			30.6		34.9	123	534	3.49	PGI RAS
2B48	B48		87.6			29.5		34.8	126	519	3.32	PGI RAS
3B48	B48		106.6			33.0		42.9	129	497	3.14	PGI RAS
1B50	B50		11.3			22.9		6.6	40	459	2.49	PGI RAS
2B50	B50		11.9			22.5		6.6	40	397	2.15	PGI RAS
3B50	B50		10.9			19.5		13.2	40	408	2.15	PGI RAS
1B49	B49		179.0	16.0	2.1	39.0			131	520	3.7	POI FEB RAS
2B49	B49		138.0	14.5	2.4	36.0			122	470	3.5	POI FEB RAS
3B49	B49		154.0	12.0	2.6	38.0			111	483	2.6	POI FEB RAS
1B11B	B11B		76.0	11.5	2.2	32.0			91	379	2.1	POI FEB RAS
2B11B	B11B		100.0	14.0	2.2	31.0			106	431	2.9	POI FEB RAS
3B11B	B11B		84.0	13.5	1.6	28.0			76	477	1.9	POI FEB RAS
1B38	B38		100.0	12.0	2.2	31.0			133	392	2.4	POI FEB RAS
2B38	B38		73.0	12.0	1.7	30.0			104	340	2.3	POI FEB RAS
3B38	B38		105.0	11.5	2.9	34.0			123	379	2.5	POI FEB RAS
1B41B	B41B		74.0	10.0	3.4	31.0			114	340	2.1	POI FEB RAS
2B41B	B41B		74.0	10.0	2.2	31.0			110	366	2.1	POI FEB RAS
3B41B	B41B		72.0	9.8	3.0	27.0			89	287	2.6	POI FEB RAS
1B3A	B3A		296.0	10.5	2.1	28.0			174	392	1.7	POI FEB RAS
2B3A	B3A		330.0	10.5	2.1	24.0			199	431	2.3	POI FEB RAS
3B3A	B3A		432.0	12.0	3.2	33.0			313	549	3.1	POI FEB RAS
1B48	B48		78.0	11.0	1.8	30.0			93	477	1.9	POI FEB RAS
2B48	B48		63.0	11.5	2.2	31.0			89	520	1.9	POI FEB RAS
3B48	B48		49.0	11.0	1.8	25.0			59	327	1.8	POI FEB RAS
1B50	B50		12.0	9.8	1.3	20.0			46	455	1.7	POI FEB RAS
2B50	B50		9.0	11.0	1.9	30.0			42	418	1.6	POI FEB RAS
3B50	B50		7.0	11.0	1.8	28.0			34	346	1.5	POI FEB RAS

TINRO-Centre = Pacific Research Centre of Fisheries and Oceanography , Vladivostok, Russia
PGI FEB RAS = Pacific Geographical Institute, Far East Branch, Russian Academy of Sciences, Vladivostok, Russia
POI FEB RAS = Pacific Oceanological Institute, Far East Branch, Russian Academy of Sciences, Vladivostok, Russia

Each value is an analysis of one sediment grab. Three sediment grabs were collected at each site.

Table 11

PCB (chlorobiphenyl) congeners (IUPAC) in liver of English sole from Vancouver Harbour (ng/g, wet weight).

Investigators: Ms. Jennie Bolton and Ms. Carla Stehr

Site	T11B			T38			T48			T49			T50		
Location	Lonsdale Quay			Port Moody			Indian Arm			West Vancouver Lab			Gibsons, Howe Sound		
Fish ID	990046-050	990051-055	990056-060	990076-080	990081-085	990086-090	990106-110	990106-110	990116-120	990016-020	990021-025	990026-030	990136-140	990141-145	990146-150
Composite #	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Sample wt (g)	1.71	2.4	1.93	3.47	3.54	2.53	2.13	2.36	2.21	2.56	2.78	3.07	1.91	1.81	1.6
Congener #															
17	bd	0.36	bd	0.42	0.68	0.61	0.42	0.43	0.47	bd	bd	bd	bd	bd	bd
18	0.91	0.94	0.91	0.54	0.59	0.65	0.81	0.78	0.88	bd	0.58	0.53	bd	bd	bd
28	1.8	1.6	1.5	0.98	1.6	1.1	1.7	1.9	2.5	0.71	0.78	0.7	bd	1	bd
31	1.2	1.3	1.1	0.69	0.98	0.79	1.1	1.2	1.5	0.61	0.59	0.6	0.68	0.74	0.79
33	0.91	0.91	0.88	0.49	0.5	0.49	0.79	0.69	0.8	bd	0.56	0.54	bd	bd	bd
44	1.5	0.98	1.1	0.99	1.4	0.99	1.6	1.7	2.1	0.56	0.56	0.55	bd	bd	bd
49	3.7	2.3	2.7	1.6	4.4	2	2.9	4.4	6.7	0.65	0.93	0.92	1.1	1.3	bd
52	5.3	3.6	4.3	2.6	6.8	2.8	4.5	6.7	10	0.93	1.4	1.4	1.4	1.6	1.4
70	6	4.1	4.4	2	5.9	2.4	4.8	6.2	10	1.1	1.6	1.7	1.3	1.5	1.3
74	4.5	2.5	2.7	1.6	4.8	2	2.9	3.6	6.6	0.71	0.88	0.93	1.1	1.2	1.2
82	1.2	0.72	0.85	0.76	1.4	0.86	0.99	1.2	1.8	bd	0.32	0.29	bd	bd	bd
87	12	6.4	7.2	5.2	14	6.5	7.3	9.7	18	1.8	2.3	2.6	7.7	2.2	3.4
95	7.5	5	5.9	5.6	12	5.4	6.6	9.9	16	1.6	2.2	2.5	1.4	1.8	1.3
99	24	13	13	9.6	26	12	12	18	32	3	3.7	4.2	1.6	3.1	2.2
101	44	22	25	18	43	24	24	31	52	5.9	7.4	8.6	3.5	4.8	3.3
105	14	6.4	7.1	4.5	2.9	5.9	7.2	9.9	16	1.9	2.3	2.5	2.5	1.5	1.2
110	22	13	15	11	28	14	17	22	38	4.1	5.3	6	2.6	3.6	2.5
118	46	21	23	16	42	20	22	29	53	5.6	6.6	7.6	3.5	4.7	3.5
128	14	6.9	7.2	4.4	11	5.3	5.2	6.3	10	2.1	2.2	2.1	1.8	2.2	2.1
138	130	57	54	48	100	56	47	54	110	19	19	20	7.7	11	7.4
149	47	22	24	18	48	25	23	30	52	8.3	9	10	3.3	4.7	5
151	18	9.9	9.7	7.7	19	9.8	6.9	8.7	16	2.8	3.1	3.3	1.8	2.1	1.7
153	150	69	66	60	140	75	55	69	130	24	24	26	9.9	15	9.6
156	8	4.2	4.3	1.1	1.6	3.8	3.7	4	7.4	1.2	1.2	1.4	bd	1.5	1.5
158	12	5.7	5.6	3.8	9.8	4.5	3.9	4.6	10	1.5	1.7	1.8	0.66	0.87	0.73
170	42	19	16	12	30	14	12	12	26	6.4	5.9	6.3	1.7	2.3	1.6
171	10	5.7	4.2	3.1	7	3.7	3.2	3.2	6.7	1.6	1.5	1.6	1.5	1.7	1.8
177	21	11	9.2	7.2	16	8.3	6.9	7.2	16	3.9	3.8	3.8	1.9	2.3	2.1
180	83	32	33	34	67	42	27	27	56	14	12	13	4.2	5.6	4.5
183	29	15	12	9.8	21	12	7.5	8.8	19	4.1	4.1	4.1	1.9	2.3	2
187	65	28	25	23	47	27	18	26	44	11	11	11	3.7	5	3.8
191	2.5	0.81	0.61	0.99	1.4	1.3	1.4	1.3	1.7	bd	bd	0.24	bd	bd	bd

Table 11

PCB (chlorobiphenyl) congeners (IUPAC) in liver of English sole from Vancouver Harbour (ng/g, wet weight).

Investigators: Ms. Jennie Bolton and Ms. Carla Stehr

Site	T11B			T38			T48			T49			T50		
Location	Lonsdale Quay			Port Moody			Indian Arm			West Vancouver Lab			Gibsons, Howe Sound		
Fish ID	990046-050	990051-055	990056-060	990076-080	990081-085	990086-090	990106-110	990106-110	990116-120	990016-020	990021-025	990026-030	990136-140	990141-145	990146-150
Composite #	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Sample wt (g)	1.71	2.4	1.93	3.47	3.54	2.53	2.13	2.36	2.21	2.56	2.78	3.07	1.91	1.81	1.6
194	21	12	7.1	6.7	13	7.3	5.8	6.1	13	3.9	3.6	3.7	2	2.3	2.3
195	6.5	3.3	1.8	2.2	4.2	2.5	2.3	2.2	4.3	1.1	0.88	0.91	bd	1.5	bd
199	19	11	7.2	7.2	14	8.1	6.1	6.4	13	4.7	4	4	1.9	2.4	2.2
205	2.2	0.61	0.39	0.91	1.2	1.2	1.4	1.2	1.5	bd	bd	bd	bd	bd	bd
206	5.4	3.4	1.8	2.3	3.6	2.6	2.4	2.7	3.7	1.6	1.3	1.4	1.8	2.1	2.1
208	2.2	0.53	0.34	1.1	1.4	1.4	1.4	1.4	1.7	0.33	0.23	0.3	bd	bd	bd
209	1.9	bd	bd	0.93	1.1	1.3	bd	bd	1.6	bd	bd	bd	bd	bd	bd
Total PCBs	1200	560	550	470	1000	570	480	580	1100	190	190	210	86	120	83

bd = below detection limits. Detection limits vary depending on the analyte and sample weight. If detection limit data is needed, please contact Carla Stehr at Carla.m.stehr@noaa.gov.

CB Numbers refer to PCB congeners by IUPAC (International Union of Pure and Applied Chemistry) number.

The concentrations of analytes were calculated using CB103 as the surrogate standard.

The concentrations reported for "Total PCBs" is an estimate of the total PCB concentration, obtained by taking the sum of the concentrations of 17 selected congeners (CBs 18, 28, 44, 52, 95, 101, 105, 118, 128, 138, 153, 170, 180, 187, 195, 206 and 209), and multiplying by 2.

Each value represents the data from the analysis of one sample. Each sample is a composite made by combining equal amounts of liver tissue from five fish. The individual fish contributing to each composite are indicated in the column labeled "Fish ID". For instance, the first composite for Site T11B, includes tissue from the five fish with ID numbers 990046, 990047, 990048, 990049 and 990050.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/mass spectrometry using scan mode.

Table 12

Chlorinated pesticides in liver of English sole from Vancouver Harbour (ng/g, wet weight).

Investigators: Ms. Jennie Bolton and Ms. Carla Stehr

Site	T11-B			T38			T48			T49			T50		
Location	Lonsdale Quay			Port Moody			Indian Arm			West Vancouver Lab			Gibson, Howe Sound		
Fish ID	990046-050	990051-055	990056-060	990076-080	990081-085	990086-090	990106-110	990106-110	990116-120	990016-020	990021-025	990026-030	990136-140	990141-145	990146-150
Composite	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Sample Wt. (g)	1.71	2.40	1.93	3.47	3.54	2.53	2.13	2.36	2.21	2.56	2.78	3.07	1.91	1.81	1.60
α-HCH	0.94	bd	bd	0.78	0.78	0.86	bd	0.71	bd	bd	bd	bd	bd	bd	bd
β-HCH	4.5	4.8	3.9	1.8	1.7	1.9	2.8	3	2.6	3.8	3	4.1	2.9	2.9	3.1
lindane (γ-HCH)	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
oxychlordane	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
***cis* -chlordane**	2.9	bd	bd	1.3	2.4	1.8	bd	2	bd	bd	bd	bd	bd	bd	bd
***trans* -chlordane**	bd	bd	bd	bd	1.5	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
cis-nonachlor	3.2	bd	bd	1.2	2.4	2	bd	bd	2.3	bd	bd	bd	bd	bd	bd
trans-nonachlor	4.4	1.7	2	2.7	4.6	2.3	bd	4.2	2.5	bd	bd	0.86	bd	bd	bd
aldrin	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
dieldrin	bd	4	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	3.1	bd	bd
endosulfan II	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
endosulfan I	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
endosulfan sulfate	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
hexachlorobenzene	1	1	1	0.74	0.83	0.66	1.1	1.2	1.3	0.58	0.61	0.56	bd	0.66	bd
heptachlor	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
heptachlor epoxide	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd	bd
mirex	2.2	0.94	0.78	0.84	1.5	1	1	0.99	1.4	0.71	0.56	0.65	bd	1.1	bd
o,p'-DDD	2.6	1.8	2.8	1.1	2.1	1.4	1.6	1.8	2.7	bd	0.68	0.78	bd	0.93	bd
o,p'-DDE	1.6	0.66	bd	0.84	0.81	0.7	bd	0.75	0.99	bd	bd	bd	bd	bd	bd
o,p'-DDT	3.7	4.3	3.4	0.9	2.4	0.83	1.9	2.5	4.5	bd	bd	1	bd	bd	bd
p,p'-DDD	16	11	17	5	19	6.5	6.7	10	19	1.9	2.3	3.7	1.6	1.9	1.9
p,p'-DDE	73	27	29	17	73	23	18	23	48	11	13	19	9.1	14	8.2
p,p'-DDT	11	13	12	2.2	bd	2.4	3.9	7.9	13	1.8	2.1	3.2	bd	bd	bd

bd = below detection limits. Detection limits vary depending on the analyte and sample weight. If detection limit data is needed, please contact Carla Stehr at Carla.m.stehr@noaa.gov.

α-HCH = alpha-hexachlorocyclohexane; β-HCH = beta-hexachlorocyclohexane; γ-HCH = gamma-hexachlorocyclohexane; lindane is the same as γ-HCH

Each value represents the data from the analysis of one sample. Each sample is a composite made by combining equal amounts of liver tissue from five fish.
For instance, the first composite for Site T11B, includes tissue from the five fish with ID numbers 990046, 990047, 990048, 990049 and 990050.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/mass spectrometry using scan mode.

Table 13

Quality assurance data for chlorinated hydrocarbon analyses of liver in English sole (ng/g wet weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

Sample	112-44	112-53	112-43	112-52
SampleType	Method Blank	Method Blank	SRM 1974a	SRM 1974a
Sample wt (g)	2.33	2.55	4.79	4.72
CB17	bd	bd	2.9	3
CB18	bd	bd	3.2	3.5
CB28	bd	0.62	9.6	10
CB31	0.53	0.5	7	7.4
CB33	bd	bd	1.5	1.6
CB44	bd	bd	8.2	9.3
CB49	bd	bd	10	11
CB52	bd	bd	14	14
CB70	bd	bd	13	14
CB74	bd	bd	8.3	9.2
CB82	bd	bd	1.8	2.2
CB87	bd	bd	6.7	7.8
CB95	bd	bd	9.7	9.9
CB99	bd	bd	8.3	9.8
CB101	0.9	bd	16	15
CB105	bd	bd	6.1	5.7
CB110	bd	0.53	15	15
CB118	bd	0.53	13	15
CB128	bd	bd	2.2	2.7
CB138	bd	bd	14	16
CB149	bd	bd	8.8	11
CB151c	bd	bd	2.1	2.8
CB153	bd	bd	18	20
CB156	bd	bd	0.96	0.95
CB158	bd	bd	1.2	1.8
CB170	bd	bd	1.3	0.52
CB171	bd	bd	0.9	0.76
CB177	bd	bd	1.4	1.7
CB180	bd	bd	1.4	1.7
CB183	bd	bd	1.7	2
CB187	bd	bd	3.2	4.2
CB191	bd	bd	bd	bd
CB194	bd	bd	bd	bd
CB195t	bd	bd	bd	bd
CB199	bd	bd	bd	bd
CB205	bd	bd	bd	bd
CB206	bd	bd	bd	bd
CB208	bd	bd	bd	bd
CB209	bd	bd	bd	bd
PCB Est. total	3.7	2.3	240	260
aldrin	bd	bd	bd	bd
cis -chlordane	bd	bd	1.8	2.2
trans -chlordane	bd	bd	1.4	1.8
α-HCH	bd	bd	0.52	0.85
β–HCH	2.2	1.8	7.7	8.7
lindane (γ-HCH)	bd	bd	bd	bd

Table 13

Quality assurance data for chlorinated hydrocarbon analyses of liver in English sole (ng/g wet weight).

Investigators: Ms. Jennie Bolton, Ms. Carla Stehr

Sample	112-44	112-53	112-43	112-52
SampleType	Method Blank	Method Blank	SRM 1974a	SRM 1974a
cis -nonachlor	bd	bd	0.98	0.89
trans -nonachlor	bd	bd	1.7	2.2
oxychlordane	bd	bd	bd	bd
dieldrin	bd	bd	0.98	bd
endosulfan I	bd	bd	bd	4.3
endosulfan II	bd	bd	14	bd
enfosulfan sulfate	bd	bd	bd	bd
hexachlorobenzene	bd	bd	bd	bd
heptachlor	bd	bd	bd	bd
heptachlor epoxide	bd	bd	bd	bd
mirex	bd	bd	0.4	0.27
o,p'-DDD	bd	bd	2.1	2.8
o,p'-DDE	bd	bd	0.39	0.43
o,p'-DDT	bd	bd	bd	bd
p,p'-DDD	bd	bd	5.3	6.4
p,p'-DDT	bd	bd	bd	bd
p,p'-DDE	bd	bd	6.1	6.8

SRM = standard reference material

bd = below detection limits. Detection limits vary depending on the analyte and sample weight.
If below detection limit data is needed, please contact Carla Stehr at Carla.m.stehr@noaa.gov.

α-HCH = alpha-hexachlorocyclohexane; β-HCH = beta-hexachlorocyclohexane; γ-HCH = gamma-hexachlorocyclohexane; lindane is the same as γ-HCH.

CB Numbers refer to PCB congeners by IUPAC (International Union of Pure and Applied Chemistry) number.

The concentrations of analytes were calculated using CB103 as the surrogate standard.

The concentrations reported for "PCBs Est. Total" is an estimate of the total PCB concentration, obtained by taking the sum of the concentrations of 17 selected congeners (CBs 18, 28, 44, 52, 95, 101, 105, 118, 128, 138, 153, 170, 180, 187, 195, 206 and 209), and multiplying by 2.

The sample weight used to calculate analyte concentrations for method and field blanks is the mean sample weight of all field samples (excluding field blanks) in the same sample set.

Methods are published by Sloan et al. 1993, NOS/ORCA/CMBAD Tech memo 71 Vol III. Methods include extraction with methylene chloride, high performance liquid chromatography – size exclusion chromatography clean up, and analysis by gas chromatograph/mass spectrometry using scan mode.

Table 14

Polycyclic aromatic hydrocarbons in liver of English sole (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Fish Id	990041-45	990046-50	990056-60	990073-75	990076-80	990086-90	990106-110	990111-115	990116-120	990011-15	990016-20	990021-25	990026-30	990136-140	99141-145
Site	T11B	T11B	T11B	T38	T38	T38	T48	T48	T48	T49	T49	T49	T49	T50	T50
Nap	19.26	9.04	5.05	10.16	2.18	1.38	2.92	2.18	1.89	6.31	0.49	27.28	14.09	3.64	4.59
1Mnap	1.36	0.64	0.45	0.56	0.18	0.13	0.22	0.24	0.08	0.25	0.04	0.90	0.63	0.00	0.42
2Mnap	1.09	0.72	0.53	0.27	0.15	0.16	0.22	0.12	0.12	0.29	0.04	1.14	0.51	0.00	0.27
Acenap	1.35	0.40	0.24	0.57	0.13	0.09	0.08	0.10	0.12	0.43	0.02	0.80	0.50	0.00	0.11
Bip	0.45	0.16	0.10	0.22	0.06	0.07	0.04	0.00	0.07	0.20	0.01	0.09	0.12	0.01	0.06
Acenapt	0.36	0.26	0.24	0.65	0.09	0.06	0.00	0.12	0.05	0.52	0.00	0.21	0.00	0.00	0.29
Flure	1.12	0.46	0.27	0.45	0.17	0.17	0.15	0.17	0.07	0.41	0.02	0.00	0.42	0.00	0.16
Dibenz	1.05	0.58	0.43	0.54	0.23	0.16	0.17	0.18	0.12	0.17	0.01	0.38	0.52	0.31	0.35
Phen	6.27	4.45	4.20	3.44	1.42	1.12	1.41	1.16	0.88	1.72	0.15	4.05	2.76	0.00	3.02
Ant	1.00	0.45	0.33	0.84	0.11	0.19	0.06	0.10	0.12	0.37	0.03	0.70	0.59	2.42	0.45
Flura	0.81	0.65	0.60	0.20	0.14	0.13	0.33	0.13	0.09	0.21	0.02	0.50	5.00	0.00	0.38
Pyr	1.47	0.79	0.75	0.64	0.25	0.20	0.32	0.16	0.20	0.51	0.01	2.34	1.01	0.00	0.61
Bat	0.50	0.13	0.10	0.48	0.00	0.04	0.14	0.08	0.09	0.17	0.00	0.28	0.49	0.00	0.24
Chr	0.12	0.00	0.00	0.02	0.00	0.02	0.02	0.01	0.04	0.17	0.02	0.54	1.07	0.00	0.15
Bbf	13.14	0.00	0.63	1.46	0.57	0.00	0.89	0.22	0.58	0.00	0.04	0.00	1.40	0.00	0.00
Bkf	14.71	0.00	0.16	0.00	0.45	0.00	0.10	0.47	0.85	0.00	0.01	0.23	0.00	0.00	0.00
Bap	4.97	0.00	0.53	2.26	0.70	0.19	0.10	0.30	0.51	0.68	0.03	0.60	1.36	0.00	0.39
Inp	0.00	0.00	0.01	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dba	1.69	0.64	0.13	0.40	0.06	0.00	0.00	0.00	0.16	0.33	0.00	0.45	0.49	0.00	0.00
Bpe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Nap = Naphthalene, 1Mnap = 1-Methylnaphthalene, 2Mnap = 2-Methylnaphthalene,
Bip = Biphenyl; Acenap = Acenaphthylene; Acenapt = Acenaphthene; Dibenz = Dibenzothlophene; Phen= Phenanthrene;
Ant = Anthracene; Flura = Fluoranthene; Flure = Fluorene; Pyr = Pyrene; Bat = 1,2-Benzo[a]anthracene; Chr = Chrysene;
Bdf = Benzo[b]fluoranthene; Bkf = Benzo[k] fluoranthene; Bap = Benzo[a]pyrene; Inp = Indeno[1,2,3-cd]pyrene;
Dba = Dibenz[a,h]anthracene; Bpe = Benzo[g,h,l]perylene

The method used by Dr. Uno includes supercritical fluid extraction using CO_2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Each value represents the analysis of one sample. Each sample is a composite made by combining equal mounts of liver tissue from five fish. For instance, the first composite for site T11B is composed of liver tissue from fish with ID numbers 990041, 990042, 990043, 990044, and 990045.

Table 15

Polycyclic aromatic hydrocarbons in muscle of English sole (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Fish ID	990034-36	990037-39	990040	990069-71	990066-68	990072	990091-93	990094-96	990097-99	990001-3	990007-9	990010	990129-131	990132-134
Site	T11B	T11B	T11B	T38	T38	T38	T48	T48	T48	T49	T49	T49	T50	T50
Nap	12.29	3.20	11.50	6.96	9.85	14.47	8.92	5.47	6.70	2.83	9.88	16.26	3.81	10.71
1Mnap	0.73	0.61	1.73	0.58	0.85	1.03	11.29	2.34	3.34	5.05	1.28	6.28	0.98	0.71
2Mnap	1.07	0.85	1.86	0.37	0.70	0.81	7.43	3.11	4.22	6.70	1.68	7.60	0.81	0.59
Acenap	0.86	0.51	0.70	0.25	0.34	0.42	0.34	2.00	2.65	4.30	1.16	5.50	0.42	0.32
Bip	0.41	0.00	0.13	0.05	0.06	0.14	3.65	0.08	0.09	0.11	0.09	0.29	0.06	0.12
Acenapt	0.88	0.14	0.61	0.18	0.41	0.63	1.10	1.00	1.43	0.04	0.69	2.84	0.54	0.38
Flure	0.73	0.45	0.99	0.19	0.38	0.60	0.84	0.03	0.37	0.00	0.32	0.91	0.50	0.76
Dibenz	0.07	0.32	0.88	0.11	0.30	0.51	4.47	0.03	0.28	0.53	0.23	0.71	0.91	0.50
Phen	3.43	2.03	4.75	0.79	1.54	2.48	0.25	1.55	1.39	2.20	1.08	3.42	2.58	2.78
Ant	0.01	0.85	0.10	0.05	0.14	0.22	0.44	1.42	0.11	0.11	0.07	0.18	0.38	0.15
Flura	0.04	0.00	0.35	0.27	0.13	0.23	0.81	0.02	0.24	0.60	0.17	0.64	0.32	0.19
Pyr	0.00	0.27	0.66	0.41	0.25	0.42	0.06	0.46	0.44	1.21	0.35	1.26	0.63	0.51
Bat	0.08	0.05	0.08	0.00	0.08	0.14	0.03	0.05	0.17	0.00	0.04	0.14	0.17	0.08
Chr	0.26	0.00	0.06	0.06	0.04	0.05	0.00	0.01	0.34	0.25	0.66	3.56	0.13	0.22
Bbf	0.02	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.07	0.06	0.02
Bkf	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.04	0.07	0.00
Bap	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Inp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.03	0.00
Dba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00
Bpe	0.00	0.00	0.00	0.00	0.00	0.03		0.00	0.00	0.00	0.04	0.09	0.00	0.00

Nap = Naphthalene, 1Mnap = 1-Methylnaphthalene, 2Mnap = 2-Methylnaphthalene,
Bip = Biphenyl; Acenap = Acenaphthylene; Acenapt = Acenaphthene; Dibenz = Dibenzothlophene; Phen= Phenanthrene;
Ant = Anthracene; Flura = Fluoranthene; Flure = Fluorene; Pyr = Pyrene; Bat = 1,2-Benzo[a]anthracene; Chr = Chrysene;
Bdf = Benzo[b]fluoranthene; Bkf = Benzo[k] fluoranthene; Bap = Benzo[a]pyrene; Inp = Indeno[1,2,3-cd]pyrene;
Dba = Dibenz[a,h]anthracen; Bpe = Benzo[g,h,l]perylene

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up.
Samples were analyzed by Gas Chromatography /Mass Spectometry.

Each value represents the analysis of one sample. Each sample is either an indivdiual fish, or a composite made by combining equal amounts of muscle tissue from two or more fish. For instance, the first composite for site T11B is composed of muscle tissue from fish with ID numbers 990043, 990035 and 990036.

Table 16

Polycyclic aromatic hydrocarbons in ovaries of English sole (ng/kg wet weight)

Investigator: Dr. Seiichi Uno

Fish ID	990038,41-42, 44-45	990056-60	990068-70	990073-77	990079, 82, 84	990087-89	990091-95	990101-105	990106-110	990111-115	990006, 14, 15, 02	990128-130, 132-137	990146-150
Site	T11B	T11B	T38	T38	T38	T38	T48	T48	T48	T48	T49	T50	T50
Analyte													
Nap	13.92	32.71	12.39	13.54	13.76	7.32	6.49	8.79	13.05	23.37	1.31	24.99	5.00
1Mnap	1.12	2.60	1.28	1.13	1.18	0.66	3.59	0.68	1.33	23.52	2.32	1.34	0.45
2Mnap	0.69	1.66	1.47	0.91	1.00	0.55	4.86	0.42	1.30	33.24	3.29	1.04	0.27
Acenap	0.51	1.38	0.89	0.52	0.54	0.31	3.47	0.31	1.10	23.42	1.84	0.56	0.22
Bip	0.12	0.36	0.24	0.12	0.17	0.13	0.11	0.08	0.12	0.79	0.14	0.11	0.00
Acenapt	0.28	1.21	1.36	0.67	0.76	0.37	1.64	0.23	0.80	10.77	0.07	0.91	0.21
Flure	0.74	2.69	1.80	0.52	1.18	0.83	0.62	0.52	1.62	3.93	0.65	1.82	0.39
Dibenz	0.51	1.91	1.42	0.51	0.90	0.61	0.45	0.34	1.29	2.91	0.00	1.64	0.35
Phen	3.28	10.60	7.62	3.04	4.87	3.38	2.21	1.80	8.24	13.86	0.00	9.00	3.28
Ant	0.20	0.62	2.26	0.24	0.49	0.14	1.34	0.11	0.76	0.51	0.54	0.74	0.55
Flura	0.99	2.27	0.17	0.37	0.42	0.31	4.27	0.42	0.46	0.83	2.13	0.57	0.40
Pyr	1.78	5.09	0.41	0.73	1.23	0.88	0.70	0.91	1.02	1.75	0.17	2.21	0.58
Bat	0.00	0.26	0.05	0.00	0.10	0.03	0.06	0.00	0.10	0.17	0.19	0.13	0.11
Chr	0.02	0.45	0.06	0.00	0.27	0.00	0.04	0.19	0.13	0.14	0.44	0.11	0.04
Bbf	0.02	0.13	0.00	0.00	0.03	0.00	0.02	0.00	0.00	0.00	1.02	0.00	0.65
Bkf	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bap	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.53	0.00	0.44
Inp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Dba	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.15
Bpe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Nap = Naphthalene, 1Mnap = 1-Methylnaphthalene, 2Mnap = 2-Methylnaphthalene,
Bip = Biphenyl, Acenap = Acenaphthylene, Acenapt = Acenaphthene, Dibenz = Dibenzothlophene, Phen= Phenanthrene,
Ant = Anthracene, Flura = Fluoranthene, Flure = Fluorene , Pyr = Pyrene, Bat = 1,2-Benzo[a]anthracene, Chr = Chrysene,
Bdf = Benzo[b]fluoranthene , Bkf = Benzo[k] fluoranthene, Bap = Benzo[a]pyrene, Inp = Indeno[1,2,3-cd]pyrene,
Dba = Dibenz[a,h]anthracene, Bpe = Benzo[g,h,l]perylene

The method used includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up.
Samples were analyzed by Gas Chromatography /Mass Spectometry.

Each value represents the analysis of one sample. Each sample is a composite made by combining equal amounts of ovary tissue from two or more fish. For instance, the first composite for site T11B is composed of muscle tissue from fish with ID numbers 990038, 990041, 990042, 990044 and 990045.

Table 17

Polycyclic aromatic hydrocarbons in testis of English sole (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site	T49	T11B	T38	T48	T50
Fish ID	all males	all males	all males	all males	all males
Nap	7.3	159.2	11.8	57.1	32.7
1Mnap	12.6	57.7	4.8	12.5	8.3
2Mnap	18.0	63.3	4.9	10.6	6.5
Acenap	10.1	32.0	3.1	4.8	4.0
Bip	0.6	4.2	0.3	1.1	0.7
Acenapt	4.0	11.9	1.2	4.0	2.9
Flure	1.9	23.0	4.5	7.4	8.4
Dibenz	4.3	76.5	18.8	24.6	32.4
Phen	1.3	4.2	0.0	3.6	1.7
Ant	2.2	25.9	3.3	5.5	9.1
Flura	4.1	42.9	7.4	13.8	21.3
Pyr	4.3	20.6	0.7	1.7	1.7
Bat	6.5	8.1	0.8	1.3	1.6
Chr	1.1	0.0	0.0	0.0	0.2
Bbf	0.9	0.0	0.0	0.2	0.6
Bkf	0.9	0.0	0.0	0.0	0.0
Bap	1.0	2.2	0.0	0.0	0.0
Inp	0.9	0.0	0.0	0.0	0.0
Dba	1.0	0.0	0.0	0.0	0.0
Bpe	1.0	0.0	0.0	0.0	0.0

Nap = Naphthalene; 1Mnap = 1-Methylnaphthalene; 2Mnap = 2-Methylnaphthalene;
Bip = Biphenyl; Acenap = Acenaphthylene; Acenapt = Acenaphthene; Dibenz = Dibenzothlophene;
Phen= Phenanthrene; Ant = Anthracene; Flura = Fluoranthene; Flure = Fluorene; Pyr = Pyrene;
Bat = 1,2-Benzo[a]anthracene; Chr = Chrysene; Bdf = Benzo[b]fluoranthene; Bkf = Benzo[k]fluoranthene;
Bap = Benzo[a]pyrene; Inp = Indeno[1,2,3-cd]pyrene; Dba = Dibenz[a,h]anthracene; Bpe = Benzo[g,h,l]perylene

The method used includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Each value represents one analysis. Each analysis is a composite of equal amounts of tissue from all males sampled at each site.

Table 18

PCB congeners (IUPAC) (ng/kg wet weight) in liver of English sole.

Investigator: Dr. Seiichi Uno

Fish ID	990076-80	990026-30	990011-15	990041-45	990046-50	990051-55	990056-60	990073-75	990086-90	990081-85	990116-120	990111-115	990106-110	990103-105	990136-140	990141-145	990135
Site	T38	T49	T49	T11B	T11B	T11B	T11B	T38	T38	T38	T48	T48	T48	T48	T50	T50	T50
Congener #																	
17	nd	nd	nd	nd	nd	851	nd	nd	nd	nd	561	nd	nd	nd	nd	nd	nd
18	nd	nd	nd	nd	nd	2303	nd	nd	nd	nd	1100	nd	nd	224	nd	nd	nd
22	nd	nd	nd	nd	4461	nd	3458	nd	nd	nd	nd	nd	317	0	nd	nd	nd
28	543	nd	74	362	2325	384	1605	753	nd	nd	1134	698	255	0	nd	nd	nd
31	317	nd	16	960	4264	1351	4174	nd	nd	nd	928	676	326	1111	nd	nd	nd
32	nd	nd	89	665	nd	nd	nd	nd	nd	nd	nd	nd	nd	155	nd	nd	nd
33	440	nd	nd	357	1551	nd	2818	nd	nd	nd	nd	nd	99	248	nd	nd	nd
41	767	3315	97	670	974	1161	1333	209	639	638	1261	496	251	312	nd	nd	nd
42	nd	nd	nd	nd	2428	nd	nd	nd	nd	nd	721	488	323	nd	nd	1139	936
47	753	840	193	192	2328	835	1326	809	90	785	892	750	387	763	nd	1005	nd
48	221	710	nd	299	2752	931	1567	957	106	165	1055	887	120	nd	nd	nd	nd
49	646	1058	155	643	3705	1517	2101	1492	333	944	1321	1235	378	1074	1491	1162	nd
52	1022	1112	115	812	4086	2255	nd	1401	753	1168	1809	2036	702	1154	831	867	533
56	504	654	231	2003	nd	nd	nd	nd	nd	367	20	472	nd	nd	475	496	305
59	883	nd	nd	nd	837	nd	nd	nd	nd	nd	410	213	145	nd	nd	nd	nd
60	288	496	nd	1146	4924	nd	1651	833	nd	838	22	448	nd	1137	2024	1389	nd
63	1008	nd	nd	nd	5184	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
64	189	589	24	130	nd	233	565	522	333	194	522	523	148	275	1629	2076	nd
66	477	2619	551	1879	nd	3346	5009	2325	1263	2041	2994	2333	914	4926	2714	1274	nd
69	nd	nd	nd	nd	nd	nd	2726	nd	8860	2835	nd	nd	nd	nd	nd	nd	nd
70	2286	2126	336	1810	8204	2712	3559	2615	1318	1943	2867	1669	1123	3127	nd	nd	nd
74	1756	2387	291	467	9035	2557	4171	nd	1575	1698	nd	2750	973	nd	nd	nd	nd
84	2257	3146	103	2683	12662	2955	4990	nd	2592	3804	5293	4046	2087	649	784	1336	3094
85	759	578	381	1288	6281	2264	2821	3014	729	1551	1660	1303	658	1900	4015	2962	nd
87	1369	1840	506	1602	7478	1714	3120	4222	1240	2553	3171	2250	1017	3226	740	1755	nd
92	501	1310	446	736	3449	853	473	2886	638	1010	1280	1463	661	2091	nd	1422	257
95	986	1512	218	738	nd	1039	1643	2082	832	1177	1702	1572	657	1785	731	896	3976
97	569	771	142	520	2146	431	897	1177	426	607	1037	747	357	1134	1801	3906	842
98	nd	nd	nd	nd	2967	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
99	3948	4427	1376	4947	23796	5061	8320	12111	4163	7100	8566	6195	3016	10833	633	855	nd
101/90	8094	9293	2395	9107	41725	9724	14484	19393	7788	12938	16765	11935	5714	17482	1610	2834	6296
105	1028	1576	631	957	5344	1251	1812	2144	600	1416	1515	2596	504	1597	2333	3117	908
110	5391	6830	1672	5624	25434	6860	8620	15505	4253	7923	10623	7661	3940	11143	nd	nd	nd
118	6850	7865	2732	8575	40651	10234	11165	18400	5313	11663	13746	nd	4148	15191	nd	nd	nd
123	nd	480	nd	144	792	109	226	nd	nd	nd	280	2407	nd	nd	nd	nd	nd
124	nd	785	nd	nd	nd	355	nd	nd	nd	nd	233	nd	nd	nd	nd	nd	nd
127	nd	7402	nd	1268	6958	3420	4976	nd	nd	nd	4204	2790	991	nd	nd	nd	nd
128	146	1353	472	991	7163	970	nd	2734	154	118	nd	nd	nd	1313	492	668	nd
130	nd	nd	295	921	5334	1130	1882	1277	1754	3505	1042	576	816	2059	nd	1549	nd
132	nd	1575	nd	2081	161425	1930	1095	nd	731	1651	3013	1574	435	nd	nd	1830	nd
134	677	nd	nd	300	nd	nd	nd	nd	nd	1930	401	340	nd	nd	nd	692	nd
135	280	1477	485	1023	5428	1016	2299	2456	571	465	1556	1040	577	1674	nd	nd	nd
136	1185	368	102	291	1304	343	731	846	1142	1623	482	416	222	559	5708	6891	16527
137	340	637	309	595	3883	705	1443	924	221	439	728	619	367	1398	nd	1739	312
138	487	18234	10699	21507	113128	21497	24284	50892	463	788	27392	16770	8885	40295	876	3833	3026
141	19972	2689	1137	2656	12630	2389	3219	4677	13849	28887	2853	1661	1159	3365	1558	1673	748
146	2811	3413	1655	3409	nd	3483	4182	7343	1803	3628	3292	2686	1149	nd	1228	3176	nd

Table 18

PCB congeners (IUPAC) (ng/kg wet weight) in liver of English sole.

Investigator: Dr. Seiichi Uno

Fish ID	990076-80	990026-30	990011-15	990041-45	990046-50	990051-55	990056-60	990073-75	990086-90	990081-85	990116-120	990111-115	990106-110	990103-105	990136-140	990141-145	990135
Site	T38	T49	T49	T11B	T11B	T11B	T11B	T38	T38	T38	T48	T48	T48	T48	T50	T50	T50
Congener #																	
149	3312	4180	1572	3305	17649	3697	5128	9396	2677	5174	5126	3904	1745	6773	7031	7495	15156
151	3712	3952	1328	3099	17543	4631	5833	9315	2683	4692	4120	2927	1348	4894	nd	989	nd
153	27279	25310	11826	27955	14376	38918	32532	50462	18204	41183	25294	22011	9942	32973	nd	nd	2290
156	1631	1054	682	1635	6267	2143	1887	2972	705	2025	2052	872	566	2966	nd	nd	nd
158	952	1505	493	1261	7662	1515	1781	3247	1010	1786	1747	1060	634	2470	nd	nd	nd
170/190	8679	8926	1428	7707	43549	8439	7018	nd	4213	9238	8227	1095	nd	nd	nd	nd	nd
171	2348	1901	934	1222	9470	1258	3910	2809	628	2484	nd	nd	nd	2126	nd	333	nd
172	1062	2797	1981	855	6718	1167	1321	nd	665	1707	1961	1328	480	nd	nd	nd	nd
174	2228	4189	nd	2417	13881	2624	3319	6224	1616	4004	1239	428	nd	5471	547	693	nd
175	168	nd	nd	nd	790	347	307	nd	nd	nd	3086	2253	1067	nd	1262	1663	nd
176	360	1417	268	570	1739	1051	1050	1198	261	461	346	nd	nd	667	nd	nd	nd
177	3036	2587	2192	2614	14610	2685	3477	5854	1468	4012	579	315	262	4080	1024	734	nd
178	1188	2218	871	1068	8054	1644	2099	3465	986	1554	3389	1916	804	1072	nd	3473	4139
179	1624	1711	855	1539	6678	1720	1962	4188	1099	2198	1346	1154	595	2071	978	2054	nd
180	17679	17005	6075	22705	109497	20041	18022	35147	13222	23305	1418	1265	537	33643	1147	nd	nd
183	3949	4196	2339	4355	23204	5618	3667	7871	2519	4612	21071	14182	8049	5905	1405	1174	5713
185	193	nd	nd	541	3281	558	nd	nd	457	651	4551	2369	1355	nd	nd	623	nd
187	4024	4055	3265	4002	22765	4889	4325	8816	2550	5555	637	466	222	6534	nd	nd	nd
191	nd	220	nd	99	nd	nd	nd	nd	nd	nd	4543	2901	1475	nd	nd	nd	nd
194	316	2204	*	2706	965	2583	1088	*	153	306	484	170	157	*	nd	nd	nd
195	888	nd	*	849	18639	1346	nd	*	nd	nd	1122	1942	413	*	nd	nd	nd
197	98	247	*	146	413	56	nd	*	55	145	95	nd	nd	*	nd	4534	nd
199	2998	4242	*	3602	4734	4806	4294	*	2120	3092	3540	434	1718	*	622	nd	nd
200	249	564	*	nd	869	658	nd	*	nd	nd	993	nd	452	*	nd	nd	nd
201	405	0	*	371	1492	349	638	*	180	357	326	5111	nd	*	nd	nd	2170
203/196	1596	5673	*	3408	7324	4570	2135	*	1134	1750	1849	524	664	*	nd	1035	nd
205	775	nd	*	nd	5735	nd	nd	*	527	475	nd	nd	nd	*	nd	nd	nd
Total PCBs	160499	193618	64040	182391	914941	217483	244544	314962	123663	229157	227593	154947	76306	243845	45687	75342	67227

nd = not detected
IUPAC = International Union of Pure and Applied Chemistry.
*= not analyzed.

Each value represents one analysis. Each analysis contains tissue either from an individual fish, or equal amounts of tissue from several fish. The Fish ID label indicates which fish are included in each analysis. For instance, 990076-80 indicates that five fish with the ID numbers 990076, 990077, 990078, 990079 and 990080, were combined into one composite sample.

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 19

PCB congeners (IUPAC) (ng/kg wet weight) in English sole muscle.

Investigator: Dr. Seiichi Uno

Fish ID	990031-35	990036-39	990040	990062,63,65	990066-68	990069-71	990072	990087-90	990007-9	990010	990091-93	990094-96	990126-131	990132-134
Site	T11B	T11B	T11B	T38	T38	T38	T38	T38	T49	T49	T48	T48	T50	T50
Congener #														
17	nd	nd	nd	241	38	619	nd	198	413	nd	6	nd	nd	nd
18	nd	nd	nd	0	135	468	nd	685	143	nd	98	nd	nd	nd
22	nd	nd	nd	nd	nd	nd	nd	nd	nd	108	nd	nd	nd	nd
28	451	983	1443	nd	66	268	519	687	15	nd	6	275	16	11
31	131	1420	1536	nd	255	600	904	350	86	215	301	479	41	85
32	nd	nd	nd	nd	141	nd	nd	356	186	193	31	nd	nd	nd
33	467	1001	1275	nd	nd	179	438	314	281	nd	118	232	10	47
41	88	624	288	nd	171	301	489	653	31	111	43	153	2	30
42	466	nd	1077	nd	154	596	347	nd	61	109	1	103	17	nd
47	135	821	777	nd	153	nd	544	nd	96	101	nd	142	3	20
48	159	695	657	nd	84	280	572	185	81	264	89	168	9	nd
49	517	858	1452	77	96	329	577	398	79	23	1936	205	31	10
52	490	769	1630	54	167	398	874	297	73	39	101	223	14	nd
56	60	nd	35	nd	91	294	201	nd	4	10	nd	59	4	19
59	nd	nd	nd	nd	61	285	109	nd	nd	nd	349	nd	4	nd
60	104	0	20	nd	52	168	115	nd	2	1	33	33	14	11
63	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
64	157	385	824	nd	61	155	260	92	21	400	30	101	3	11
66	1074	1124	3438	159	460	1023	1825	574	148	9	285	50	42	47
69	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
70	793	994	2203	121	235	742	1097	398	114	52	242	389	31	25
74	714	1456	1819	nd	287	829	1450	621	128	127	192	366	33	56
84	nd	1234	2653	nd	531	1284	3087	952	261	248	nd	470	nd	44
85	1040	1104	1580	nd	312	709	1422	439	157	208	nd	284	30	22
87	1111	891	1978	205	366	698	1997	484	210	204	185	395	26	38
92	nd	530	1091	nd	163	579	895	294	165	67	0	210	nd	17
95	308	444	1203	100	182	460	1106	226	108	92	104	179	15	21
97	291	198	606	70	131	316	589	235	74	78	84	105	9	12
98	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
99	2722	2769	3745	476	1060	2450	5134	1233	572	651	647	1050	77	64
101/90	5233	4455	9644	772	1711	4228	10259	2415	1091	1027	1046	1561	125	101
105	956	789	1266	129	204	nd	1348	321	154	134	188	303	18	22
110	3373	3500	6235	620	1309	3081	7668	1771	1034	862	854	1340	100	101

Table 19

PCB congeners (IUPAC) (ng/kg wet weight) in English sole muscle.

Investigator: Dr. Seiichi Uno

Fish ID	990031-35	990036-39	990040	990062,63,65	990066-68	990069-71	990072	990087-90	990007-9	990010	990091-93	990094-96	990126-131	990132-134
Site	T11B	T11B	T11B	T38	T38	T38	T38	T38	T49	T49	T48	T48	T50	T50
Congener #														
118	5456	4364	8142	718	1967	3820	8745	2010	1205	1030	987	1825	157	98
123	nd	nd	375	nd	nd	86	150	25	25	28	nd	32	nd	2
124	nd	nd	1671	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
127	nd	nd	nd	nd	511	1122	2751	nd	nd	nd	nd	522	nd	61
128	787	557	1093	131	77	nd	1867	268	136	121	133	193	18	23
130	nd	1163	781	nd	166	402	988	438	143	162	nd	154	nd	34
132	nd	nd	nd	nd	262	776	1182	173	836	119	nd	154	nd	9
134	nd	854	1472	nd	nd	nd	323	274	nd	nd	nd	nd	20	nd
135	nd	990	1001	57	218	871	1319	518	155	93	nd	148	14	nd
136	189	154	287	45	55	190	356	nd	33	30	nd	38	59	5
137	729	562	395	90	130	459	673	265	52	63	nd	79	nd	13
138	12254	10355	14877	1971	4229	8927	28059	5682	2600	1601	2108	2888	53	254
141	1516	2010	2233	196	617	1199	3856	838	350	198	220	341	nd	31
146	1904	1510	2831	352	678	1246	4388	1038	354	222	311	416	128	34
149	2002	1797	3451	333	577	1753	4517	1068	459	260	306	481	nd	40
151	1400	2030	2690	354	603	1691	4289	1364	431	239	238	nd	45	38
153	13878	12811	16110	2445	6385	11661	40438	7651	9972	1698	2053	3976	319	338
156	1032	3439	3956	130	382	432	3024	555	500	339	207	338	19	26
158	884	1024	1209	138	270	574	1759	496	231	133	127	260	69	16
170/190	4785	3113	3964	386	1119	2667	7995	2083	1043	404	591	685	99	50
171	663	526	906	nd	nd	nd	nd	nd	115	60	142	146	nd	15
172	nd	969	700	129	196	594	1131	nd	109	51	nd	103	nd	nd
174	1910	1528	2446	529	385	1158	2833	1080	242	233	539	372	40	28
175	nd	334	340	nd	nd	80	120	117	59	26	nd	nd	nd	nd
176	nd	313	630	nd	120	164	525	244	31	37	79	90	30	nd
177	1767	1215	1820	343	519	1104	2876	776	216	132	246	369	38	21
178	nd	656	733	335	216	541	1330	637	148	64	nd	119	84	nd
179	711	667	1435	283	280	604	2076	484	177	128	154	171	nd	nd
180	11752	9055	9274	2765	2265	6262	26777	5519	1696	897	1444	1724	242	133
183	2294	1774	2855	567	329	1671	4950	843	473	222	275	269	253	33
185	nd	445	408	nd	131	162	674	588	67	37	nd	83	52	40
187	2376	2611	2532	601	605	1728	5765	1237	504	243	267	440	21	nd
191	nd	nd	150	nd	nd	nd	nd	nd	25	16	nd	nd	*	81

Table 19

PCB congeners (IUPAC) (ng/kg wet weight) in English sole muscle.

Investigator: Dr. Seiichi Uno

Fish ID	990031-35	990036-39	990040	990062,63,65	990066-68	990069-71	990072	990087-90	990007-9	990010	990091-93	990094-96	990126-131	990132-134
Site	T11B	T11B	T11B	T38	T38	T38	T38	T38	T49	T49	T48	T48	T50	T50
Congener #														
194	nd	nd	nd	*	990	3118	3497	531	nd	nd	*	2186	*	nd
195	nd	nd	nd	*	183	nd	965	nd	nd	nd	*	nd	*	nd
197	nd	nd	nd	*	29	nd	136	nd	14	nd	*	nd	*	nd
199	nd	3190	2966	*	629	1550	4095	629	nd	261	*	328	*	49
200	nd	nd	nd	*	nd	nd	271	nd	34	nd	*	nd	*	nd
201	nd	nd	424	*	158	nd	466	148	78	36	*	nd	*	nd
203/196	nd	1233	1999	*	313	642	2167	1124	718	135	*	187	*	26
205	nd	nd	nd	*	nd	nd	149	nd	nd	nd	*	nd	nd	nd
Total PCBs	89129	98295	144633	15924	34269	78590	221310	52882	29016	14652	17399	27996	2430	2312

nd = not detected
IUPAC = International Union of Pure and Applied Chemistry.
*= not analyzed.

Each value represents one analysis. Each analysis contains tissue either from an individual fish, or equal amounts of tissue from several fish. The Fish ID label indicates which fish are included in each analysis. For instance, 990031-35 indicates that five fish with the ID numbers 990031, 990032, 990033, 990034 and 990035, were combined into one composite sample. Fish ID number 990062, 63, 65 indicates that three fish with ID numbers 99062, 99063, and 99065 are included in this composite sample.

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 20

PCB congeners (IUPAC) (ng/kg wet weight) in English sole ovaries.

Investigator: Dr. Seiichi Uno

FishID	990033-37	990038,41,42,44,45	990056-60	990073-77	990068-70	990079, 82, 84	990061-63, 65-66	990091-95	990101-105	990106-110	990111-115	990006, 14, 15, 02	990026-30	990138, 141, 143	990128-130, 132, 137
Site	T11B	T11B	T11B	T38	T38	T38	T38	T48	T48	T48	T48	T49	T49	T50	T50
Congener #															
17	nd	131	nd	nd	nd	26	nd	965	nd	106	nd	75	40	nd	nd
18	nd	193	nd	nd	nd	217	130	523	nd	113	nd	75	74	nd	nd
22	nd	nd	65	nd	nd	76	nd	nd	nd	nd	nd	nd	nd	nd	nd
28	339	101	64	178	159	168	80	949	139	175	348	508	332	nd	299
31	82	479	71	161	331	180	12	1214	326	194	815	144	400	nd	296
32	nd	nd	40	nd	nd	140	nd	nd	nd	nd	nd	139	55	nd	nd
33	304	284	59	101	nd	123	48	419	100	206	nd	1762	nd	nd	178
41	26	235	629	276	nd	203	28	686	293	256	250	73	206	nd	nd
42	nd	nd	166	nd	nd	98	nd	nd	nd	nd	nd	nd	nd	nd	nd
47	47	89	402	159	77	160	27	647	133	294	732	103	479	nd	nd
48	40	289	233	134	91	135	32	764	187	300	334	121	132	nd	nd
49	153	135	508	119	145	181	45	1085	139	306	468	336	288	nd	nd
52	202	nd	422	227	131	201	54	1423	164	325	347	nd	140	nd	nd
56	nd	148	347	nd	nd	84	nd	689	nd	nd	411	nd	nd	nd	nd
59	nd	nd	40	nd	nd	10	nd	nd	nd	nd	nd	nd	nd	14	nd
60	nd	85	198	nd	nd	48	9	394	nd	nd	323	nd	nd	nd	nd
63	nd	300	nd	nd	nd	38	16	nd	129	nd	0	nd	nd	17	nd
64	22	142	70	64	nd	74	nd	621	137	400	343	54	110	nd	nd
66	372	121	289	493	251	353	160	3562	nd	413	171	335	380	27	nd
69	nd	105	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
70	215	598	849	425	302	268	74	2543	69	438	550	119	271	nd	nd
74	nd	303	352	408	249	370	nd	2798	220	463	421	nd	475	nd	nd
84	nd	nd	470	902	nd	465	nd	3596	168	525	763	nd	nd	27	297
85	263	1694	297	408	141	229	139	2090	305	531	1325	183	nd	33	241
87	283	1678	236	569	273	397	101	3011	530	544	395	156	142	29	197
92	nd	1478	nd	327	nd	157	42	6615	nd	nd	0	0	0	12	185
95	77	985	234	250	151	161	59	1472	nd	575	415	55	113	17	64
97	45	246	155	209	119	106	48	1524	158	594	0	46	0	28	119
98	nd	nd	nd	nd	nd	nd	nd	1077	166	606	314	nd	nd	nd	nd
99	922	3958	676	1265	658	917	257	nd	nd	619	322	266	279	27	450
101/90	1258	2025	1058	2395	1012	1664	370	11581	126	631	191	558	632	105	633
105	148	2138	148	398	119	237	66	1757	129	656	958	97	117	20	82
110	917	1958	550	1896	818	1302	363	nd	nd	nd	1631	459	0	38	485
118	1357	3985	750	2322	956	1743	402	10829	77	688	284	543	477	106	506
123	nd	215	nd	24	nd	12	nd	12578	383	738	1467	nd	nd	nd	nd
124	nd	nd	nd	nd	nd	nd	nd	55	nd	nd	nd	nd	nd	nd	19

Table 20

PCB congeners (IUPAC) (ng/kg wet weight) in English sole ovaries.

Investigator: Dr. Seiichi Uno

FishID	990033-37	990038,41,42,44,45	990056-60	990073-77	990068-70	990079, 82, 84	990061-63, 65-66	990091-95	990101-105	990106-110	990111-115	990006, 14, 15, 02	990026-30	990138, 141, 143	990128-130, 132, 137
Site	T11B	T11B	T11B	T38	T38	T38	T38	T48	T48	T48	T48	T49	T49	T50	T50
Congener #															
127	nd	2931	nd	nd	nd	nd	nd	2094	653	nd	nd	nd	nd	nd	nd
128	234	1150	231	350	179	194	103	1221	nd	nd	nd	211	nd	24	92
130	nd	2652	nd	404	92	281	nd	360	nd	nd	1634	nd	281	46	nd
132	nd	758	117	403	167	199	nd	1193	114	813	376	nd	63	nd	49
134	nd	nd	nd	nd	nd	13	nd	nd	587	825	377	nd	nd	nd	nd
135	162	nd	209	301	123	179	43	1372	nd	844	233	116	nd	nd	91
136	42	nd	91	128	nd	59	17	399	nd	nd	nd	nd	nd	6	nd
137	166	3837	546	289	104	66	35	892	654	856	nd	756	nd	nd	nd
138	3804	1837	1714	5554	2468	3959	849	27444	150	863	nd	1849	1117	193	1367
141	359	2084	345	696	327	473	85	3285	151	881	3414	192	260	nd	153
146	859	4019	367	999	484	546	151	3070	93	913	858	373	241	59	318
149	448	819	278	925	432	634	148	4735	nd	931	724	313	312	40	271
151	461	nd	339	1091	673	716	167	4397	1366	944	643	267	439	44	228
153	3918	2587	2069	6634	2878	5070	789	30147	343	956	539	1818	1253	255	1867
156	423	1217	122	473	223	261	48	1876	289	975	4000	237	nd	26	73
158	292	7237	148	354	132	257	85	1886	257	988	511	125	nd	14	132
170/190	1620	5993	555	1185	589	nd	247	7176	436	563	1136	806	542	50	459
171	282	nd	nd	221	114	112	56	1163	215	1069	324	228	nd	nd	128
172	nd	3135	302	345	371	138	nd	865	1600	nd	nd	nd	nd	nd	nd
174	764	315	690	651	440	500	154	3378	204	1088	293	818	nd	92	329
175	nd	nd	nd	40	87	nd	nd	170	130	nd	nd	nd	nd	nd	43
176	nd	nd	69	89	nd	nd	nd	432	117	nd	458	nd	nd	nd	35
177	475	5384	293	658	318	nd	105	2739	183	1106	1093	271	nd	25	193
178	291	1893	199	406	nd	nd	40	1293	437	nd	715	216	nd	107	157
179	208	nd	175	319	248	nd	66	1473	nd	1119	233	165	nd	nd	91
180	3113	565	133	4590	1989	nd	655	15821	286	1125	2166	1610	917	213	1155
183	585	3080	227	773	441	nd	136	3531	93	1144	450	296	nd	299	427
185	nd	8815	1117	78	122	nd	nd	1076	867	nd	nd	nd	nd	nd	126
187	821	223	276	985	459	nd	145	4589	180	1169	809	506	327	57	420
191	22	43	0	nd	nd	nd	nd	nd	324	1213	nd	nd	nd	10	nd
194	*	6254	nd	nd	nd	*	*	1759	332	*	nd	*	*	*	222
195	*	nd	236	337	317	*	*	837	nd	*	nd	*	*	*	nd
197	*	nd	nd	162	nd	*	*	154	nd	*	nd	*	*	*	26
199	*	3066	349	730	723	*	*	3841	455	*	830	*	*	*	325
200	*	333	nd	nd	nd	*	*	296	nd	*	nd	*	*	*	nd
201	*	1830	148	49	nd	*	*	521	nd	*	nd	*	*	*	48

Table 20

PCB congeners (IUPAC) (ng/kg wet weight) in English sole ovaries.

Investigator: Dr. Seiichi Uno

FishID	990033-37	990038,41,42,44,45	990056-60	990073-77	990068-70	990079, 82, 84	990061-63, 65-66	990091-95	990101-105	990106-110	990111-115	990006, 14, 15, 02	990026-30	990138, 141, 143	990128-130, 132, 137
Site	T11B	T11B	T11B	T38	T38	T38	T38	T48	T48	T48	T48	T49	T49	T50	T50
Congener #															
203/196	*	nd	nd	415	196	*	*	1794	146	*	1091	*	*	*	137
205	*	nd	nd	nd	nd	*	*	215	nd	*	366	*	*	*	nd
Total PC	26424	96153	20723	44346	20677	24201	6681	212960	14740	31075	36851	17381	10897	2059	13013

nd = not detected
IUPAC = International Union of Pure and Applied Chemistry.
*= not analyzed.

Each value represents one analysis. Each analysis contains tissue either from an individual fish, or equal amounts of tissue from several fish. The Fish ID label indicates which fish are included in each analysis. For instance, 990033-37 indicates that five fish with the ID numbers 990033, 990034, 990035, 990036 and 990037, were combined into one composite sample. Fish ID number 990038,41-42,44-45 indicates that three fish with ID numbers 99038, 99041, 99042, 99044, and 99045 are included in this composite sample.

The method used by Dr. Uno includes supercritical fluid extraction using CO_2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 21

PCB congeners (IUPAC) in English sole testis (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site	T11B	T38	T48	T49	T50
Congener #					
17	nd	nd	nd	nd	nd
18	nd	nd	nd	nd	nd
22	nd	nd	nd	nd	nd
28	nd	208	nd	nd	nd
31	nd	nd	nd	nd	nd
32	nd	nd	nd	nd	nd
33	nd	104	nd	nd	nd
41	nd	nd	nd	nd	nd
42	nd	nd	nd	nd	nd
47	nd	78	nd	nd	nd
48	nd	136	nd	nd	nd
49	103	99	nd	nd	nd
52	nd	91	nd	nd	nd
56	nd	60	nd	nd	nd
59	nd	nd	nd	nd	nd
60	nd	51	nd	nd	nd
63	67	nd	nd	nd	nd
64	nd	nd	nd	nd	nd
66	nd	nd	nd	nd	nd
69	nd	nd	nd	nd	nd
70	140	190	nd	nd	nd
74	nd	257	nd	nd	nd
84	nd	109	nd	nd	nd
85	nd	205	nd	nd	nd
87	nd	221	nd	nd	nd
92	nd	142	nd	nd	nd
95	84	82	nd	nd	nd
97	nd	74	nd	nd	nd
98	nd	nd	nd	nd	nd
99	1491	526	175	175	nd
101/90	344	nd	228	228	nd
105	112	140	147	147	nd
110	1391	691	nd	nd	nd
118	362	948	260	260	nd
123	nd	nd	nd	nd	nd
124	nd	nd	nd	nd	nd
127	nd	nd	nd	nd	nd

Table 21

PCB congeners (IUPAC) in English sole testis (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site	T11B	T38	T48	T49	T50
Congener #					
128	nd	111	nd	nd	nd
130	nd	nd	nd	nd	nd
132	nd	nd	nd	nd	nd
134	nd	130	nd	nd	nd
135	nd	147	nd	nd	nd
136	nd	nd	nd	nd	nd
137	nd	nd	nd	nd	nd
138	7832	2623	587	587	nd
141	nd	0	nd	nd	nd
146	nd	331	nd	nd	nd
149	381	468	111	111	nd
151	213	334	nd	nd	707
153	8922	2515	715	715	nd
156	nd	364	nd	nd	3513
158	125	308	80	80	5708
170/190	297	nd	297	358	nd
171	nd	nd	nd	nd	nd
172	4918	601	nd	nd	nd
174	nd	138	nd	nd	nd
175	nd	64	nd	nd	nd
176	nd	143	nd	nd	nd
177	nd	238	nd	nd	nd
178	nd	482	nd	nd	nd
179	nd	nd	nd	nd	nd
180	2370	1783	766	766	nd
183	259	413	nd	nd	nd
185	4750	nd	211	nd	nd
187	nd	464	nd	211	nd
191	nd	216	nd	nd	nd
194	*	*	*	*	*
195	*	*	*	*	*
197	*	*	*	*	*
199	*	*	*	*	*
200	*	*	*	*	*
201	*	*	*	*	*
203/196	*	*	*	*	*
205	*	*	*	*	*

Table 21
PCB congeners (IUPAC) in English sole testis (ng/kg wet weight).
Investigator: Dr. Seiichi Uno

Site	T11B	T38	T48	T49	T50
Congener #					
Total PCBs	34162	16068	3577	3639	9928

nd = not detected
*= not analyzed

IUPAC = International Union of Pure and Applied Chemistry

Each value represents one analysis. Each analysis is a composite of equal amounts of tissue from all males sampled at each site.

The method used includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 22

Organochlorine pesticides in liver of English sole (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

FishID	Site	HCB	αHCH	βHCH	γHCH	Heptachlor	HeptachlorEIB	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
990011-15	T49	nd	349	474	546	122	nd	242	12551	380	2490	1202	3528
990016-20	T49	nd	490	775	561	30	nd	nd	308	222	459	563	2539
990021-25	T49	nd	403	872	1069	nd	nd	748	2683	670	825	5153	7770
990026-30	T49	nd	nd	699	727	175	nd	410	3843	899	1999	2519	4128
990041-45	T11B	nd	nd	nd	nd	nd	nd	nd	82780	nd	25703	nd	nd
990046-50	T11B	nd	nd	5784	6372	1618	nd	523	4898	2329	2673	2374	4838
990051-55	T11B	nd	483	736	1010	nd	nd	nd	3150	711	742	nd	939
990056-60	T11B	nd	2435	4565	5235	1475	nd	744	3176	1516	3299	4206	3977
990068-70	T38	nd	143	480	355	nd	nd	nd	39	576	281	300	8214
990073-75	T38	nd	1097	913	1838	nd	nd	nd	1691	1531	4362	1607	4056
990081-85	T38	nd	1753	2417	1789	410	nd	nd	4772	2261	2859	2309	3981
990086-90	T38	nd	1180	1392	1682	nd	nd	nd	1112	376	925	1038	2143
990106-109	T48	nd	nd	2296	2476	nd	nd	200	765	nd	951	1570	1581
990111-115	T48	349	1621	1584	1994	354	nd	nd	866	136	565	nd	1448
990116-120	T48	nd	1084	1190	1798	290	nd	nd	5241	nd	1872	81	827
990136-140	T50	252	632	1288	1117	nd	nd	459	250	500	475	563	650
990141-145	T50	nd	nd	3340	4504	nd	nd	nd	nd	1089	19802	nd	4502
990146-150	T50	nd	1370	nd	nd	1754	nd	1682	4716	374	nd	262	949

nd = not detected.

HCB = Hexachlorobenzene; α-HCH = alpha- hexachlorocyclohexane; β-HCH = beta- hexachlorocyclohexane; γ-HCH = gamma- hexachlorocyclohexane;
HeptachlorEIB = heptachlor epoxide Isomer B.

Each value is a single analysis. Each analysis contains equal weight of liver from five fish. The Fish ID number indicates which fish were included in the composite sample.
For instance, Fish ID 990011-15 indicates that tissue from fish number 990011, 990012, 990013, 990014 and 990015 are included in this sample.

The method used by Dr. Uno includes supercritical fluid extraction using CO_2 and 1% methanol with a florisil clean up.
Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 23

Organochlorine pesticides in muscle of English sole (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Fish ID	990010	990001-3	990040	990034-36	990037-39	990072	990066-68	990062, 63, 65	990097-99	990094-96
Site	T49	T49	T11B	T11B	T11B	T38	T38	T38	T48	T48
HCB	154		286	nd	76	444	0		88	
αHCH	59		653	115	416	151	128		nd	
βHCH	978		1005	nd	676	783	385		696	
γHCH	1177		1642.43	nd	606	nd	392		791	
Heptachlor	152		53	nd	nd	nd	nd		nd	
HeptachlorEIB	nd		34	13	nd	nd	nd		nd	
o,p'-DDE	37	nd	37	nd	10	nd	nd	37	44	107
p,p'-DDE	161	481	288	11	27	381	241	224	116	nd
o,p'-DDD	36	nd	56	34	17	384	156	46	64	38
p,p'-DDD	70	36	102	31	22	61	40	134	37	nd
o,p'-DDT	162	nd	118	40	20	nd	nd	nd	64	nd
p,p'-DDT	151	28	206	86	21	26077	7860	38	117	nd

nd = not detected.

HCB = Hexachlorobenzene; α-HCH = alpha- hexachlorocyclohexane; β-HCH = beta- hexachlorocyclohexane;

γ-HCH = gamma hexachlorocyclohexane; heptachlor EIB =heptachlor Epoxide Isomer B

The method used by Dr. Uno includes supercritical fluid extraction using CO_2 and 1% methanol with a florisil clean up.
Samples were analyzed by Gas Chromatography /Mass Spectometry.

Each value represents the analysis of one sample. Each sample is either an indivdiual fish, or a composite made by combining equal amounts of muscle tissue from two or more fish. For instance, the first sample at site T-49 is composed of an individual fish with ID number 990010.
The second sample at site T49 is a composite sample containing muscle tissue from fish with ID numbers 990001, 990002 and 990003.

Table 24

Organochlorine pesticides in ovary of English sole (ng/kg wet weight).

Investigator: Dr Seiichi Uno

Fish ID	990002,6,14,15	990026-30	990033-37	990038,41-42,44-45	990056-60	990061-63,65-66	990068-70	990073-77	990079,82,84	990087-89	990091-95	990096-100	990106-110	990111-115	990126-128	990128-130,132-137
Site	T49	T49	T11B	T11B	T11B	T38	T38	T38	T38	T38	T48	T48	T48	T48	T50	T50
HCB		2612	nd	nd	2415		nd	153	140	81	179		10231	277		4859
αHCH		nd	nd	nd	177		1497	300	942	799	519		8264	1617		10103
βHCH		4855	nd	nd	1930		2454	1025	1363	1152	482		0	1598		nd
γHCH		1404	707	463	3185		3570	1043	1659	1188	611		909	2294		nd
Heptachlor		nd	nd	nd	nd		nd	nd	nd	43	nd		nd	nd		nd
HeptachlorEIB		nd	nd	nd	59		nd	nd	nd	nd	nd		nd	nd		nd
o,p'-DDE	nd	191	2287	nd	25377	39	83	nd	nd	20	38	nd	48	159	nd	nd
p,p'-DDE	81	419	15627	2702	11425	635	148	272	375	108	264	nd	222	81	nd	303
o,p'-DDD	nd	114	4192	3396	8575	106	70	97	24	nd	24	1877	28	nd	19	103
p,p'-DDD	nd	191	5717	4105	10424	221	93	210	72	35	84	3969	115	nd	18	nd
o,p'-DDT	nd	152	2287	28313	34826	546	233	57	261	nd	55	818	135	90	nd	nd
p,p'-DDT	18	267	6479	22186	53006	88	219	175	94	24	29	3343	377	144	nd	nd

nd = not detected.

HCB = Hexachlorobenzene; α-HCH = alpha- hexachlorocyclohexane; β-HCH = beta- hexachlorocyclohexane;

γ-HCH = gamma -hexachlorocyclohexane; heptachlor EIB =heptachlor Epoxide Isomer B

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up.
Samples were analyzed by Gas Chromatography /Mass Spectometry.

Each value represents the analysis of one sample. Each sample is a composite made by combining equal amounts of ovary tissue from two or more fish. For instance, the first sample at site T-49 is composed of ovary tissue from fish with ID numbers 990002, 990006, 9900014 and 990015.

Table 25

DDT and its derivatives in testis of English sole (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Fish ID	Site	o,p'-DDE	p,p'-DDE	o,p'-DDD	p,p'-DDD	o,p'-DDT	p,p'-DDT
All Males	T48	29	158	84	70	nd	nd
All Males	T11B	nd	2681	447	850	nd	291
All Males	T38	nd	750	50	153	nd	161
All Males	T48	0	1858	0	426	0	350
All Males	T50	0	41076	0	0	0	0

nd = not detected.

Each value represents one analysis. Each analysis is a composite of equal amounts of tissue from all males sampled at each site.

The method used includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 26

Metals in muscle of English sole (dry weight).

Investigators: Dr. Alexander Tkalin and Tatiana Lishavskaya

Fish ID	Site	Al	Cu	Co	Cr	Ni	Cd	Pb	Zn	Mn	Fe	Laboratory
		%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	
990002	T49	5.8	1.76	<0.1	<0.2	0.08	0.01	0.19	16.1	0.69	12.2	TINRO-Centre
990005	T49	6.0	1.40	<0.1	<0.2	<0.05	0.01	0.24	15.8	0.66	58.5	TINRO-Centre
990006	T49	6.7	1.09	<0.1	<0.2	<0.05	0.02	0.20	16.8	0.22	14.1	TINRO-Centre
990008	T49	6.2	1.35	<0.1	<0.2	0.54	0.01	0.23	15.8	0.54	20.8	TINRO-Centre
990009	T49	6.3	1.50	<0.1	<0.2	0.90	0.03	0.30	15.0	0.45	15.0	TINRO-Centre
990033	T11B	6.5	0.94	<0.1	<0.2	<0.05	0.05	0.47	17.3	0.28	11.3	TINRO-Centre
990034	T11B	6.4	1.12	<0.1	<0.2	0.38	0.01	0.80	17.6	0.40	13.6	TINRO-Centre
990035	T11B	5.9	1.23	<0.1	<0.2	<0.05	0.03	0.68	19.8	0.82	23.2	TINRO-Centre
990036	T11B	7.2	1.66	<0.1	<0.2	<0.05	0.01	0.61	14.0	0.44	10.5	TINRO-Centre
990041	T11B	5.8	1.00	<0.1	<0.2	<0.05	0.02	0.56	16.2	0.56	38.1	TINRO-Centre
990068	T38	6.3	1.27	<0.1	<0.2	<0.05	0.05	0.26	22.7	0.32	27.5	TINRO-Centre
990069	T38	6.5	1.22	<0.1	<0.2	<0.05	0.03	0.23	25.8	0.28	18.8	TINRO-Centre
990070	T38	6.8	0.79	<0.1	<0.2	<0.05	0.01	0.36	20.4	0.29	17.2	TINRO-Centre
990071	T38	7.2	1.50	<0.1	<0.2	0.42	0.01	0.47	24.7	0.19	13.3	TINRO-Centre
990072	T38	7.2	1.27	<0.1	<0.2	<0.05	0.01	0.58	24.8	0.23	19.6	TINRO-Centre
990091	T48	7.3	1.25	<0.1	<0.2	0.38	0.03	0.21	18.8	0.28	18.1	TINRO-Centre
990092	T48	6.2	3.02	<0.1	<0.2	<0.05	0.04	0.21	16.7	0.21	15.6	TINRO-Centre
990093	T48	7.5	1.23	<0.1	<0.2	<0.05	0.10	0.88	17.2	0.24	14.8	TINRO-Centre
990094	T48	7.4	1.14	<0.1	<0.2	<0.05	0.02	0.75	17.0	0.28	13.6	TINRO-Centre
990096	T48	7.2	0.95	<0.1	<0.2	<0.05	0.02	0.53	15.8	0.32	12.7	TINRO-Centre
990121	T50	6.8	1.41	<0.1	<0.2	<0.05	0.02	0.35	22.6	0.35	17.0	TINRO-Centre
990122	T50	6.5	1.84	<0.1	<0.2	<0.05	0.07	0.26	21.6	0.26	26.7	TINRO-Centre
990123	T50	5.9	1.44	<0.1	<0.2	<0.05	0.01	0.51	16.4	0.30	17.0	TINRO-Centre
990124	T50	6.4	1.13	<0.1	<0.2	<0.05	0.02	0.39	19.8	0.14	17.0	TINRO-Centre
990125	T50	6.3	1.42	<0.1	<0.2	<0.05	0.01	0.51	21.3	0.20	12.7	TINRO-Centre

TINRO-Centre = Pacific Research Centre of Fisheries and Oceanography , Vladivostok, Russia

Five fish from each site were indivdiually analyzed for metals.

Table 27

Polycyclic aromatic hydrocarbons in bivalves (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site	I2	I2	I4	I4	I4	I4	I6	I6	I6
Species	Pacific Little Neck	Butter Clam	Pacific Little Neck	Butter Clam	Nuttall's Cockle	Pacific Little Neck	Pacific Little Neck	Butter Clam	Pacific Oyster
Analyte									
Naphthalene	2.32	2.94	2.26	1.39	2.84	2.51	2.07	2.33	4.40
1-Methynaphthalene	4.27	4.53	4.47	1.93	8.46	6.39	2.86	4.27	9.64
2-Methynaphthalene	5.53	4.51	5.84	2.73	10.95	9.60	3.92	5.70	12.73
Biphenyl	4.24	4.87	4.36	2.40	5.63	4.29	3.02	4.66	8.65
Acenaphthylene	0.36	0.82	0.30	0.19	0.32	0.28	0.27	0.48	2.02
Dimethylnaphthalene	0.22	0.56	0.14	0.11	0.77	0.16	0.45	0.13	2.44
Acenaphthene	2.50	3.04	1.95	1.81	2.54	2.45	1.52	2.32	6.01
Fluorene	1.77	2.07	1.26	0.79	1.62	1.79	0.97	1.73	3.20
Dibenzothiophene	1.53	2.21	1.16	1.08	1.63	1.60	0.96	1.29	3.98
Phenanthrene	9.86	8.92	7.74	5.63	12.80	14.74	5.58	10.47	31.71
Anthracene	1.41	1.49	0.75	0.63	1.14	2.35	0.71	0.83	7.95
Dimethyldibenzothiophene	0.31	1.14	0.18	0.14	0.66	0.43	0.73	1.05	0.00
Fluoranthene	15.53	9.23	14.50	6.92	25.31	22.89	12.23	13.13	107.00
Pyrene	13.18	8.08	11.00	7.16	18.78	16.52	7.62	11.10	80.09
1,2-Benzoanthracene	2.18	1.34	1.22	1.78	8.29	7.77	0.82	0.93	14.15
Chrysene	3.80	17.06	2.94	2.30	12.23	13.10	1.78	2.66	38.61
Benzo(b)fluorancene	1.39	1.95	0.41	1.17	4.46	2.59	0.97	1.40	19.44
Benzo(k)fluorancene	0.85	1.26	0.41	1.08	3.86	1.48	0.54	0.83	12.14
Benzo(a)pyrene	0.15	0.90	0.10	0.93	2.58	0.28	0.43	0.24	1.23
Indeno(1,2,3-cd)pyrene	0.03	0.08	0.06	0.00	0.31	0.09	0.31	0.14	0.14
Dibenz(a,h)anthracene	0.04	0.06	0.08	0.71	0.37	0.09	0.13	0.15	0.27
Benzo(g,h,I)perylene	0.05	0.02	0.10	0.26	1.21	0.12	0.91	0.19	0.89

The analysis method used by Dr. Uno includes supercritical fluid extraction using CO_2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

One composite sample was analyzed for each species, at each site. Tissue from 3 to 15 animals of the same species were combined for each composite sample.

Table 28

Polycyclic aromatic hydrocarbons in *Mytilus trossulus* (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site	I1	I2	I3A	I3B	I3C	I4	I5B	I6	I7
Analyte									
Naphthalene	2.84	3.30	4.12	2.84	4.60	3.89	3.18	4.30	2.92
1-Methynaphthalene	6.27	6.82	6.66	8.10	8.95	13.38	9.03	8.01	7.33
2-Methynaphthalene	6.45	6.74	6.49	8.01	8.86	10.83	9.60	8.12	7.49
Biphenyl	3.25	3.62	3.37	4.22	4.51	4.72	4.64	3.93	3.69
Acenaphthylene	0.40	0.38	0.60	0.52	0.43	1.51	0.23	0.85	0.44
Dimethylnaphthalene	0.13	0.17	0.00	0.08	1.69	0.53	0.12	0.26	0.34
Acenaphthene	1.78	2.22	2.13	2.43	3.63	3.55	1.99	3.37	2.63
Fluorene	1.34	1.26	1.29	1.42	1.58	1.58	1.64	1.42	1.39
Dibenzothiophene	1.21	1.48	1.76	1.68	1.89	2.74	0.53	3.38	1.31
Phenanthrene	12.67	13.17	16.69	11.18	19.13	34.56	2.48	44.51	13.95
Anthracene	1.27	1.22	2.03	1.03	1.94	3.20	0.21	2.79	1.16
Dimethyldibenzothiophene	1.09	0.14	0.63	0.56	0.51	1.98	0.24	2.28	0.49
Fluoranthene	30.90	24.22	35.99	12.63	32.92	80.52	4.75	55.89	42.23
Pyrene	15.15	13.69	23.39	9.65	18.97	46.02	2.86	29.81	19.73
1,2-Benzoanthracene	3.97	3.34	6.75	1.49	3.07	8.18	0.58	3.67	2.79
Chrysene	9.11	7.35	16.59	3.69	9.05	19.17	2.34	10.65	8.68
Benzo(b)fluorancene	1.40	1.58	6.76	1.27	3.34	6.72	0.37	2.41	1.93
Benzo(k)fluorancene	2.28	2.15	2.19	2.42	2.69	2.70	2.80	2.43	2.38
Benzo(a)pyrene	0.21	0.19	0.20	0.22	0.24	0.24	0.25	0.22	0.22
Indeno(1,2,3-cd)pyrene	0.00	0.00	0.02	0.00	0.00	0.37	0.02	0.05	0.08
Dibenz(a,h)anthracene	0.00	0.33	0.86	1.68	2.72	3.55	4.56	4.52	4.99
Benzo(g,h,I)perylene	0.00	0.57	0.95	0.97	1.08	1.74	0.11	1.71	1.55

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

One composite sample was analyzed at each site. Tissue from 15 mussels were combined for each composite sample.

Table 29

PCB congeners (IUPAC) in bivalves (ng/kg wet weight) at site I4.

Investigator: Dr. Seiichi Uno

Species	Pacific Littleneck	Nuttall's Cockle	Butter Clam
Congener #			
16	0.00	0.00	0.00
17	61.69	111.03	200.13
18	132.92	385.82	695.44
28	121.60	0.00	0.00
31	185.01	0.00	0.00
33	94.23	0.00	0.00
40	0.00	0.00	144.25
41	29.51	35.27	125.60
42	0.00	63.50	154.85
44	159.22	226.08	134.46
45	0.00	391.59	0.00
47	65.74	58.58	97.33
48	114.87	102.36	79.50
49	94.92	66.92	134.77
52	138.31	120.57	192.15
53	0.00	0.00	637.97
59	0.00	13.64	97.33
60	41.36	61.84	410.93
64	49.31	58.94	25.40
66	212.90	365.23	69.31
70	223.85	220.69	24.30
74	301.27	191.54	469.89
82	63.35	85.29	197.12
84	80.62	129.18	39.22
85	85.61	119.05	195.84
87	117.63	144.77	159.32
92	82.58	104.67	288.19
95	103.84	124.45	159.25
97	41.74	61.75	73.88
99	189.97	324.76	96.26
101/90	799.29	572.23	831.53
105	45.80	112.49	30.06
110	455.86	726.92	116.50
118	340.39	566.66	476.15
128	49.75	87.48	49.50
130	26.99	0.00	0.00
132	45.84	33.41	0.00

Table 29

PCB congeners (IUPAC) in bivalves (ng/kg wet weight) at site I4.

Investigator: Dr. Seiichi Uno

Species	Pacific Littleneck	Nuttall's Cockle	Butter Clam
Congener #			
16	0.00	0.00	0.00
135	58.41	64.08	357.39
136	20.07	15.84	249.83
138	734.27	740.72	13.24
146	97.05	78.89	22.09
149	155.86	198.87	17.89
151	116.80	107.61	21.50
153	611.49	552.63	16.89
156	69.56	60.64	63.52
158	71.04	78.96	33.47
167	17.52	0.00	0.00
171	0.00	44.23	27.00
174	79.23	79.53	35.31
176	122.18	0.00	329.53
177	0.00	73.16	28.91
178	0.00	189.89	0.00
179	0.00	0.00	0.00
180	336.61	152.76	6.37
183	515.65	791.34	9.00
185	0.00	57.77	0.00
187	77.44	0.00	59.51
170/190	123.50	147.04	979.87

IUPAC = International Union of Pure and Applied Chemistry.

Each value represents one analysis. Each analysis contains tissue from 3 to 15 individuals of the same species.

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 30

PCB congeners (IUAPC) in *Mytilus trossulus* (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site / **Congener #**	I1	I2	I3A	I3B	I3C	I4	I5	I6	I7
16	0.00	0.00	0.00	0.00	0.00	75.83	0.00	0.00	0.00
17	1.88	0.00	1.90	7.00	10.80	13.29	0.00	17.40	4.45
18	4.56	0.00	4.20	13.80	30.70	33.41	0.00	17.82	5.83
28	69.44	0.00	107.50	84.58	108.87	246.66	0.00	137.25	40.65
31	4.92	0.00	7.10	4.00	6.73	13.73	0.00	15.23	2.14
32	0.00	0.00	0.00	0.00	0.00	16.30	37.35	31.60	25.04
33	10.97	0.00	12.53	13.49	23.03	26.43	3.27	27.22	9.77
41	8.74	8.81	11.26	15.91	18.58	30.96	2.23	24.68	7.40
42	2.50	0.00	0.00	5.60	0.00	2.64	0.00	5.36	0.00
44	37.23	41.40	70.37	37.10	69.52	5.30	9.41	84.15	19.11
45	0.00	0.00	0.00	2.80	3.20	2.67	1.90	6.77	2.26
47	2.68	4.05	9.93	4.70	2.83	16.12	0.00	6.40	2.04
48	3.35	0.67	4.50	0.00	2.20	14.11	0.00	6.18	3.00
49	6.21	4.10	10.34	5.60	9.86	20.40	2.61	15.83	3.30
52	53.29	37.12	126.27	72.70	87.54	381.59	12.59	149.90	31.68
59	0.00	0.00	4.50	1.27	5.30	6.14	0.00	2.62	0.00
60	4.39	2.10	6.29	6.34	6.51	17.52	15.09	12.14	6.35
64	5.49	1.69	5.74	5.08	4.20	4.60	1.85	9.78	0.76
66	50.21	34.85	137.27	74.84	83.75	297.62	0.00	187.79	24.57
70	9.31	6.48	21.83	13.56	16.96	56.27	5.77	27.47	8.03
74	111.64	83.29	222.69	130.78	118.61	460.99	37.38	536.88	56.28
84	3.87	0.00	9.50	6.60	5.30	27.22	0.00	9.30	0.00
85	3.75	2.90	10.33	6.45	5.87	23.21	0.00	8.07	1.60
87	33.18	28.10	119.67	41.27	64.27	295.21	10.87	88.54	6.10
91	0.77	0.00	3.14	0.00	0.00	5.83	0.00	3.49	0.00
92	3.69	3.26	12.27	5.20	6.15	21.98	0.00	10.33	0.00
95	9.26	6.36	38.21	18.78	18.93	79.39	0.00	33.11	3.89
97	4.43	4.20	17.79	10.57	7.54	38.79	0.00	15.17	1.92
99	63.95	56.78	258.38	127.25	125.00	469.33	0.00	220.48	37.17
101/90	17.41	16.48	87.39	39.94	39.71	150.73	2.40	68.34	7.57
105	5.07	6.25	21.32	12.33	9.64	39.42	0.00	19.97	3.29
110	88.94	58.15	327.28	160.00	161.38	727.85	19.61	307.28	29.86
118	17.13	15.50	72.85	35.53	34.77	130.90	3.48	60.73	8.68
128	4.76	3.40	22.25	9.75	9.85	34.00	0.00	17.95	1.40

Table 30

PCB congeners (IUAPC) in *Mytilus trossulus* (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site / **Congener #**	I1	I2	I3A	I3B	I3C	I4	I5	I6	I7
135	3.22	2.47	23.12	9.48	8.00	21.79	0.00	13.86	0.00
136	2.02	0.88	11.39	4.66	3.78	12.76	0.00	2.86	0.70
138	204.68	212.04	1209.08	520.96	417.03	1250.18	15.59	837.17	92.48
141	0.00	0.00	8.34	0.00	0.00	7.10	0.00	3.49	0.00
146	26.03	31.41	187.35	80.36	60.23	182.97	0.00	124.61	12.30
149	14.10	13.03	95.47	38.73	31.64	90.95	1.83	54.86	4.77
151	5.76	6.06	41.03	16.69	12.30	33.00	0.00	22.93	2.20
153	205.62	215.31	1327.79	550.00	435.84	1219.04	9.59	895.87	86.37
156	0.00	3.40	13.22	7.42	4.70	15.28	0.00	7.01	1.20
158	3.03	2.80	12.99	6.00	4.60	15.64	0.00	8.80	0.00
167	0.00	0.00	7.84	4.23	2.20	8.28	0.00	3.38	0.00
190/170	2.95	3.50	22.77	6.14	4.90	6.95	1.05	14.14	0.00
171	0.65	1.30	9.45	4.34	4.05	5.41	0.00	4.47	0.00
176	0.00	1.20	5.09	1.46	0.00	3.60	0.00	2.72	0.00
177	31.36	15.00	91.74	62.89	48.03	84.34	0.00	99.79	8.00
178	2.56	2.20	9.13	3.68	2.80	4.22	0.00	5.21	0.00
179	18.80	21.16	117.73	46.19	38.76	69.01	0.00	62.91	0.00
180	31.46	23.94	191.18	59.52	44.40	105.26	0.00	108.19	7.70
183	4.25	5.06	27.52	10.89	7.58	14.43	0.00	16.58	1.42
187	69.09	71.69	398.96	163.95	138.94	248.75	0.00	288.92	29.49
193	0.00	0.00	3.27	1.40	0.00	0.00	0.00	1.80	0.00

IUPAC = International Union of Pure and Applied Chemistry.

Each value represents one analysis. Each analysis contains tissue from 15 mussels.

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

Table 31

PCB congeners (IUPAC) in Pacific Oyster from site I6 (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Congener #	
16/32	748.29
17	20.92
18	129.57
22	783.47
25	193.49
26	4554.82
28	98.16
31	38.39
33	108.85
37	0.00
40	236.24
41	225.78
42	0.00
44	0.00
45	174.36
46	0.00
47	48.23
48	0.00
49	28.77
51	0.00
52	334.18
53	0.00
59	19.57
60/56	28.02
64	49.69
66	2326.49
70	38.28
74	4284.54
82	0.00
84	67.13
85	44.55
87	675.94
91	39.23
92	53.51
95	108.08
97	80.16
99	293.13
101/90	251.11
105	70.02

Table 31

PCB congeners (IUPAC) in Pacific Oyster from site I6 (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Congener #	
110	1579.32
118	231.77
128	58.30
130	0.00
134	0.00
135	57.38
136	26.72
137	21.29
138	4029.32
141	14.87
146	504.46
149	247.02
151	109.54
153	5070.36
156	1.66
158	46.22
167	46.94
170/190	0.00
171	16.87
174	0.00
176	24.86
177	258.08
178	24.64
179	290.23
180	134.68
183	37.51
187	1340.47
193	0.00

IUPAC = International Union of Pure and Applied Chemistry.

Each value represents one analysis. Each analysis contains tissue from several oysters

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed with Gas Chromatography/Mass Spectometry.

Table 32

Organochlorine pesticides in bivalves from site I-4 (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Species	Pacific Little Neck	Nuttall's Cockle	Butter Clam
analyte			
aHCH	6003.79	4264.33	13751.08
ßHCH	749.73	736.15	657.47
γHCH	1032.40	849.01	0.00
Heptachlors	969.60	3227.50	2687.56
o,p'-DDE	76.91	183.17	189.45
p,p'-DDE	120.84	185.74	103.68
o,p'-DDD	119.48	42.21	60.59
p,p'-DDD	567.70	5298.81	1090.76
o,p'-DDT	114.95	112.23	0.00
p,p'-DDT	189.44	318.46	56.44

α-HCH = alpha hexachlorocyclohexane; β-HCH = beta hexachlorocyclohexane;

γ-HCH gamma hexachlorocyclohexane.

The method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

One composite sample was analyzed for each species. Tissue from 3 to 15 individuals of the same species were combined for each composite sample.

Table 33

Organochlorine pesticides in *Mytilus trossulus* (ng/kg wet weight).

Investigator: Dr. Seiichi Uno

Site	I1	I2	I3A	I3B	I3C	I4	I5B	I6	I7
Analyte									
αHCH	1478.09	1320.64	1394.70	1132.02	932.97	1270.27	267.36	1946.52	887.15
ßHCH	435.11	1186.71	2095.53	1253.16	3218.42	749.68	1387.19	1918.38	688.97
γHCH	241.04	1446.59	2253.23	1244.46	3403.28	835.46	891.69	1849.10	767.13
Heptachlor	692.05	343.90	528.06	208.45	214.10	862.15	524.91	868.96	622.91
HeptaEIB	48.22	0.00	4.65	0.00	0.00	29.04	0.00	87.55	24.58
o,p'-DDE	118.65	0.00	68.74	70.56	74.77	188.34	0.00	0.00	0.00
p,p'-DDE	648.43	277.34	384.98	422.48	454.86	721.17	40.38	789.76	480.19
o,p'-DDD	0.00	0.00	0.00	0.00	66.22	88.54	0.00	95.73	134.84
p,p'-DDD	84.10	40.89	94.16	55.44	7677.27	247.67	50.38	258.87	131.17
o,p'-DDT	0.00	30.41	0.00	0.00	58.81	129.93	0.00	189.96	37.10
p,p'-DDT	0.00	78.98	179.73	272.33	703.42	1203.70	35.06	427.42	161.48

α-HCH = alpha hexachlorocyclohexane; β-HCH = beta hexachlorocyclohexane;

γ-HCH gamma hexachlorocyclohexane; HeptEIB = Heptachlor Epoxide Isomer B

The analysis method used by Dr. Uno includes supercritical fluid extraction using CO2 and 1% methanol with a florisil clean up. Samples were analyzed by Gas Chromatography /Mass Spectometry.

One composite sample was analyzed at each site. Tissue from 15 mussels were combined for each composite sample.

Table 34

Metals in the mussel *Mytilus trossulus* (ppm dry weight).

Investigators: Dr. Alexander Tkalin and Tatiana Lishavskaya

Site	Al	Cu	Co	Cr	Ni	Cd	Pb	Zn	Mn	Fe	Laboratory
I1	50	6.7	0.2	0.3	0.6	2.8	1.0	112	8.6	240	TINRO-Centre
I3A	62	9.9	0.4	0.4	1.2	3.8	7.9	325	11.3	336	TINRO-Centre
I6	50	6.1	0.1	0.1	0.7	1.7	2.9	146	7.4	197	TINRO-Centre
I6*	77	165.0	0.2	0.2	0.7	4.0	1.7	2700	32.0	195	TINRO-Centre
I2A	255	60.8	0.3	0.3	1.5	5.9	218.7	179	17.9	530	TINRO-Centre
I4	68	8.8	0.2	0.2	1.0	2.3	3.0	168	7.9	197	TINRO-Centre
I5B	64	6.3	0.1	0.1	0.6	2.2	2.0	156	7.5	150	TINRO-Centre
I7	52	7.0	0.2	0.2	0.8	3.2	2.0	165	7.0	170	TINRO-Centre
I1		9.6			3.0		<4.0	145	13.0	352	PGI RAS
I3A		15.4			4.7		11.0	459	17.0	638	PGI RAS
I6		9.0			2.4		<4.0	197	12.0	319	PGI RAS
I6*		233.4			2.2		<4.0	3169	46.0	299	PGI RAS
I2A		99.1			5.2		299.0	698	28.0	857	PGI RAS
I4		14.4			4.4		<4.0	276	13.0	419	PGI RAS
I5B		8.4			2.4		<4.0	188	10.0	220	PGI RAS
I7		9.5			3.1		<4.0	207	12.0	259	PGI RAS
I1		10.5				4.0		98	8.0	285	POI FEB RAS
I3A		10.7				4.5	14.7	276	13.5	407	POI FEB RAS
I6		10.3				2.8		135	8.1	247	POI FEB RAS
I6*											POI FEB RAS
I2A		55.7				7.3	237.0	385	17.7	478	POI FEB RAS
I4		15.1				4.1		181	8.0	276	POI FEB RAS
I5B		7.8				2.9	11.7	138	9.6	193	POI FEB RAS
I7		11.1				4.3		141	6.7	236	POI FEB RAS

I6* = oyster

TINRO-Centre = Pacific Research Centre of Fisheries and Oceanography , Vladivostok, Russia

PGI FEB RAS = Pacific Geographical Institute, Far East Branch, Russian Academy of Sciences, Vladivostok, Russia

POI FEB RAS = Pacific Oceanological Institute, Far East Branch, Russian Academy of Sciences, Vladivostok, Russia

Approximately 30 mussels were combined and analyzed at each site.

Table 35

Tributyltin (ng/g wet weight) in mussels *(M. trossulus)* from Vancouver Harbour.

Investigator: Dr. Toshihiro Horiguchi

Site	Species	Butyltin	Dibutyltin	Tributyltin
I1	Foolish Mussel	27.5	31.4	33.6
I2	Foolish Mussel	32.4	73	120.8
I3A	Foolish Mussel	91.8	222.6	120
I4	Foolish Mussel	12.7	61.1	173.2
I5B	Foolish Mussel	13.1	27.4	87.2
I6	Foolish Mussel	16.3	47.4	51.4
I7	Foolish Mussel	12.3	13.6	14.8

Each value is one analysis of a composite of 5-12 individuals

Table 36

Tributyltin (ng/g wet weight) in all molluscs sampled from Vancouver Harbour and Victoria.

Investigator: Dr. Toshihiro Horiguchi

Site	Species	butyltin	dibutyltin	tributyltin	Sex
Clover Pt.	*Nucella lima*	14.4	bd	14.4	m
Clover Pt.	*Nucella lima*	9.6	bd	9.6	f
Ogden Pt.	*Nucella lima*	2.3	bd	9.4	m
Ogden Pt.	*Nucella lima*	2.4	4.7	2.4	f
Ten Mile Pt.	*Nucella lima*	7	bd	7	m
Ten Mile Pt.	*Nucella lima*	bd	bd	7.3	f
Ten Mile Pt.	*Nucella lima*	bd	4.3	6.5	m
Ten Mile Pt.	*Nucella lima*	8.7	bd	8.7	f
Mission Pt.	*Nucella lima*	12.2	9.8	22	m
Mission Pt.	*Nucella lima*	bd	12.5	21.9	f
I4	Pacific little neck	23.9	19.5	143.2	
I4	Horse clam	6.9	57.5	2230	
I4	Nuttall's cockle	7.1	14.3	166.3	
I4	Softshell-clam	17.4	67.2	435.3	
I4	Butter clam	bd	9.3	201.4	
I4	Foolish mussel	12.7	61.1	173.2	
I1	Pacific oyster	bd	17.2	86	
I1	Foolish mussel	27.5	31.4	33.6	
I6	Japanese littleneck	19.7	9.9	105.9	
I6	Pacific littleneck	20	bd	30	
I6	Pacific oyster	bd	19.7	103.2	
I6	Butter clam	7.4	22.1	63.9	
I6	Foolish mussel	16.3	47.4	51.4	
I2	Pacific littleneck	16.9	24.2	152.2	
I2	Butter clam	bd	27.3	89.3	
I2	Foolish mussel	32.4	73	120.8	
T49	Milky venus	14.7	17.2	27	
I7	Pacific oyster	bd	bd	29.6	
I7	Dark mahogany clam	bd	bd	14.5	
I7	Foolish mussel	12.3	13.6	14.8	

For bivalves, each value shown in this table represents one analysis of a composite of 5-12 individuals, without regard to sex.

For gastropods, each value shown in this table represents one analysis of a composite of 6-18 individuals, either male or female.

bd=below detection limits

Table 37

Lipid Composition in *Mytilus trossulus* (%).

Investigator: Dr. Seiichi Uno

Site	TG	FFA	ST	PL	Phospholipid Components				
					PE	Unknown	CAEP+PS+LPE	PC	LPC
I1	15.29	33.76	3.84	45.97	30.70	0.00	53.23	11.92	4.15
I2	11.90	33.87	3.93	48.13	27.31	3.20	47.11	17.63	4.76
I3A	14.10	24.28	6.48	53.17	36.91	0.74	28.06	25.38	8.91
I4	9.73	38.80	7.40	42.77	30.53	0.00	49.74	16.27	3.46
I5B	10.93	28.30	5.73	55.10	29.72	0.00	41.20	22.10	6.98
I6	17.80	33.00	6.08	42.70	36.33	0.00	41.58	18.10	3.98
I7	23.39	36.53	5.17	35.50	28.53	1.37	55.22	11.09	3.78

TG = triglyceride
FFA = free fatty acid
ST = sterol
PL = phospholipid
PE= phosphatidylethanolamine
CAEP = Ceramide 2-aminoethylphosphonate
PS = phosphatidylserine
LPE = Lysophosphatidylethanolamine
PC= Phosphatidylcholine
LPC = Lysophosphatidylcholine

Tissue from approximately 15 mussels were combinded and analyzed for each site.

Table 38
Fatty acids in *Mytilus trossulus* (%).
Investigator: Dr. Seiichi Uno

Fatty Acid	Total lipid	Nonpolar lipid	Phospholipid	Site
14:0	3.59	3.69	2.88	I1
16:0	18.87	19.32	15.55	I1
16:1n-7	5.04	4.22	11.23	I1
16:2n-7	1.91	2.17	1.61	I1
17:0	1.89	1.93		I1
18:0	2.84	2.85	2.80	I1
18:1n-9	3.07	3.21	1.96	I1
18:1n-7	5.87	6.15	3.74	I1
18:2n-6	2.21	2.33	1.31	I1
18:3n-3	2.99	3.29		I1
18:4n-3	7.11	7.66	2.97	I1
20:1n-11	0.77	0.65	1.68	I1
20:1n-9	1.46	1.24	3.10	I1
20:1n-7	4.16	4.42	2.23	I1
20:2A	3.41	3.50	2.73	I1
20:2B	1.14	1.13	1.16	I1
20:2n-6	1.17	1.22	0.81	I1
20:4n-6	2.00	2.07	1.52	I1
20:5n-3	8.81	7.23	20.66	I1
22:1n-11	3.34	3.16	4.69	I1
22:5n-3	1.64	1.71	1.13	I1
22:6n-3	8.12	7.64	11.71	I1
14:0	2.40	2.38	2.47	I2
16:0	15.97	15.37	17.54	I2
16:1n-7	8.51	8.26	9.18	I2
16:2n-7	1.02	1.41	1.57	I2
17:0	1.50	1.47		I2
18:0	2.83	2.73	3.10	I2
18:1n-9	2.25	2.89	0.58	I2
18:1n-7	4.33	4.74	3.26	I2
18:2n-6	1.44	1.61	1.00	I2
18:3n-3	1.85	2.06		I2
18:4n-3	4.30	4.96	2.56	I2
20:1n-11	1.01	0.87	1.36	I2
20:1n-9	4.22	4.67	3.04	I2
20:1n-7	3.03	3.31	2.32	I2
20:2A	1.74	1.28	2.93	I2
20:2B	0.71	0.66	0.86	I2
20:2n-6	0.96	1.05	0.73	I2
20:4n-6	1.87	1.95	1.64	I2

Table 38
Fatty acids in *Mytilus trossulus* (%).
Investigator: Dr. Seiichi Uno

Fatty Acid	Total lipid	Nonpolar lipid	Phospholipid	Site
20:5n-3	15.32	13.00	21.40	I2
22:1n-11	3.57	3.10	4.80	I2
22:5n-3	1.45	1.55	1.19	I2
22:6n-3	14.53	14.93	13.48	I2
14:0	1.86	2.02	1.58	I3A
16:0	15.94	16.46	15.02	I3A
16:1n-7	8.43	9.60	6.36	I3A
16:2n-7	0.77	1.21	1.58	I3A
17:0	1.53	1.50		I3A
18:0	3.07	3.04	3.13	I3A
18:1n-9	2.61	3.24	1.50	I3A
18:1n-7	4.81	5.78	3.11	I3A
18:2n-6	1.62	1.94	1.05	I3A
18:3n-3	1.29	2.02		I3A
18:4n-3	3.67	4.68	1.88	I3A
20:1n-11	1.52	1.64	1.31	I3A
20:1n-9	5.17	6.05	3.61	I3A
20:1n-7	2.64	2.79	2.36	I3A
20:2A	3.21	2.35	4.73	I3A
20:2B	1.18	0.93	1.63	I3A
20:2n-6	0.91	1.01	0.73	I3A
20:4n-6	3.37	3.82	2.59	I3A
20:5n-3	11.01	5.39	20.95	I3A
22:1n-11	5.07	4.65	5.80	I3A
22:5n-3	1.86	2.13	1.38	I3A
22:6n-3	11.85	10.21	14.76	I3A
14:0	3.03	3.21	2.78	I4
16:0	15.48	15.30	15.73	I4
16:1n-7	6.53	4.40	9.44	I4
16:2n-7	0.78	1.35	1.52	I4
17:0	1.43	1.36		I4
18:0	2.65	2.52	2.81	I4
18:1n-9	2.34	2.76	1.77	I4
18:1n-7	4.59	5.31	3.60	I4
18:2n-6	2.11	2.49	1.59	I4
18:3n-3	2.53	3.14		I4
18:4n-3	5.06	6.60	2.98	I4
20:1n-11	1.09	0.91	1.32	I4
20:1n-9	3.34	3.37	3.31	I4
20:1n-7	3.08	3.46	2.57	I4

Table 38
Fatty acids in *Mytilus trossulus* (%).
Investigator: Dr. Seiichi Uno

Fatty Acid	Total lipid	Nonpolar lipid	Phospholipid	Site
20:2A	1.94	1.15	3.00	I4
20:2B	1.04	0.89	1.25	I4
20:2n-6	1.09	1.25	0.87	I4
20:4n-6	1.96	2.08	1.80	I4
20:5n-3	17.59	16.92	18.50	I4
22:1n-11	4.10	3.31	5.18	I4
22:5n-3	1.53	1.71	1.28	I4
22:6n-3	11.35	10.21	12.89	I4
14:0	3.39	3.55	3.12	I5B
16:0	15.71	16.04	15.14	I5B
16:1n-7	6.51	3.71	11.29	I5B
16:2n-7	0.96	1.52	1.15	I5B
17:0	1.26	1.32		I5B
18:0	2.51	2.40	2.70	I5B
18:1n-9	2.96	3.52	2.00	I5B
18:1n-7	4.84	5.42	3.85	I5B
18:2n-6	2.61	3.13	1.73	I5B
18:3n-3	3.38	3.43		I5B
18:4n-3	4.80	7.60	3.31	I5B
20:1n-11	1.11	0.90	1.47	I5B
20:1n-9	3.48	3.83	2.89	I5B
20:1n-7	2.98	3.38	2.29	I5B
20:2A	1.87	1.15	3.11	I5B
20:2B	0.73	0.72	0.76	I5B
20:2n-6	1.32	1.36	1.24	I5B
20:4n-6	1.66	1.82	1.38	I5B
20:5n-3	16.83	15.07	19.83	I5B
22:1n-11	3.60	3.08	4.48	I5B
22:5n-3	1.61	1.64	1.56	I5B
22:6n-3	9.32	8.22	11.19	I5B
14:0	2.86	2.84	2.95	I6
16:0	15.91	15.83	16.21	I6
16:1n-7	6.66	5.67	10.25	I6
16:2n-7	0.98	1.25	1.47	I6
17:0	1.49	1.50		I6
18:0	2.67	2.66	2.71	I6
18:1n-9	2.74	2.96	1.93	I6
18:1n-7	5.07	5.44	3.71	I6
18:2n-6	2.40	2.56	1.80	I6
18:3n-3	2.24	2.85		I6

Table 38
Fatty acids in *Mytilus trossulus* (%).
Investigator: Dr. Seiichi Uno

Fatty Acid	Total lipid	Nonpolar lipid	Phospholipid	Site
18:4n-3	5.28	6.07	2.42	I6
20:1n-11	1.15	0.90	2.08	I6
20:1n-9	4.31	4.67	3.01	I6
20:1n-7	3.49	3.78	2.42	I6
20:2A	1.65	1.05	3.85	I6
20:2B	0.87	0.83	0.99	I6
20:2n-6	1.21	1.27	1.01	I6
20:4n-6	2.42	2.61	1.75	I6
20:5n-3	14.47	13.59	17.71	I6
22:1n-11	4.14	3.71	5.70	I6
22:5n-3	1.78	1.91	1.31	I6
22:6n-3	9.43	8.91	11.35	I6
14:0	5.40	5.68	4.39	I7
16:0	14.95	15.34	13.54	I7
16:1n-7	10.64	9.16	16.03	I7
16:2n-7	1.51	1.93	1.37	I7
17:0	1.59	1.65		I7
18:0	2.18	2.16	2.26	I7
18:1n-9	2.61	2.92	1.50	I7
18:1n-7	6.15	6.90	3.44	I7
18:2n-6	2.00	2.23	1.19	I7
18:3n-3	1.62	1.56		I7
18:4n-3	1.42	1.81	1.84	I7
20:1n-11	0.88	0.72	1.46	I7
20:1n-9	3.29	3.57	2.27	I7
20:1n-7	2.87	3.17	1.76	I7
20:2A	1.46	0.77	3.95	I7
20:2B	0.88	0.69	1.55	I7
20:2n-6	0.71	0.77	0.52	I7
20:4n-6	2.54	2.65	2.11	I7
20:5n-3	18.81	18.63	19.47	I7
22:1n-11	4.20	3.60	6.37	I7
22:5n-3	1.19	1.24	1.01	I7
22:6n-3	6.44	5.66	9.27	I7

* = the position of the double bond was not identified

Tissue from approximately 15 mussels was combined and analyzed for each site.

Table 39

Fluorescent aromatic compounds in bile of English sole as an indicator of aromatic hydrocarbon metabolites.

Investigators: Dr. Sylvester Spencer and Ms. Carla Stehr

Fish ID	**Site**	**BaP** ng/g BaP equivalents	**NpH** ng/g NpH equivalents	**PhN** ng/g PhN equivalents	**protein** mg/ml	**BaP/protein** micrograms Bap equiv./ g protein	**NpH/protein** micrograms NpH equiv./ g protein	**PhN/protein** micrograms PhN equiv./ g protein
990018	T49	43	67984	17219	5.78	7	11800	3000
990021	T49	103	63747	18063	1.21	85	52700	14900
990023	T49	17	39975	7737	1.45	12	27600	5300
990024	T49	0	46381	10788	0.73	0	63500	14800
990025	T49	2	34963	6756	0.74	3	47200	9100
990026	T49	126	92543	20100	3.82	33	24200	5300
990027	T49	146	65597	18872	4.45	33	14700	4200
990028	T49	68	60419	18387	1.22	56	49500	15100
990029	T49	8	47221	10798	2.61	3	18100	4100
990030	T49	34	58343	12366	3.62	9	16100	3400
990046	T11B	39	32035	8237	1.26	31	25400	6500
990047	T11B	65	25186	7841	2.69	24	9400	2900
990048	T11B	59	15953	3260	0.37	159	43100	8800
990050	T11B	61	36938	10084	0.78	78	47400	12900
990051	T11B	12	24338	4197	0.59	20	41300	7100
990056	T11B	103	52419	13400	0.80	129	65500	16800
990057	T11B	264	77572	23551	2.36	112	32900	10000
990058	T11B	193	37488	10262	0.89	217	42100	11500
990059	T11B	66	43457	8768	2.97	22	14600	3000
990060	T11B	24	31106	7506	0.76	32	40900	9900
990076	T38	145	50537	17149	0.39	372	129600	44000
990077	T38	640	113577	39821	3.29	195	34500	12100
990078	T38	653	157332	48605	1.41	463	111600	34500
990079	T38	264	61821	21043	0.98	269	63100	21500
990080	T38	542	109260	35919	0.82	661	133200	43800
990081	T38	317	78125	27623	1.00	317	78100	27600
990082	T38	613	109489	40691	0.65	943	168400	62600
990083	T38	187	66444	22008	0.67	279	99200	32800
990084	T38	871	208133	69907	1.03	846	202100	67900
990085	T38	1286	196675	78234	1.39	925	141500	56300
990106	T48	354	93895	34511	1.62	219	58000	21300
990107	T48	264	115193	28954	0.69	383	166900	42000
990108	T48	202	90608	28082	0.82	246	110500	34200
990109	T48	154	89655	22214	1.05	147	85400	21200
990110	T48	149	117084	28480	0.61	244	191900	46700
990111	T48	442	278040	66008	9.43	47	29500	7000
990112	T48	187	67919	17871	0.98	191	69300	18200
990113	T48	76	57373	17320	0.47	162	122100	36900
990114	T48	233	95952	25810	0.67	348	143200	38500
990115	T48	172	76422	22175	0.91	189	84000	24400
990136	T50	13	50016	13443	1.07	12	46700	12600
990137	T50	11	64390	16542	3.19	3	20200	5200
990138	T50	12	56892	14763	2.54	5	22400	5800
990139	T50	12	48196	10765	1.70	7	28400	6300
990140	T50	72	83530	23289	2.66	27	31400	8800
990141	T50	8	44505	9109	0.98	8	45400	9300
990142	T50	7	32261	8624	1.14	6	28300	7600
990143	T50	14	42137	9852	2.14	7	19700	4600
990144	T50	54	76427	19346	5.70	9	13400	3400
990145	T50	32	47542	14708	1.29	25	36900	11400

BaP = Benzo[a]pyrene wavelength equivalents
NpH = naphthalene wavelength equivalents
PhN = Phenanthrene wavelength equivalents

Ten fish from each site were individually analyzed for biliary metabolites.

Table 40

Quality assurance data for fluorescent aromatic compounds in bile of English sole.

Investigators: Dr. Sylvester Spencer and Ms. Carla Stehr

Quality Control number	Control Name	BaP ng/g BaP equivalents	NpH ng/g NpH equivalents	PhN ng/g PhN equivalents	Replicate number
B48031	Blank	0	0	0	1
B48001	Initial Calibration	98	14460	5941	1
B48002	Initial Calibration	98	15512	5929	2
B48003	Continuing Calibration	99	16059	6055	1
B48004	Continuing Calibration	100	16328	6042	2
B48010	Continuing Calibration	98	16021	6024	3
B48017	Continuing Calibration	98	15772	6111	4
B48024	Continuing Calibration	103	16294	5781	5
B48038	Continuing Calibration	103	16013	6059	6
B48005	Bile Reference Material	353	97483	47222	1
B48040	Bile Reference Material	495	100475	55983	2
B47902	Blank	1	129	31	1
B47931	Blank	4	0	0	2
B47901	Initial Calibration	111	15095	5653	1
B47903	Initial Calibration	105	16790	6344	2
B47904	Continuing Calibration	111	17181	6718	1
B47910	Continuing Calibration	105	16879	5863	2
B47917	Continuing Calibration	88	15203	5210	3
B47924	Continuing Calibration	89	15840	6045	4
B47938	Continuing Calibration	91	15011	6166	5
B47905	Bile Reference Material	466	107127	57562	1
B47940	Bile Reference Material	398	91295	49358	2

BaP = Benzo[a]pyrene wavelength equivalents
NpH = naphthalene wavelength equivalents
PhN = Phenanthrene wavelength equivalents

Table 41

Cytochrome P4501A activity and protein levels in liver microsomes of English sole.

Investigator: Dr. Stelvio Bandiera

FishID	**Site**	**CYP Conc.** (nmol/mL)	**Protein Conc.** (mg/mL)	**Specific Content** (nmol/mg protein)	**EROD Activity A** (pmol/min/nmol total CYP)	**EROD Activity B** (pmol/min/mg protein)	**CYP1A Level A** (ROD/pmol total CYP)	**CYP1A Level B** (ROD/mg protein)
990001-03	T49	5.94	24.9	0.24	4830	1152	0.26	62.16
990004	T49	4.18	13.5	0.31	2699	837	0.21	65.10
990005	T49	5.61	23.5	0.24	8636	2065	0.35	84.84
990006	T49	7.04	24.3	0.29	2983	863	0.18	51.77
990007	T49	3.14	10.1	0.31	3578	1108	0.38	118.73
990008	T49	4.62	24.4	0.19	7049	1335	0.18	34.87
990009	T49	3.03	14.0	0.22	4886	1058	0.14	30.03
990010	T49	6.27	16.5	0.38	5114	1946	0.18	68.59
990031	T11B	1.98	10.4	0.19	2691	511	0.28	53.20
990032	T11B	1.76	10.9	0.16	3337	540	0.27	42.48
990033	T11B	5.94	13.9	0.43	4034	1726	0.35	150.29
990034	T11B	10.56	23.2	0.45	4830	2195	0.27	119.93
990035	T11B	4.9	14.4	0.34	5483	1863	0.20	67.32
990036	T11B	4.29	15.4	0.28	3153	879	0.15	42.56
990037	T11B	4.29	11.0	0.39	13011	5065	0.29	111.15
990038	T11B	7.48	18.0	0.41	5273	2188	0.27	109.06
990039	T11B	0.99	6.6	0.15	946	142	0.21	31.88
990040	T11B	1.98	6.8	0.29	1767	511	0.44	126.88
990061	T38	3.85	12.0	0.32	6026	1932	0.63	202.40
990062	T38		26.0			3011		301.90
990063	T38	7.04	20.6	0.34	8908	3040	0.83	282.37
990064	T38	2.31	8.6	0.27	11476	3068	0.81	219.24
990065	T38	6.82	14.1	0.48	8282	4006	0.80	382.08
990066	T38	5.94	16.1	0.37	10318	3807	1.01	373.33
990067	T38	4.73	10.4	0.45	11931	5426	1.03	462.38
990068	T38	9.02	22.3	0.40	14947	6051	0.51	203.80
990069	T38	9.46	21.1	0.45	13383	5994	0.48	217.80

Table 41

Cytochrome P4501A activity and protein levels in liver microsomes of English sole.

Investigator: Dr. Stelvio Bandiera

FishID	**Site**	**CYP Conc.** (nmol/mL)	**Protein Conc.** (mg/mL)	**Specific Content** (nmol/mg protein)	**EROD Activity A** (pmol/min/nmol total CYP)	**EROD Activity B** (pmol/min/mg protein)	**CYP1A Level A** (ROD/pmol total CYP)	**CYP1A Level B** (ROD/mg protein)
990070	T38	7.26	18.9	0.38	14215	5455	0.54	205.01
990071	T38	6.86	24.1	0.28	19047	5426	0.62	173.60
990072	T38	7.26	20.9	0.35	11881	4119	1.11	386.58
990091	T48	5.94	15.5	0.38	7853	3011	1.25	474.43
990092	T48	7.26	18.5	0.39	5707	2244	1.04	404.82
990093	T48	9.24	21.3	0.43	8113	3523	0.86	371.09
990094	T48	5.5	15.0	0.37	4959	1818	0.67	247.53
990095	T48	5.5	15.7	0.35	6569	2301	0.80	281.23
990096	T48	3.63	8.1	0.45	6379	2869	0.74	331.43
990097	T48	7.48	18.2	0.41	10685	4403	0.51	210.13
990098	T48	6.16	13.7	0.45	3026	1364	0.33	148.50
990099	T48	2.53	6.3	0.40	8560	3438	0.73	290.80
990100	T48	3.96	15.0	0.26	7425	1960	0.54	139.36
990101	T48	0.77	5.8	0.13	1495	199	0.21	26.59
990102	T48	7.26	14.9	0.49	5597	2727	0.48	232.75
990121	T50	3.74	9.6	0.39	16619	6488	0.75	292.11
990122	T50	7.7	20.0	0.38	15710	6042	0.91	344.47
990123	T50	3.3	8.6	0.38	22102	8452	0.70	266.19
990124	T50	2.6	10.8	0.24	10689	2585	1.40	334.80
990125	T50	8.8	19.7	0.45	9375	4198	0.92	415.13
990126	T50	3.43	5.3	0.65	8626	5625	0.58	377.98
990127	T50	7.26	13.5	0.54	3722	2000	0.62	332.37
990128	T50	9.68	18.0	0.54	5994	3225	0.89	481.95
990129	T50	5.83	11.4	0.51	13097	6715	0.66	336.09
990130	T50	1.91	6.3	0.30	7753	2358	1.28	384.30
990131	T50	6.71	13.9	0.48	14773	7152	1.37	656.88
990132	T50	5.35	12.3	0.44	13295	5807	1.37	601.48

Table 41

Cytochrome P4501A activity and protein levels in liver microsomes of English sole.

Investigator: Dr. Stelvio Bandiera

FishID	Site	CYP Conc. (nmol/mL)	Protein Conc. (mg/mL)	Specific Content (nmol/mg protein)	EROD Activity A (pmol/min/nmol total CYP)	EROD Activity B (pmol/min/mg protein)	CYP1A Level A (ROD/pmol total CYP)	CYP1A Level B (ROD/mg protein)
990133	T50	5.28	9.2	0.57	14574	8373	1.45	828.78
990134	T50	5.06	9.9	0.51	15682	7999	1.03	524.28
990151	T49	3.96	14.6	0.27	7933	2159	0.27	71.82
990152	T49	4.4	15.7	0.28	6906	1932	0.22	61.74
990153	T49	3.3	12.2	0.27	6849	1847	0.29	78.17
990154	T49	7.26	14.9	0.49	8915	4347	0.31	149.45
990155	T49	5.5	10.8	0.51	3950	2017	0.15	74.97
990156	T49	3.96	12.8	0.31	6046	1875	0.21	65.72
990157	T49	5.39	15.7	0.34	4971	1705	0.22	73.95
990158	T49	1.98	8.7	0.23	2884	653	0.16	35.65
990159	T49	3.52	14.7	0.24	2840	682	0.25	60.96
990160	T49	2.2	11.6	0.19	1499	284	0.12	22.14
990161	T49	2.97	15.5	0.19	5054	966	0.20	38.38
990162	T49	4.29	17.3	0.25	6625	1648	0.28	69.50

CYP1A = cytochrome P4501A
EROD = ethoxyresorufin *O* -deethylase activity
ROD = relative optical density
CYP Conc. = Microsomal cytochrome P450 concentration
Protein Conc. = Microsomal protein concentration
CYP = total Cytochrome P450 enzymes, (includes CYP1A and other Cytochrome P450 enzymes)

Ten or more fish were indivdiually analyzed from each site.
A composite sample, where equal amounts of liver from three fish were combined (Fish ID numbers 990001, 990002, and 990003), was also analyzed.

Table 42

Cytochrome P4501A activity and protein levels in treated English sole.

Investigator: Dr. Stelvio Bandiera

Treatment Fish ID/ Treatment	CYP Conc. (nmol/mL)	Protein Conc. (mg/mL)	Specific Content (nmol/mg protein)	EROD Activity A (pmol/min/nmol total CYP)	EROD Activity B (pmol/min/mg protein)	CYP1A Level A (ROD/pmol total CYP)	CYP1A Level B (ROD/mg protein)
BNF1	3.41	7.6	0.45	18807	8494	0.95	428.18
BNF2	3.41	6.1	0.56	18693	10382	0.82	457.24
BNF3	2.68	9.1	0.30	14403	4256	0.75	225.15
BNF4	8.8	10.2	0.86	14972	12904	1.07	915.90
BNF5	10.56	13.8	0.77	16619	12736	1.05	807.73
BNF6	3.74	6.2	0.60	13097	7900	1.01	608.10
BNF7	2.53	4.8	0.53	14907	7841	0.92	485.22
BNF8	1.21	2.8	0.43	17810	7642	0.86	370.66
BNF9	4.18	11.3	0.37	13750	5068	0.72	267.33
BNF10	3.52	6.3	0.56	18153	10111	0.56	313.60
CornOil1	2.53	13.8	0.18	4063	748	0.12	22.23
CornOil2	5.65	20.5	0.28	1619	446	0.13	35.84
CornOil3	6.16	17.7	0.35	313	109	0.02	8.05
CornOil4	2.97	10.2	0.29	795	233	0.08	23.20
CornOil5	1.1	6.5	0.17	833	142	0.11	18.28
CornOil6	4.18	14.5	0.29	4688	1354	0.21	60.61
CornOil7	3.89	11.6	0.33	3409	1141	0.20	66.66
CornOil8		23.2			142		6.05
CornOil9	5.5	15.0	0.37	881	323	0.26	97.31
CornOil10	3.08	8.8	0.35	739	259	0.09	31.04

CYP1A = cytochrome P4501A
EROD = ethoxyresorufin*O* -deethylase activity
ROD = relative optical density
CYP Conc. = microsomal cytochrome P450 concentration
Protein Conc. = microsomal protein concentration
CYP = total Cytochrome P450 enzymes, (includes CYP1A and other Cytochrome P450 enzymes)

Table 43

Vitellogenin in blood plasma from English sole (ng/ml plasma).

Investigators. Mr. Dan Lomax, Dr. Munetaka Shimizu

Fish ID	Site	Sex	Vitellogenin	Investigator
990001	T49	male	ND	Shimizu
990002	T49	female	ND	Shimizu
990003	T49	male	ND	Shimizu
990004	T49	male	ND	Shimizu
990005	T49	male	ND	Shimizu
990006	T49	male	ND	Shimizu
990007	T49	male	ND	Shimizu
990008	T49	male	ND	Shimizu
990008	T49	male	ND	Lomax
990009	T49	male	ND	Shimizu
990009	T49	male	ND	Lomax
990010	T49	male	79*	Shimizu
990010	T49	male	ND	Lomax
990011	T49	male	ND	Lomax
990016	T49	male	ND	Lomax
990017	T49	male	ND	Lomax
990018	T49	male	ND	Lomax
990019	T49	male	ND	Lomax
990020	T49	male	ND	Lomax
990031	T11B	male	ND	Shimizu
990031	T11B	male	ND	Lomax
990032	T11B	male	ND	Shimizu
990032	T11B	male	ND	Lomax
990033	T11B	female	ND	Shimizu
990034	T11B	female	ND	Shimizu
990035	T11B	female	ND	Shimizu
990038	T11B	female	ND	Shimizu
990039	T11B	male	ND	Shimizu
990039	T11B	male	ND	Lomax
990040	T11B	male	ND	Shimizu
990040	T11B	male	ND	Lomax
990047	T11B	male	ND	Shimizu
990047	T11B	male	ND	Lomax
990048	T11B	male	ND	Shimizu
990048	T11B	male	ND	Lomax

ND = not detected
*value is very close to the non-detect limit.

The method used by Dr. Shimizu was an enzyme-linked immunosorbent assay for carp vitellogenin.
The method used by Mr. Lomax was an enzyme-linked immunosorbent assay for English sole vitellogenin.

Table 44
Imposex measurements in gastropods from Victoria and Mission Point.
Investigator: Dr. Zhengyan Li

Site	Sample	Species	Shell Height (mm)	Aperture Length (mm)	Sex	Penis Length (mm)	VDS
Ogden Point	1	*Nucella emarginata*	26	17.2	F	2.2	2
Ogden Point	2	*Nucella emarginata*	24	17.5	F	2.5	2
Ogden Point	3	*Nucella emarginata*	26	17.1	F	1.7	2
Ogden Point	4	*Nucella emarginata*	23.3	16	F	2.5	2
Ogden Point	5	*Nucella emarginata*	22.4	16.2	F	1.9	2
Ogden Point	6	*Nucella emarginata*	21	15.2	M	5.2	
Ogden Point	7	*Nucella emarginata*	23.5	16	M	4.9	
Ogden Point	8	*Nucella emarginata*	22	14.2	F	1.5	2
Ogden Point	9	*Nucella emarginata*	23.3	19.4	M	6.8	
Ogden Point	10	*Nucella emarginata*	21.1	18.7	F	2.5	2
Ogden Point	11	*Nucella emarginata*	25.5	18	F	2	2
Ogden Point	12	*Nucella emarginata*	25.5	16	F	1.9	2
Ogden Point	13	*Nucella emarginata*	25.8	17	F	2.8	2
Ogden Point	14	*Nucella emarginata*	20.3	14	F	1.8	2
Ogden Point	15	*Nucella emarginata*	20.3	14.5	M	5.5	
Ogden Point	16	*Nucella emarginata*	21.6	15.6	F	2.5	2
Ogden Point	17	*Nucella emarginata*	26.3	18.8	F	2.1	2
Ogden Point	18	*Nucella emarginata*	23.7	16.3	M	6.5	
Ogden Point	19	*Nucella emarginata*	22	16.1	F	1.4	2
Ogden Point	20	*Nucella emarginata*	23.1	16	F	2	2
Ogden Point	21	*Nucella emarginata*	21.1	14.6	F	2.2	4
Ogden Point	22	*Nucella emarginata*	22	15.7	F	1.2	2
Ogden Point	23	*Nucella emarginata*	22.2	15	F	2	2
Ogden Point	24	*Nucella emarginata*	23.5	16	F	1	2
Ogden Point	25	*Nucella emarginata*	22.8	16	F	2.2	2
Ogden Point	26	*Nucella emarginata*	23.5	15.6	F	2.1	2
Ogden Point	27	*Nucella emarginata*	22	15.4	F	2	2
Ogden Point	28	*Nucella emarginata*	21.5	15	F	1.2	2
Ogden Point	29	*Nucella emarginata*	21.5	14.9	F	1.5	2
Ogden Point	30	*Nucella emarginata*	21.1	14.1	F	1.9	2
Ten Mile Point	1	*Nucella emarginata*	22	14	F	0.9	2
Ten Mile Point	2	*Nucella emarginata*	21.5	13	F	1.2	2
Ten Mile Point	3	*Nucella emarginata*	22	13.9	M	6	
Ten Mile Point	4	*Nucella emarginata*	20	13.5	F	0.5	2
Ten Mile Point	5	*Nucella emarginata*	16.4	10.1	F	0.6	2
Ten Mile Point	1	*Nucella lamellosa*	39.6	22.9	M	5.8	
Ten Mile Point	2	*Nucella lamellosa*	37.1	23.9	M	4.2	
Ten Mile Point	3	*Nucella lamellosa*	42	27.8	F	0	0
Ten Mile Point	4	*Nucella lamellosa*	36	23.2	F	0	0
Ten Mile Point	5	*Nucella lamellosa*	40.2	26	F	0	0
Ten Mile Point	6	*Nucella lamellosa*	39.8	25	F	0	0
Ten Mile Point	7	*Nucella lamellosa*	41.8	26.8	F	0	0
Ten Mile Point	8	*Nucella lamellosa*	39.2	25.9	F	0	0
Ten Mile Point	9	*Nucella lamellosa*	36.7	22.8	F	0	0

Table 44
Imposex measurements in gastropods from Victoria and Mission Point.
Investigator: Dr. Zhengyan Li

Site	Sample	Species	Shell Height (mm)	Aperture Length (mm)	Sex	Penis Length (mm)	VDS
Ten Mile Point	10	*Nucella lamellosa*	43.8	27.5	M	6.2	
Ten Mile Point	11	*Nucella lamellosa*	35.5	23.5	M	5	
Ten Mile Point	12	*Nucella lamellosa*	38.1	24.2	M	5.5	
Ten Mile Point	13	*Nucella lamellosa*	35.3	20.2	M	5.3	
Ten Mile Point	14	*Nucella lamellosa*	42	26	F	0	0
Ten Mile Point	15	*Nucella lamellosa*	39	25	F	0.3	2
Ten Mile Point	16	*Nucella lamellosa*	35	22	M	7	
Ten Mile Point	17	*Nucella lamellosa*	33.5	22.1	M	5.6	
Ten Mile Point	18	*Nucella lamellosa*	33.2	20.8	F	0	0
Ten Mile Point	19	*Nucella lamellosa*	36	22.6	M	6	
Ten Mile Point	20	*Nucella lamellosa*	44	27	M	7.6	
Ten Mile Point	21	*Nucella lamellosa*	45	27.2	F	0.8	2
Ten Mile Point	22	*Nucella lamellosa*	37.5	23.2	F	0.4	2
Ten Mile Point	23	*Nucella lamellosa*	31.9	20.8	M	5.8	
Ten Mile Point	24	*Nucella lamellosa*	32.2	20.8	M	5.6	
Ten Mile Point	25	*Nucella lamellosa*	34	22.8	M	7	
Ten Mile Point	26	*Nucella lamellosa*	39.6	22.1	F	0	0
Ten Mile Point	27	*Nucella lamellosa*	42.5	26.9	F	0	0
Ten Mile Point	28	*Nucella lamellosa*	39	25.1	F	0	0
Ten Mile Point	29	*Nucella lamellosa*	41	27	F	0	0
Ten Mile Point	30	*Nucella lamellosa*	36	21.1	M	7.2	
Mission Point	1	*Nucella lamellosa*	43	26	M	7.1	
Mission Point	2	*Nucella lamellosa*	40.1	24.9	F	0.5	2
Mission Point	3	*Nucella lamellosa*	47.2	26.9	F	2	2
Mission Point	4	*Nucella lamellosa*	43	27.5	F	1.2	2
Mission Point	5	*Nucella lamellosa*	35.9	22.5	M	7.2	
Mission Point	6	*Nucella lamellosa*	39.9	24.1	F	1.2	2
Mission Point	7	*Nucella lamellosa*	36.3	22.2	M	6.5	
Mission Point	8	*Nucella lamellosa*	37.6	22.4	M	5	
Mission Point	9	*Nucella lamellosa*	36.6	23.2	M	5.3	
Mission Point	10	*Nucella lamellosa*	34.7	21.6	M	7.5	
Mission Point	11	*Nucella lamellosa*	35.3	21.3	M	6	
Mission Point	12	*Nucella lamellosa*	41.1	23.6	F	1.2	4
Mission Point	13	*Nucella lamellosa*	35.3	23	M	7	
Mission Point	14	*Nucella lamellosa*	34.1	20.3	M	7	
Mission Point	15	*Nucella lamellosa*	35	21.1	F	1.3	2
Mission Point	16	*Nucella lamellosa*	37.8	23.1	F	2.2	2
Mission Point	17	*Nucella lamellosa*	36.8	23	F	1	2
Mission Point	18	*Nucella lamellosa*	37	23.3	F	1	2
Mission Point	19	*Nucella lamellosa*	36.9	22.1	M	5.5	
Mission Point	20	*Nucella lamellosa*	41.6	23.9	F	1.5	3
Mission Point	21	*Nucella lamellosa*	43.1	22.9	F	0.8	3
Mission Point	22	*Nucella lamellosa*	43.9	22.7	F	1.3	4
Mission Point	23	*Nucella lamellosa*	14.2	9.6	M	1.5	

Table 44
Imposex measurements in gastropods from Victoria and Mission Point.
Investigator: Dr. Zhengyan Li

Site	Sample	Species	Shell Height (mm)	Aperture Length (mm)	Sex	Penis Length (mm)	VDS
Mission Point	24	*Nucella lamellosa*	14.6	11	M	1.6	
Ogden Point	1	*Nucella canaliculata*	32.5	21.1	F	1.5	2
Ogden Point	2	*Nucella canaliculata*	30	20.3	F	1.3	2
Ogden Point	3	*Nucella canaliculata*	33.1	21	M	8.6	
Ogden Point	4	*Nucella canaliculata*	34.1	21.1	F	1.2	2
Ogden Point	5	*Nucella canaliculata*	35	21.8	F	3.3	4
Ogden Point	6	*Nucella canaliculata*	33.5	22.1	M	8	
Ogden Point	7	*Nucella canaliculata*	36.3	24	F	1.2	2
Ogden Point	8	*Nucella canaliculata*	35	21.1	F	1.1	2
Ogden Point	9	*Nucella canaliculata*	31	20	M	10	
Ogden Point	10	*Nucella canaliculata*	32.3	21	F	1	2
Ogden Point	11	*Nucella canaliculata*	31.5	20.1	F	1	2
Ogden Point	12	*Nucella canaliculata*	33.1	21.5	M	10	
Ogden Point	13	*Nucella canaliculata*	29.6	20.9	M	8.2	
Ogden Point	14	*Nucella canaliculata*	30	20	F	0	0
Ogden Point	15	*Nucella canaliculata*	30.6	20	F	1	2
Ogden Point	16	*Nucella canaliculata*	31.3	19	M	7.1	
Ogden Point	17	*Nucella canaliculata*	29	18.3	F	2.7	2
Ogden Point	18	*Nucella canaliculata*	28.8	18.3	F	0	0
Ogden Point	19	*Nucella canaliculata*	29.1	19	F	1.2	2
Ogden Point	20	*Nucella canaliculata*	30.3	19.2	F	0.8	2
Ogden Point	21	*Nucella canaliculata*	27.1	18	F	1.5	2
Ogden Point	22	*Nucella canaliculata*	26.8	17.5	M	8.1	
Ogden Point	23	*Nucella canaliculata*	16.5	12	M	4.8	
Ogden Point	24	*Nucella canaliculata*	20.8	15.1	M	5.1	
Ogden Point	25	*Nucella canaliculata*	20.5	14.3	F	0	2
Ogden Point	26	*Nucella canaliculata*	25.7	17	F	0.5	2
Ogden Point	27	*Nucella canaliculata*	19	13.2	M	6.5	
Ogden Point	28	*Nucella canaliculata*	30.1	18.9	F	1.8	2
Ogden Point	29	*Nucella canaliculata*	25.5	17.1	M	7.2	
Ogden Point	30	*Nucella canaliculata*	21.8	15	F	0	1
Clover Point	1	*Nucella canaliculata*	28	17.5	M	5.2	
Clover Point	2	*Nucella canaliculata*	31.2	19.3	M	9	
Clover Point	3	*Nucella canaliculata*	33.6	20.1	M	6	
Clover Point	4	*Nucella canaliculata*	26.6	18.1	F	0	2
Clover Point	5	*Nucella canaliculata*	26	17.4	F	0.6	2
Clover Point	6	*Nucella canaliculata*	28.8	17.6	M	7.3	
Clover Point	7	*Nucella canaliculata*	32	19.9	F	1.2	2
Clover Point	8	*Nucella canaliculata*	28	17.5	F	0.5	2
Clover Point	9	*Nucella canaliculata*	25.9	17.1	M	7.8	
Clover Point	10	*Nucella canaliculata*	33.1	20.9	M	7.5	
Clover Point	11	*Nucella canaliculata*	29.5	19	F	0.5	2
Clover Point	12	*Nucella canaliculata*	28.5	19	F	0	0
Clover Point	13	*Nucella canaliculata*	29	18.7	M	8	

Table 44
Imposex measurements in gastropods from Victoria and Mission Point.
Investigator: Dr. Zhengyan Li

Site	Sample	Species	Shell Height (mm)	Aperture Length (mm)	Sex	Penis Length (mm)	VDS
Clover Point	14	*Nucella canaliculata*	28.4	17.6	F	0.9	2
Clover Point	15	*Nucella canaliculata*	30.9	18.8	F	0.5	2
Clover Point	16	*Nucella canaliculata*	30	18.1	M	4	
Clover Point	17	*Nucella canaliculata*	29.7	18.8	F	0.8	2
Clover Point	18	*Nucella canaliculata*	29.1	18	F	0.8	2
Clover Point	19	*Nucella canaliculata*	30.2	18.6	F	0	1
Clover Point	20	*Nucella canaliculata*	29	18	M	6.1	
Clover Point	21	*Nucella canaliculata*	28.5	18	M	6.3	
Clover Point	22	*Nucella canaliculata*	28	18	M	5.2	
Clover Point	23	*Nucella canaliculata*	28	18.5	M	5.5	
Clover Point	24	*Nucella canaliculata*	29.6	18	F	1.2	2
Clover Point	25	*Nucella canaliculata*	28.6	18	F	0	0
Clover Point	26	*Nucella canaliculata*	29	17.2	M	6.2	
Clover Point	27	*Nucella canaliculata*	25.3	16	M	7	
Clover Point	28	*Nucella canaliculata*	29.2	17	M	3	
Clover Point	29	*Nucella canaliculata*	33	20.7	M	6.1	
Clover Point	30	*Nucella canaliculata*	30	18.9	F	0	0
Ten Mile Point	1	*Nucella canaliculata*	28.1	18.8	F	0	0
Ten Mile Point	2	*Nucella canaliculata*	25.9	16.3	F	0	0
Ten Mile Point	3	*Nucella canaliculata*	26	15.2	F	0	0
Ten Mile Point	4	*Nucella canaliculata*	28.5	17.2	F	0	1
Ten Mile Point	5	*Nucella canaliculata*	25.4	17	F	0	0
Ten Mile Point	6	*Nucella canaliculata*	30.9	19	F	0	0
Ten Mile Point	7	*Nucella canaliculata*	29.9	19	F	0	0
Ten Mile Point	8	*Nucella canaliculata*	24	14.9	F	0	1
Ten Mile Point	9	*Nucella canaliculata*	26	15.6	M	8	
Ten Mile Point	10	*Nucella canaliculata*	26	16	F	0.5	1
Ten Mile Point	11	*Nucella canaliculata*	25.5	16	M	8.1	
Ten Mile Point	12	*Nucella canaliculata*	24.2	15.8	M	9	
Ten Mile Point	13	*Nucella canaliculata*	25.2	16	F	0	0
Ten Mile Point	14	*Nucella canaliculata*	26.9	16.1	F	0	0
Ten Mile Point	15	*Nucella canaliculata*	27.5	17	M	8.8	
Ten Mile Point	16	*Nucella canaliculata*	27.1	16	M	6.2	
Ten Mile Point	17	*Nucella canaliculata*	26	15.1	M	7.5	
Ten Mile Point	18	*Nucella canaliculata*	25.6	15.9	F	0	0
Ten Mile Point	19	*Nucella canaliculata*	25.9	15.6	F	0	0
Ten Mile Point	20	*Nucella canaliculata*	22.8	13.8	F	0	0
Ten Mile Point	21	*Nucella canaliculata*	24.5	16	F	0	0
Ten Mile Point	22	*Nucella canaliculata*	23	15	M	4.8	
Ten Mile Point	23	*Nucella canaliculata*	20	12.5	F	0	0
Ten Mile Point	24	*Nucella canaliculata*	25	15.2	M	7.5	
Ten Mile Point	25	*Nucella canaliculata*	22.5	14	M	7.1	
Ten Mile Point	26	*Nucella canaliculata*	23	13.5	F	0.3	2
Ten Mile Point	27	*Nucella canaliculata*	24	15.1	F	0	0

Table 44

Imposex measurements in gastropods from Victoria and Mission Point.

Investigator: Dr. Zhengyan Li

Site	Sample	Species	Shell Height (mm)	Aperture Length (mm)	Sex	Penis Length (mm)	VDS
Ten Mile Point	28	*Nucella canaliculata*	22.2	15	M	7.2	
Ten Mile Point	29	*Nucella canaliculata*	24	15	M	7.4	
Ten Mile Point	30	*Nucella canaliculata*	22	13.5	F	0	0
Clover Point	1	*Searlesia dira*	38.5	18.7	M	8.9	
Clover Point	2	*Searlesia dira*	39	21	M	12.5	
Clover Point	3	*Searlesia dira*	36	17	F	0	0
Clover Point	4	*Searlesia dira*	33.5	18	M	10	
Clover Point	5	*Searlesia dira*	33.6	18	M	8	
Clover Point	6	*Searlesia dira*	31	17.5	F	0	0
Clover Point	7	*Searlesia dira*	30.9	17.1	M	9	
Clover Point	8	*Searlesia dira*	27.6	15.9	F	0	0
Clover Point	9	*Searlesia dira*	26.8	14.5	M	5	
Clover Point	10	*Searlesia dira*	23.9	13.1	F	0	0

VDS = vas deferens sequence index; stages are based on Gibbs et al., 1987. J. Mar. Biol. Ass. U.K. 67:507-523.
M=male; F=female

Table 45

Imposex measurements in gastropods from Victoria and Mission Point.

Investigator: Dr. Toshihiro Horiguchi

Sample Date: 990531 **Location:** Victoria, Odgen Point **Species:** *Nucella lima*

Specimen No.	Shell height (mm)	Shell width (mm)	Shell weight (g)	Soft tissue weight (g)	First sex determination	Penis present?	Penis length curved (mm)	Penis length straight (mm)	VDS Index	Opening of vulva blocked?	Second sex determination
1	33.9	20.4	6.6	1.6	F	Y	3		3	N	imposex
2	31.8	19.9	4.7	1.1	F	Y	2		3	N	imposex
3	32.7	20.0	5.5	1.2	M	Y	10				M
4	32.3	20.2	5.2	1.2	F	Y	1		3	N	imposex
5	30.7	19.1	4.8	1.0	M	Y	11				M
6	31.7	19.6	6.0	1.2	M	Y	13				M
7	34.5	20.0	6.0	1.6	F	Y	2		3	N	imposex
8	32.0	20.2	5.1	1.2	F	Y	1.5		3	N	imposex
9	32.2	18.8	4.8	1.3	M	Y	11				M
10	33.3	19.8	5.7	1.5	F	Y	2		3	N	imposex
11	36.8	22.0	8.9	2.1	M	Y	8.5				M
12	30.0	18.1	4.4	1.2	M	Y	12				M
13	29.4	17.7	3.9	1.0	M	Y	10				M
14	31.7	20.5	5.3	1.6	F	Y	2		3	N	imposex
15	37.3	21.9	7.1	2.0	F	Y	1		3	N	imposex
16	29.5	19.2	4.4	1.0	M	Y	8				M
17	29.2	18.8	3.9	1.0	F	Y	1		3	N	imposex
18	27.8	17.0	3.5	0.7	M	Y	8				M
19	33.9	21.0	6.9	1.7	M	Y	11				M
20	32.0	20.6	4.8	1.2	M	Y	11				M
21	38.1	23.9	8.38	2.68	F	Y	3	2.7	3	N	imposex
22	41.2	24.8	11.66	3.50	F	Y	4	3	4	N	imposex
23	39.0	23.2	8.24	2.42	F	N			1	N	imposex
24	35.8	22.7	8.79	2.49	F	Y	2	2	3	N	imposex
25	39.8	22.4	8.11	2.14	F	Y	1.5	1.4	3	N	imposex
26	35.5	20.8	6.28	1.99	F	Y	2	2.2	3	N	imposex
27	35.4	21.5	7.71	1.88	M	Y	6	5.7			M
28	35.3	21.6	6.60	1.97	F	Y	2	2	3	N	imposex
29	34.7	21.9	6.64	1.58	F	Y	2	2	3	N	imposex
30	34.7	21.2	7.54	1.67	F	Y	2	2.1	3	N	imposex

Table 45

Imposex measurements in gastropods from Victoria and Mission Point.

Investigator: Dr. Toshihiro Horiguchi

Sampling Date: 990531 **Location:** Victoria, Clover Point **Species:** *Nucella lima*

Specimen No.	Shell height (mm)	Shell width (mm)	Shell weight (g)	Soft tissue weight (g)	First sex determination	Penis present?	Penis length curved (mm)	Penis length straight (mm)	VDS Index	Opening of vulva blocked?	Second sex determination
1	33.9	19.0	5.2	1.4	F	Y	1		3	N	imposex
2	30.4	19.4	4.2	1.4	F	Y	1		2	N	imposex
3	33.0	19.4	5.3	1.7	F	Y	1.5		3	N	imposex
4	30.2	17.5	4.0	1.1	F	Y	1.5		2	N	imposex
5	25.5	17.5	3.5	0.8	F	Y	2.5		3	N	imposex
6	27.0	16.6	3.0	1.0	F	Y	1.5		2	N	imposex
7	28.8	17.5	3.2	0.9	M	Y	7.5				M
8	29.8	17.5	3.6	1.0	F	Y	2		3	N	imposex
9	29.8	17.8	3.9	1.2	F	Y	1		3	N	imposex
10	27.7	17.1	3.2	0.9	M	Y	11				M
11	31.8	18.5	4.53	1.46	F	Y	1.5	1	3	N	imposex
12	31.0	18.6	4.48	1.30	F	Y	2	1.4	3	N	imposex
13	30.7	18.0	4.17	1.29	F	N			0	N	F
14	32.4	19.7	4.95	1.58	F	N			0	N	F
15	33.0	19.0	5.08	1.30	F	Y	1.5	0.9	3	N	imposex
16	29.4	17.9	4.11	1.14	F	Y	1.2	1	4	N	imposex
17	29.4	17.6	3.88	1.11	F	Y	1	1	3	N	imposex
18	29.5	17.1	3.47	1.12	F	N			0	N	F
19	29.6	16.5	3.48	0.94	F	N			0	N	F
20	27.5	17.0	3.25	0.79	F	N			0	N	F

Table 45

Imposex measurements in gastropods from Victoria and Mission Point.

Investigator: Dr. Toshihiro Horiguchi

Sampling Date: 990531 **Location:** Victoria, Ten-mile Point **Species:** *Nucella lima*

Specimen No.	Shell height (mm)	Shell width (mm)	Shell weight (g)	Soft tissue weight (g)	First sex determination	Penis present?	Penis length curved (mm)	Penis length straight (mm)	VDS Index	Opening of vulva blocked?	Second sex determination
1	29.0	17.4		1.2	F	Y	<1	0.5	2	N	imposex
2	28.0	15.6		0.7	M	Y	10				M
3	26.0	15.3		0.8	F	N	0			N	F
4	26.0	16.9		1.0	F	N	0			N	F
5	26.0	14.4		0.7	F	N	0		1	N	imposex
6	30.5	17.6		1.0	F	Y	<1	0.5	2	N	imposex
7	29.0	16.3		0.9	M	Y	10.5				M
8	29.3	17.1		1.0	F	Y	1		2	N	imposex
9	27.1	15.2		0.8	F	N	0		1	N	imposex
10	31.3	17.3		1.0	M	Y	6.5				M
11	37.1	22.7	10.40	1.45	F	N			1	N	imposex
12	44.4	25.6	12.55	2.61	M	Y	7	5.8			M
13	37.2	22.4	9.61	1.31	F	Y	<0.5	0.6	2	N	imposex
14	39.6	24.4	8.66	1.84	M	Y	7	7			M
15	40.9	25.4	9.43	2.05	F	Y	1	1	3	N	imposex
16	41.4	23.9	9.60	2.43	F	Y	1	0.9	2	N	imposex
17	35.4	22.2	7.20	1.48	F	N			1	N	imposex
18	35.4	22.7	7.73	1.42	M	Y	8	5.9			M
19	36.8	21.5	6.49	1.56	M	Y	7	6.6			M
20	34.9	21.4	6.49	1.50	F	Y	1	0.8	2	N	imposex

Table 45

Imposex measurements in gastropods from Victoria and Mission Point.

Investigator: Dr. Toshihiro Horiguchi

Sampling Date: 990602 **Location:** Mission Point (Wilson Creek) **Species:** *Nucella lamellosa*

Specimen No.	Shell height (mm)	Shell width (mm)	Shell weight (g)	Soft tissue weight (g)	First sex determination	Penis present?	Penis length curved (mm)	Penis length straight (mm)	VDS Index	Opening of vulva blocked?	Second sex determination
1	38.7	23.6	9.84	1.95	F	Y	2	1.6	3	N	imposex
2	41.2	25.2	11.41	2.36	F	Y	2	1.5	3	N	imposex
3	37.5	22.0	8.01	1.59	M	Y	9	7			M
4	38.8	22.4	9.32	1.74	M	Y	8	7			M
5	38.2	22.3	8.00	1.91	F	Y	1.5	1	3	N	imposex
6	35.8	20.4	7.05	1.43	M	Y	8.5	5.8			M
7	36.0	20.0	5.71		M	Y	6.5	5.9			M
8	33.3	20.1	5.36		M	Y	9	7			M
9	34.2	18.8	5.81	0.89	M	Y	7.5	6.6			M
10	32.7	20.2	6.13	1.36	M	Y	6	4.8			M

VDS Index = Vas Deferens Sequence Index. This is based on stages described by Gibbs et al., 1987. J. Mar. Biol. Ass. U.K. 67:507-523.

M = Male; F = Female; Y = Yes; N = No

A gastropod penis is curved. Two methods were used to measure its length:
The curved length was measured with thread. This measurement was used to calculate the indicies used in Table 46.
The straight length was measured from the bottom to the tip of the penis.

imposex = females with penis development, and/or vas deferens development

Table 46

Imposex indicies and tributyltin (ng/g wet weight) in gastropods from Victoria and Mission Point.

Investigators: Dr. Toshihiro Horiguchi

Site	Species	Tributyltin*	RPL Index	RPS Index	VDS Index	N**
Clover Pt.	*Nucella lima*	9.6	11.8	0.2	2.1	14f/16m
Ogden Pt.	*Nucella lima*	2.4	19	0.7	2.9	19f/11m
Ten-Mile Pt.	*Nucella lima*	7.3	3.3	0.004	1.1	19f/11m
Ten-Mile Pt.	*Nucella lamellosa*	8.7	8.2	0.1	1	16f/14m
Mission Pt.	*Nucella lamellosa*	21.9	23.1	1.2	1	12f/12m

*each value is the analysis of one sample containing 6-18 female gastropods of the same species.
** = number of females (f) and males (m) measured to obtain the indicies. Measurements of individual animals are listed in Dr. Horiguchi's imposex measurements data (Table 45) of this report.

RPL Index = Relative Penis length [(mean penis length in females)/ (mean penis length in males)]*100

RPS Index = Relative Penis size Index = [(mean penis length in females)3/(mean penis length in males)3]*100.

VDS Index = Vas Deferens sequence index. Stages based on Gibbs et al., 1987. J. Mar. Biol Ass. U.K. 67:507-523.

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	length (mm)	weight (g)	Gross Sex	Histo Sex	Age (yr)	Liver Necrosis	Liver Apoptosis	Liver Hemosid	Liver NP/MH SDN	Liver RegenProlif Prolif	Liver Cholfibrosis Prolif	Liver TotProlif
T49	990001	262	131	M	M	8	0	0	0	0	0	0	0
T49	990002	263	152	F	F	8	0	0	0	0	0	0	0
T49	990003	204	63	M	M	3	0	0	0	0	0	0	0
T49	990004	200	63	M	M	3	0	0	0	0	0	0	0
T49	990005	240	112	M	M	10	0	0	0	0	0	0	0
T49	990006	311	261	M	F	9	0	0	0	0	0	0	0
T49	990007	215	80	M	M	9	0	0	0	0	0	0	0
T49	990008	250	130	M	M	6	0	0	0	0	0	0	0
T49	990009	223	98	M	M	5	0	0	0	0	0	0	0
T49	990010	218	90	M	M	5	0	0	0	0	0	0	0
T49	990011	207	78	M	M	6	0	0	0	0	0	0	0
T49	990012	261	158	M	M	2	0	0	0	0	0	0	0
T49	990013	243	115	M	M	5	0	0	0	0	0	0	0
T49	990014	274	165	F	F	6	0	0	0	0	0	0	0
T49	990015	290	220	F	F	9	0	0	0	0	0	0	0
T49	990016	251	137	M	M	9	0	0	0	0	0	0	0
T49	990017	257	158	M	M	8	0	0	0	0	0	0	0
T49	990018	230	103	M	M	8	0	0	0	0	0	0	0
T49	990019	227	109	M	M	8	0	0	0	0	0	0	0
T49	990020	227	110	M	M	5	0	0	0	0	0	0	0
T49	990021	295	193	F	F	7	0	0	0	0	0	0	0
T49	990022	263	157	F	F	6	0	0	0	0	0	0	0
T49	990023	265	161	F	F	5	0	0	0	0	0	0	0
T49	990024	275	160	F	F	4	1	0	0	0	0	0	0
T49	990025	260	140	F	F	4	0	0	0	0	0	0	0
T49	990026	259	156	F	F	6	0	0	0	0	0	0	0
T49	990027	245	133	F	M	10	0	0	0	0	0	0	0
T49	990028	265	174	F	F	7	0	0	0	0	0	0	0
T49	990029	255	150	F	F	6	0	0	0	0	0	0	0
T49	990030	278	171	F	F	6	0	0	0	0	0	0	0
T11B	990031	223	90	M	M	8	0	0	0	0	0	0	0
T11B	990032	218	87	M	M	7	0	0	0	0	0	0	0
T11B	990033	262	148	F	F	6	0	0	0	0	0	0	0
T11B	990034	311	284	F	F	11	0	0	0	0	0	0	0

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

		Liver	Liver	Liver	Liver	Liver	Liver	Liver	Liver	Kidney	Kidney	Testis	Ovary	Ovary	Spleen
		EosinFocus	BasoFocus	CCFocus		CholCarc	HepAdenoma								
Site	Fish ID	Preneo	Preneo	Preneo	TotPreneo	Neoplasm	Neoplasm	TotNeoplasm	AnyToxLes	MesScl	MesLysis	Stage	Stage	Atresia	MAFreq
T49	990001	0	0	0	0	0	0	0	0	1	0	6			5
T49	990002	0	0	0	0	0	0	0	0	0	0		3	1	5
T49	990003	0	0	0	0	0	0	0	0			2			5
T49	990004	0	0	0	0	0	0	0	0	0	0	5			5
T49	990005	0	0	0	0	0	0	0	0	0	0	6			4
T49	990006	0	0	0	0	0	0	0	0	0	0		3	1	5
T49	990007	0	0	0	0	0	0	0	0	0	0	6			7
T49	990008	0	0	0	0	0	0	0	0	0	0	5			4
T49	990009	0	0	0	0	0	0	0	0	0	0	4			5
T49	990010	0	0	0	0	0	0	0	0	0	0	6			4
T49	990011	0	0	0	0	0	0	0	0	0	0	6			4
T49	990012	0	0	0	0	0	0	0	0	0	0	4			3
T49	990013	0	0	0	0	0	0	0	0	0	0	6			6
T49	990014	0	0	0	0	0	0	0	0	0	0		2	1	5
T49	990015	0	0	0	0	0	0	0	0	0	0		2	1	5
T49	990016	0	0	0	0	0	0	0	0	0	0	6			5
T49	990017	0	0	0	0	0	0	0	0	0	0	4			5
T49	990018	0	0	0	0	0	0	0	0	0	0	4			5
T49	990019	0	0	0	0	0	0	0	0	0	0	6			5
T49	990020	0	0	0	0	0	0	0	0	0	0	2			5
T49	990021	0	0	0	0	0	0	0	0	0	0		2	1	6
T49	990022	0	0	0	0	0	0	0	0	0	0		3	1	4
T49	990023	0	0	0	0	0	0	0	0	0	0		2	1	5
T49	990024	0	0	0	0	0	0	0	0	0	0		2	1	4
T49	990025	0	0	0	0	0	0	0	0	0	0		3	0	5
T49	990026	0	0	0	0	0	0	0	0	0	0		3	0	5
T49	990027	0	0	0	0	0	0	0	0	0	0	6			5
T49	990028	0	0	0	0	0	0	0	0	0	0		3	0	5
T49	990029	0	0	0	0	0	0	0	0	0	0		2	1	4
T49	990030	0	0	0	0	0	0	0	0	0	0		2	1	6
T11B	990031	0	0	0	0	0	0	0	0	0	0	6			
T11B	990032	0	0	0	0	0	0	0	0	0	0	6			5
T11B	990033	0	0	0	0	0	0	0	0	0	0		2	1	5
T11B	990034	0	0	0	0	0	0	0	0	0	0		2	0	5

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	length (mm)	weight (g)	Gross Sex	Histo Sex	Age (yr)	Liver Necrosis	Liver Apoptosis	Liver Hemosid	Liver NP/MH SDN	Liver RegenProlif Prolif	Liver Cholfibrosis Prolif	Liver TotProlif
T11B	990035	272	188	F	F	9	0	0	0	0	0	0	0
T11B	990036	325	276	F	F	10	0	0	0	0	0	0	0
T11B	990037	254	135	F	F	5	0	0	0	0	0	0	0
T11B	990038	256	148	F	F	7	0	0	0	0	0	0	0
T11B	990039	232	100	M	M	7	0	0	0	0	0	0	0
T11B	990040	243	120	M	M	5	0	0	0	0	0	0	0
T11B	990041	273	172	F	F	9	0	0	0	0	0	0	0
T11B	990042	229	97	F	F	5	0	0	0	0	0	0	0
T11B	990043	216	81	F	M	5	0	0	0	0	0	0	0
T11B	990044	235	116	F	F	5	0	1	0	0	0	0	0
T11B	990045	247	148	F	F	7	0	0	0	0	0	0	0
T11B	990046	240	122	F	F	9	0	0	0	0	0	0	0
T11B	990047	228	108	M	M	7	0	0	0	0	0	0	0
T11B	990048	227	91	M	M	6	0	0	0	0	0	0	0
T11B	990049	217	88	F	M	6	0	0	0	0	0	0	0
T11B	990050	217	86	F	F	6	0	0	0	0	1	0	1
T11B	990051	258	145	F	F	7	0	0	0	0	0	0	0
T11B	990052	237	112	F	F	7	0	0	0	0	0	0	0
T11B	990053	241	121	F	F	8	0	0	0	0	0	0	0
T11B	990054	227	104	M	F	4	0	0	0	0	0	0	0
T11B	990055	236	111	F	F	4	1	0	0	0	0	0	0
T11B	990056	228	98	F	F	5	0	0	0	1	0	0	0
T11B	990057	226	89	F	F	4	0	0	0	0	0	0	0
T11B	990058	228	95	F	F	4	0	0	0	0	0	0	0
T11B	990059	230	103	F	F	4	0	0	0	0	0	0	0
T11B	990060	218	89	F	F	4	0	0	0	0	0	0	0
T38	990061	257	129	F	F	7	0	0	0	0	0	0	0
T38	990062	322	265	F	F	8	0	0	0	0	0	0	0
T38	990063	290	184	F	F	7	0	0	0	0	0	0	0
T38	990064	285	160	M	M	11	0	0	0	0	0	0	0
T38	990065	342	298	F	F	10	0	0	0	0	0	0	0
T38	990066	336	312	F	F	8	0	0	0	0	0	0	0
T38	990067	289	170	M	M	15	0	0	0	0	0	0	0
T38	990068	332	275	F	F	12	0	0	0	0	0	0	0

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	Liver EosinFocus Preneo	Liver BasoFocus Preneo	Liver CCFocus Preneo	Liver TotPreneo	Liver CholCarc Neoplasm	Liver HepAdenoma Neoplasm	Liver TotNeoplasm	Liver AnyToxLes	Kidney MesScl	Kidney MesLysis	Testis Stage	Ovary Stage	Ovary Atresia	Spleen MAFreq
T11B	990035	0	0	0	0	0	0	0	0	0	0		2	1	5
T11B	990036	0	0	0	0	0	0	0	0	0	0		3	1	4
T11B	990037	0	0	0	0	0	0	0	0	0	0		2	1	4
T11B	990038	0	0	0	0	0	0	0	0	0	0		2	1	6
T11B	990039	0	0	0	0	0	0	0	0	0	0	4			5
T11B	990040	0	0	0	0	0	0	0	0	0	0	6			4
T11B	990041	0	0	0	0	0	0	0	0	0	0		2	1	6
T11B	990042	0	0	0	0	0	0	0	0	0	0		2	1	6
T11B	990043	0	0	0	0	0	0	0	0	0	0	6			5
T11B	990044	1	0	0	1	0	0	0	1	0	0		2	1	5
T11B	990045	1	1	0	1	0	0	0	1	0	0		3	1	5
T11B	990046	0	0	0	0	0	0	0	0	0	0		2	1	6
T11B	990047	1	0	0	1	0	0	0	1	0	0	6			5
T11B	990048	0	0	0	0	0	0	0	0	0	0	6			5
T11B	990049	0	0	0	0	0	0	0	0	0	0	6			5
T11B	990050	0	0	0	0	0	0	0	1	0	0		2	1	4
T11B	990051	0	0	0	0	0	0	0	0	0	0		2	1	5
T11B	990052	0	0	0	0	0	0	0	0	0	0		3	0	5
T11B	990053	1	0	0	1	0	0	0	1	0	0		2	1	4
T11B	990054	0	0	0	0	0	0	0	0	0	0		2	1	5
T11B	990055	0	0	0	0	0	0	0	0	0	0		2	1	4
T11B	990056	0	0	0	0	0	0	0	1	0	0		2	1	4
T11B	990057	0	0	0	0	0	0	0	0	0	0		2	1	4
T11B	990058	0	0	0	0	0	0	0	0	0	0		2	1	4
T11B	990059	0	0	0	0	0	0	0	0	0	0		2	0	5
T11B	990060	0	0	0	0	0	0	0	0	0	0		2	1	5
T38	990061	0	0	0	0	0	0	0	0	0	0		2	1	4
T38	990062	0	0	0	0	0	0	0	0				4	1	5
T38	990063	0	0	0	0	0	0	0	0	0	0		2	1	6
T38	990064	0	0	0	0	0	0	0	0	0	0	6			7
T38	990065	0	0	0	0	0	0	0	0	0	0		2	0	5
T38	990066	1	0	0	1	1	0	1	1	0	0		2	1	6
T38	990067	0	0	0	0	0	0	0	0	0	0	6			6
T38	990068	0	0	0	0	0	0	0	0	0	1		2	0	7

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	length (mm)	weight (g)	Gross Sex	Histo Sex	Age (yr)	Liver Necrosis	Liver Apoptosis	Liver Hemosid	Liver NP/MH SDN	Liver RegenProlif Prolif	Liver Cholfibrosis Prolif	Liver TotProlif
T38	990069	332	301	F	F	9	0	0	0	0	0	0	0
T38	990070	315	242	F	F	11	0	0	0	1	0	0	0
T38	990071	344	297	F	F	11	0	0	0	0	0	0	0
T38	990072	332	313	F	F	15	0	0	0	0	1	1	1
T38	990073	338	350	F	F	9	0	0	0	0	0	0	0
T38	990074	321	266	F	F	8	0	0	0	0	0	0	0
T38	990075	304	204	F	F	8	0	0	1	0	0	0	0
T38	990076	306	220	F	F	10	0	0	0	0	0	0	0
T38	990077	297	221	F	F	11	0	0	0	0	0	0	0
T38	990078	290	168	M	M	15	0	0	0	0	0	0	0
T38	990079	295	201	F	F	6	0	0	0	0	0	0	0
T38	990080	284	170	F	F	6	0	0	0	0	0	0	0
T38	990081	262	137	F	F	7	0	0	0	0	0	0	0
T38	990082	283	183	F	F	8	0	0	0	0	0	0	0
T38	990083	280	165	M	M	14	0	0	0	0	0	0	0
T38	990084	300	220	M	M	10	0	0	0	0	0	0	0
T38	990085	271	152	M	M	10	0	0	0	0	0	0	0
T38	990086	284	153	M	M	10	1	0	0	0	0	0	0
T38	990087	258	139	F	F	5	0	0	0	0	0	0	0
T38	990088	258	137	F	F	6	0	0	0	0	0	0	0
T38	990089	265	141	F	F	6	0	0	0	0	0	0	0
T38	990090	282	202	F	F	7	0	0	0	0	0	0	0
T48	990091	302	192	F	F	10	0	0	0	0	0	0	0
T48	990092	287	192	F	F	6	0	0	0	0	0	0	0
T48	990093	290	190	F	F	9	0	0	0	0	0	0	0
T48	990094	271	152	F	F	6	0	0	0	0	0	0	0
T48	990095	255	160	F	F	9	0	0	0	0	0	0	0
T48	990096	247	125	F	F	6	0	0	0	0	0	0	0
T48	990097	286	188	F	F	7	1	0	0	0	1	0	1
T48	990098	278	178	F	F	7	0	0	0	0	0	0	0
T48	990099	230	94	M	M	8	0	0	0	0	0	0	0
T48	990100	266	40	M	M	11	0	0	0	0	0	1	1
T48	990101	256	120	M	M	5	0	0	0	0	0	0	0
T48	990102	271	176	M	M	13	0	0	0	0	0	0	0

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	Liver EosinFocus Preneo	Liver BasoFocus Preneo	Liver CCFocus Preneo	Liver TotPreneo	Liver CholCarc Neoplasm	Liver HepAdenoma Neoplasm	Liver TotNeoplasm	Liver AnyToxLes	Kidney MesScl	Kidney MesLysis	Testis Stage	Ovary Stage	Ovary Atresia	Spleen MAFreq
T38	990069	0	0	1	1	0	1	1	1	0	0		2	1	5
T38	990070	1	0	0	1	0	0	0	1	0	0		2	0	5
T38	990071	0	0	0	0	0	0	0	0	1	0		3	1	6
T38	990072	0	0	0	0	0	1	1	1	0	0		2	0	
T38	990073	0	0	0	0	0	0	0	0	0	0		2	1	
T38	990074	0	0	0	0	0	0	0	0	0	0		4	0	5
T38	990075	1	1	0	1	0	0	0	1	0	0		2	1	7
T38	990076	0	0	0	0	0	0	0	0	0	0		2	1	6
T38	990077	0	0	0	0	0	0	0	0	0	0		2	1	6
T38	990078	1	0	0	1	0	0	0	1	0	0	6			6
T38	990079	0	0	0	0	0	0	0	0	0	0		2	0	5
T38	990080	0	0	0	0	0	0	0	0	0	0		3	1	5
T38	990081	0	0	0	0	0	0	0	0	0	0		2	1	6
T38	990082	0	0	0	0	0	0	0	0	1	0		2	1	5
T38	990083	0	0	0	0	0	0	0	0	0	0	6			7
T38	990084	0	0	0	0	0	0	0	0	0	0		2	1	6
T38	990085	0	0	0	0	0	0	0	0	0	0	6			7
T38	990086	0	0	0	0	0	0	0	0	0	0	6			7
T38	990087	0	0	0	0	0	0	0	0	0	0		2	0	5
T38	990088	0	0	0	0	0	0	0	0	0	0		2	1	6
T38	990089	0	0	0	0	0	0	0	0	0	0		2	1	5
T38	990090	1	0	0	1	0	0	0	1	0	0		3	0	7
T48	990091	0	0	0	0	0	0	0	0	0	0		2	1	5
T48	990092	0	0	0	0	0	0	0	0	0	0		2	1	5
T48	990093	1	0	0	1	0	0	0	1	0	0		2	1	5
T48	990094	0	0	0	0	0	0	0	0	0	0		2	1	5
T48	990095	0	0	0	0	0	0	0	0	0	0		2	1	6
T48	990096	0	0	0	0	0	0	0	0	0	0		2	1	4
T48	990097	0	0	0	0	0	0	0	1	0	0		3	1	5
T48	990098	0	0	0	0	0	0	0	0	0	0		3	1	4
T48	990099	0	0	0	0	0	0	0	0	0	0	6			5
T48	990100	1	1	0	1	0	1	1	1	0	0				6
T48	990101	1	1	0	1	0	0	0	1	0	0	6			7
T48	990102	0	0	0	0	0	0	0	0	0	0	4			6

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	length (mm)	weight (g)	Gross Sex	Histo Sex	Age (yr)	Liver Necrosis	Liver Apoptosis	Liver Hemosid	Liver NP/MH SDN	Liver RegenProlif Prolif	Liver Cholfibrosis Prolif	Liver TotProlif
T48	990103	285	176	F	F	10	0	0	0	0	0	0	0
T48	990104	318	283	F	F	10	0	0	0	0	0	0	0
T48	990105	302	235	F	F	8	0	0	0	0	0	0	0
T48	990106	275	168	F	F	5	0	0	0	0	0	0	0
T48	990107	262	150	F	F	5	0	0	0	0	0	0	0
T48	990108	248	126	F	F	4	0	0	0	0	0	0	0
T48	990109	255	135	F	F	5	0	0	0	0	0	0	0
T48	990110	274	155	F	F	6	0	0	0	0	0	0	0
T48	990111	247	126	M	M	9	0	0	0	0	0	0	0
T48	990112	252	132	F	F	7	0	0	0	0	0	0	0
T48	990113	250	134	F	F	6	0	0	0	0	0	0	0
T48	990114	265	146	F	F	6	0	0	0	0	0	0	0
T48	990115	297	228	F	F	6	0	0	0	0	0	0	0
T48	990116	262	153	F	F	6	0	0	0	0	0	0	0
T48	990117	274	177	F	F	9	0	0	0	0	0	0	0
T48	990118	274	168	F	F	8	0	0	0	0	0	0	0
T48	990119	256	143	F	F	4	0	0	0	0	0	0	0
T48	990120		265	F	F	11	0	0	0	0	0	0	0
T50	990121	246	113	F	F	6	0	0	0	0	0	0	0
T50	990122	295	204	F	F	12	0	0	0	0	0	0	0
T50	990123		125	F	F	6	0	0	0	0	0	0	0
T50	990124	265	124	M	M	13	0	0	0	0	0	0	0
T50	990125	280	166	F	F	6	0	0	0	0	0	0	0
T50	990126		95	F	F	6	0	0	0	0	0	0	0
T50	990127	235	91	M	M	8	0	0	0	0	0	0	0
T50	990128	245	112	F	F	7	0	0	0	0	0	0	0
T50	990129	246	120	F	F	6	0	0	0	0	0	0	0
T50	990130	243	107	F	F	4	0	0	0	0	0	0	0
T50	990131	234	90	M	M	8	0	0	0	0	0	0	0
T50	990132	269	142	F	F	9	0	0	0	0	0	0	0
T50	990133	228	97	M	M	8	0	0	0	0	0	0	0
T50	990134	230	101	M	M	9	0	0	0	0	0	0	0
T50	990135	240	105	M	M	6							
T50	990136	233	96	M	M	10	0	0	0	0	0	0	0

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	Liver EosinFocus Preneo	Liver BasoFocus Preneo	Liver CCFocus Preneo	Liver TotPreneo	Liver CholCarc Neoplasm	Liver HepAdenoma Neoplasm	Liver TotNeoplasm	Liver AnyToxLes	Kidney MesScl	Kidney MesLysis	Testis Stage	Ovary Stage	Ovary Atresia	Spleen MAFreq
T48	990103	0	0	0	0	0	0	0	0	0	0		2	1	5
T48	990104	0	0	0	0	0	1	1	1	0	0		3	0	5
T48	990105	0	0	0	0	0	0	0	0	0	0		2	0	5
T48	990106	0	0	0	0	0	0	0	0	0	0		3	0	4
T48	990107	0	0	0	0	0	0	0	0	0	0		3	1	5
T48	990108	0	0	0	0	0	0	0	0	0	0		2	1	5
T48	990109	0	0	0	0	0	0	0	0	0	0		2	1	6
T48	990110	0	0	0	0	0	0	0	0	0	0		2	1	5
T48	990111	0	0	0	0	0	0	0	0	0	0	6			6
T48	990112	0	0	0	0	0	0	0	0	0	0		2	0	4
T48	990113	1	0	0	1	0	0	0	1	0	0		2	1	5
T48	990114	0	0	0	0	0	0	0	0	0	0		2	1	4
T48	990115	0	0	0	0	0	0	0	0	0	0		3	0	5
T48	990116	0	0	0	0	0	0	0	0	0	0		2	1	6
T48	990117	0	0	0	0	0	0	0	0	0	0		2	1	7
T48	990118	1	0	0	1	0	0	0	1	0	0		2	1	5
T48	990119	0	0	0	0	0	0	0	0	1	1		2	1	4
T48	990120	0	0	0	0	0	0	0	0	0	0		2	1	5
T50	990121	0	0	0	0	0	0	0	0	0	0		2	0	5
T50	990122	0	0	0	0	0	0	0	0	0	0		2	1	6
T50	990123	0	0	0	0	0	0	0	0	0	0		2	0	5
T50	990124	0	0	0	0	0	0	0	0	0	0	5			7
T50	990125	0	0	0	0	0	0	0	0	0	0		2	1	6
T50	990126	0	0	0	0	0	0	0	0	0	0		2	0	5
T50	990127	0	0	0	0	0	0	0	0	0	0	4			5
T50	990128	0	0	0	0	0	0	0	0	0	0		2	1	5
T50	990129	0	0	0	0	0	0	0	0	0	0		2	1	4
T50	990130	0	0	0	0	0	0	0	0	0	0		2	1	4
T50	990131	0	0	0	0	0	0	0	0	0	0	6			6
T50	990132	0	0	0	0	0	0	0	0	0	0		3	0	5
T50	990133	0	0	0	0	0	0	0	0	0	0	5			6
T50	990134	0	0	0	0	0	0	0	0	0	0	6			6
T50	990135														
T50	990136	0	0	0	0	0	0	0	0	0	0	6			7

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	length (mm)	weight (g)	Gross Sex	Histo Sex	Age (yr)	Liver Necrosis	Liver Apoptosis	Liver Hemosid	Liver NP/MH SDN	Liver RegenProlif Prolif	Liver Cholfibrosis Prolif	Liver TotProlif
T50	990137	229	99	F	F	7	0	0	0	0	0	0	0
T50	990138	235	94	M	M	9	0	0	0	0	0	0	0
T50	990139	224	92	F	F	7	0	0	0	0	0	0	0
T50	990140	239	89	M	M	3	0	0	0	0	0	0	0
T50	990141	246	93	F	F	3	0	0	0	0	0	0	0
T50	990142	234	92	M	M	11	0	0	0	0	0	0	0
T50	990143	225	79	M	M	8	0	0	0	0	0	0	0
T50	990144	216	61	M	M	6	0	0	0	0	0	0	0
T50	990145	237	96	J	M	7	0	0	0	0	0	0	0
T50	990146	235	92	M	M	6	0	0	0	0	0	0	0
T50	990147	234	99	F	F	6	0	0	0	0	0	0	0
T50	990148	230	85	M	M	9	0	0	0	0	0	0	0
T50	990149	225	80	F	M	6	0	0	0	0	0	0	0
T50	990150	229	85	M	M	9	0	0	0	0	0	0	0
T49	990151	285	172	F		3							
T49	990152	260	135	M		6							
T49	990153	290	178	F		6							
T49	990154	292	193	F		5							
T49	990155	265	141	F		6							
T49	990156	254	145	F		9							
T49	990157	290	213	M		6							
T49	990158	234	103	M		7							
T49	990159	265	155	M		7							
T49	990160	227	108	M		6							
T49	990161	237	107	F		4							
T49	990162	255	132	M		6							

Fish numbers 990150 - 990162 did not have any tissues collected for histopathological examination.

Thanks to Dr. Colin Levings, Dept. Fish and Oceans, Canada for the age data.

BasoFocus = basophilic focus
CCFocus = clear cell focus
CholCarc = cholangiocellular carcinoma
Cholfibrosis =cholangiofibrosis
EosinFocus = eosinophilic focus
Gross Sex = sex determined by visual observation at the time of necropsy
Hemosid = Hemosiderosis
HepAdenoma = Hepatocellular adenoma
Histo = Histology
Histo sex = sex determined by histology
Length = total length (head to tail) reported in millimeters
AnyToxLes = indicates a fish that has one or more lesions considered to be toxicopathic, including neoplasms, preneoplasms, SDN and proliferative lesions.
MAFreq= Macrophage aggregate frequency
MesLysis = Mesangial lysis
MesScl = Mesangial sclorosis
MH = Megalocytic hepatosis
NP = Nuclear Pleomorphism

Table 47

Histopathology of liver, kidney, gonad and spleen in English sole from Vancouver Harbour.

Investigators: Mr. Mark Myers and Ms. Carla Stehr

Site	Fish ID	Liver EosinFocus Preneo	Liver BasoFocus Preneo	Liver CCFocus Preneo	Liver TotPreneo	Liver CholCarc Neoplasm	Liver HepAdenoma Neoplasm	Liver TotNeoplasm	Liver AnyToxLes	Kidney MesScl	Kidney MesLysis	Testis Stage	Ovary Stage	Ovary Atresia	Spleen MAFreq
T50	990137	0	0	0	0	0	0	0	0	0	0		3	0	5
T50	990138	0	0	0	0	0	0	0	0	0	0	6			5
T50	990139	0	0	0	0	0	0	0	0	0	0		3	0	4
T50	990140	0	0	0	0	0	0	0	0	0	0	6			4
T50	990141	0	0	0	0	0	0	0	0	0	0		2	0	3
T50	990142	0	0	0	0	0	0	0	0	0	0	5			5
T50	990143	0	0	0	0	0	0	0	0	0	0	6			5
T50	990144	0	0	0	0	0	0	0	0	0	0	6			5
T50	990145	0	0	0	0	0	0	0	0	0	0	6			5
T50	990146	0	0	0	0	0	0	0	0	0	0	6			5
T50	990147	0	0	0	0	0	0	0	0	0	0		3	1	5
T50	990148	0	0	0	0	0	0	0	0	0	0	6			6
T50	990149	0	0	0	0	0	0	0	0	0	0	6			5
T50	990150	0	0	0	0	0	0	0	0	0	0	6			6
T49	990151														
T49	990152														
T49	990153														
T49	990154														
T49	990155														
T49	990156														
T49	990157														
T49	990158														
T49	990159														
T49	990160														
T49	990161														
T49	990162														

Preneo = preneoplasm (includes Basophilic focus, clear cell focus, and eosinophilic focus)

Prolif = Proliferative lesion

RegenProlif = Regenerative Proliferation

SDN = Specific Degeneration/Necrosis (includes megalocytic hepatosis and nuclear pleomorphism)

TotProl = indicates fish having one or more types of proliferative lesions

TotPreneo = indicates fish having one or more types of preneoplastic lesions.

TotNeoplasm = indicates fish having one or more types of neoplastic lesions.

A note on sex determination: Gross sex was determined by visual observations of gonads at the time of necropsy. Smaller fish have undeveloped ovaries, so it is sometimes difficult to determine sex in younger fish. Therefore, sex determination by histology is more accurate than gross sex.

Testis stages:

1=regressed; spermatogonia and primary spermatocytes

2= early recrudescence; secondary spermatocytes

3= late recrudescence; secondary spermatocytes to spermatids

4= early spermiogenesis or sperm production

5= late spermiogenesis; spawning

6= spawned out; few mature sperm remaining

M=Male, F = Female, J=Juvenile, sex undetermined

Macrophage Aggregate Frequency Ratings

0= none

1= minimal, very few

2= minimal-mild

3= mild, few

4= mild-moderate number

5= moderate number

6= moderate-severe number

7= Severe, numerous

Ovary stages:

1= regressed; oogonia and primary oocytes

2= late regressed; secondary oocytes

3= previtellogenic; vacuolated secondary oocytes

4= vitellogenic

5= some hydrated oocytes; no post-ovulatory follicles (POFs)

6= spawning; hydrated oocytes with POFs

7= spawned out

Table 48

Fish abundance **Number of individual fish and invertebrates caught in each trawl from Vancouver Harbour**

Investigator: Dr. Colin Levings

Site	T-49	T-49	T-49	T-49	T-49	T-11B	T-11B	T-11B	T-38	T-38	T-38
Trawl/site	1	2	3	4	5	1	2	3	1	2	3
Species	Trawl 1	Trawl 2	Trawl 3	Trawl 4	Trawl 5	Trawl 6	Trawl 7	Trawl 8	Trawl 9	Trawl 10	Trawl 11
Spiny dogfish		ns									
Longnose skate		ns									
Pacific herring		ns		1		10	5	8	23	3	3
Longfin smelt	1	ns				1		2	2	12	4
Eulachon		ns									
Pacific hake		ns									
Pacific tomcod	1	ns	2	4	1	16	9	16	29	20	41
Walleye pollock		ns									
Blackbelly eelpout	93	ns	37	74	65						
Shiner perch		ns		1	8		3	1	17	15	11
Copper rockfish		ns									
Greenstriped rockfish		ns									
Quillback rockfish		ns									
Kelp greenling		ns									
Whitespotted greenling		ns					1	1			
Roughback sculpin		ns				3	2	2			
Buffalo sculpin		ns						1			
Pacific staghorn sculpin	1	ns			2				15	10	10
Tadpole sculpin		ns									
Plainfin midshipman		ns	4	2					2	25	18
Sturgeon poacher	1	ns					2				
Pacific sanddab	2	ns		3	3		6	1	2	6	1
Speckled sanddab		ns									
Rex sole	20	ns	21	18	17						
Flathead sole	21	ns	20	37	28				3	4	3
Butter sole		ns									

Table 48

Fish abundance **Number of individual fish and invertebrates caught in each trawl from Vancouver Harbour**

Investigator: Dr. Colin Levings

Site	**T-49**	**T-49**	**T-49**	**T-49**	**T-49**	**T-11B**	**T-11B**	**T-11B**	**T-38**	**T-38**	**T-38**
Trawl/site	1	2	3	4	5	1	2	3	1	2	3
Species	Trawl 1	Trawl 2	Trawl 3	Trawl 4	Trawl 5	Trawl 6	Trawl 7	Trawl 8	Trawl 9	Trawl 10	Trawl 11
Rock sole	2	ns		7	5	4	16	6			
Slender sole	16	ns	8	20	22	4	2	3			
Dover sole	3	ns	2	3					138		
English sole	11	ns		24	36	79	46	47	100	173	248
Starry flounder	13	ns	2	16	14	2	5	6	100		1
Sand sole	6	ns		1	3	2	3	3	5	3	3
Dungeness crab	14	ns	19	17	14	8	9	9	52	126	82
Tanner crab	7	ns		1	1			1			
Rock crab	0	ns									
anemone	0	ns								20	
Yoldia	0	ns								4	1
Cockle	0	ns								5	2
Butter Clam	0	ns								1	
TOTALS	191	ns	96	211	204	121	100	97	436	271	343

ns = no sample due to net problems.

Table 48

Fish abundance **Number of individual fish and invertebrates caught in each trawl from Vancouver Harbour**

Investigator: Dr. Colin Levin

Site	T-48	T-48	T-48	T-11B	T-50	T-50	T-50	T-50	T-49	T-49
Trawl/site	1	2	3	4	1	2	3	4	6	7
Species	Trawl 12	Trawl 13	Trawl 14	Trawl 15	Trawl 16	Trawl 17	Trawl 18	Trawl 19	Trawl 20	Trawl 21
Spiny dogfish					1	2	ns			
Longnose skate				1			ns			
Pacific herring	2		6				ns			
Longfin smelt	1	13	2	2			ns			
Eulachon							ns			1
Pacific hake					113	75	ns	28		
Pacific tomcod	9	29	15	3	14	19	ns	23	4	2
Walleye pollock		1					ns			
Blackbelly eelpout	10	17	7	9	7	9	ns	3	114	93
Shiner perch		5				1	ns			
Copper rockfish						1	ns			
Greenstriped rockfish							ns			
Quillback rockfish							ns			
Kelp greenling							ns			
Whitespotted greenling		1	1				ns			
Roughback sculpin	1	3		1			ns		1	
Buffalo sculpin							ns			
Pacific staghorn sculpin	3	5	1	1			ns		2	
Tadpole sculpin					1		ns			
Plainfin midshipman	2	6				1	ns			1
Sturgeon poacher	2			1	7	22	ns	14		
Pacific sanddab				2		1	ns	5	2	2
Speckled sanddab					4		ns			
Rex sole					5	2	ns	5	26	25
Flathead sole	21	38	17	3	7		ns	3	34	36
Butter sole				1			ns			

Table 48

Fish abundance

Number of individual fish and invertebrates caught in each trawl from Vancouver Harbour

Investigator: Dr. Colin Levin

Site	**T-48**	**T-48**	**T-48**	**T-11B**	**T-50**	**T-50**	**T-50**	**T-50**	**T-49**	**T-49**		
Trawl/site	1	2	3	4	1	2	3	4	6	7		
Species	Trawl 12	Trawl 13	Trawl 14	Trawl 15	Trawl 16	Trawl 17	Trawl 18	Trawl 19	Trawl 20	Trawl 21		
Rock sole	1						ns	1	3	2		
Slender sole				4	3	11	ns	6	26	18		
Dover sole						1	ns		6	2		
English sole	66	116	108	67	79	88	ns	51	69	45		
Starry flounder	3	1	1	6			ns		14	12		
Sand sole	2		1	3			ns		1	5		
Dungeness crab	82	106	38	19	0	10	ns	17	26	53		
Tanner crab				20		2	ns		1	2		
Rock crab	1						ns					
anemone												
Yoldia												
Cockle												
Butter Clam												
TOTALS	123	235	159	104	241	233	0	139	302	244	Grand Total	3850

ns = no sample due to net problems.

Table 49

Average biomass of fish for 100 square meters trawled.

Investigator: Dr. Colin Levings

Species	**Site**	**Average biomass of fish/ 100 square Meters**	**Average Number fish/ 100 square Meters**
Pacific staghorn sculpin	T11B	0.000	0.00
Pacific staghorn sculpin	T38	0.020	0.34
Pacific staghorn sculpin	T48	0.009	0.07
Pacific staghorn sculpin	T49	0.002	0.01
Pacific staghorn sculpin	T50	0.000	0.00
Pacific tomcod	T11B	0.010	0.18
Pacific tomcod	T38	0.040	0.98
Pacific tomcod	T48	0.019	0.34
Pacific tomcod	T49	0.003	0.04
Pacific tomcod	T50	0.025	0.56
Plainfin midshipman	T11B	0.000	0.00
Plainfin midshipman	T38	0.012	0.52
Plainfin midshipman	T48	0.002	0.05
Plainfin midshipman	T49	0.001	0.02
Plainfin midshipman	T50	0.000	0.01
Quillback rockfish	T11B	0.000	0.00
Quillback rockfish	T38	0.000	0.00
Quillback rockfish	T48	0.000	0.00
Quillback rockfish	T49	0.000	0.00
Quillback rockfish	T50	0.000	0.00
Rex sole	T11B	0.000	0.00
Rex sole	T38	0.000	0.00
Rex sole	T48	0.000	0.00
Rex sole	T49	0.064	0.36
Rex sole	T50	0.003	0.15
Rock crab	T11B	0.000	0.00
Rock crab	T38	0.000	0.00
Rock crab	T48	0.003	0.01
Rock crab	T49	0.000	0.00
Rock crab	T50	0.000	0.00
Rock sole	T11B	0.006	0.10
Rock sole	T38	0.000	0.00
Rock sole	T48	0.005	0.01
Rock sole	T49	0.011	0.05
Rock sole	T50	0.001	0.01
Roughback sculpin	T11B	0.003	0.03
Roughback sculpin	T38	0.000	0.00
Roughback sculpin	T48	0.001	0.03
Roughback sculpin	T49	0.000	0.00
Roughback sculpin	T50	0.000	0.00
Sand sole	T11B	0.015	0.05
Sand sole	T38	0.011	0.11
Sand sole	T48	0.003	0.03

Table 49

Average biomass of fish for 100 square meters trawled.

Investigator: Dr. Colin Levings

Species	**Site**	**Average biomass of fish/ 100 square Meters**	**Average Number fish/ 100 square Meters**
Sand sole	T49	0.004	0.06
Sand sole	T50	0.000	0.00
Shiner perch	T11B	0.001	0.02
Shiner perch	T38	0.013	0.42
Shiner perch	T48	0.002	0.03
Shiner perch	T49	0.001	0.02
Shiner perch	T50	0.001	0.01
Slender sole	T11B	0.001	0.06
Slender sole	T38	0.000	0.00
Slender sole	T48	0.000	0.00
Slender sole	T49	0.007	0.31
Slender sole	T50	0.003	0.17
Speckled sanddab	T11B	0.000	0.00
Speckled sanddab	T38	0.000	0.00
Speckled sanddab	T48	0.000	0.00
Speckled sanddab	T49	0.000	0.00
Speckled sanddab	T50	0.016	0.08
Spiny dogfish	T11B	0.000	0.00
Spiny dogfish	T38	0.000	0.00
Spiny dogfish	T48	0.000	0.00
Spiny dogfish	T49	0.000	0.00
Spiny dogfish	T50	0.103	0.03
Starry flounder	T11B	0.017	0.08
Starry flounder	T38	0.130	0.65
Starry flounder	T48	0.009	0.04
Starry flounder	T49	0.044	0.21
Starry flounder	T50	0.000	0.00
Sturgeon poacher	T11B	0.000	0.01
Sturgeon poacher	T38	0.000	0.00
Sturgeon poacher	T48	0.001	0.02
Sturgeon poacher	T49	0.000	0.00
Sturgeon poacher	T50	0.009	0.37
Tadpole sculpin	T11B	0.000	0.00
Tadpole sculpin	T38	0.000	0.00
Tadpole sculpin	T48	0.000	0.00
Tadpole sculpin	T49	0.000	0.00
Tadpole sculpin	T50	0.000	0.02
Tanner crab	T11B	0.023	0.10
Tanner crab	T38	0.000	0.00
Tanner crab	T48	0.000	0.00
Tanner crab	T49	0.002	0.05
Tanner crab	T50	0.002	0.01
Walleye pollock	T11B	0.000	0.00

Table 49

Average biomass of fish for 100 square meters trawled.

Investigator: Dr. Colin Levings

Species	Site	Average biomass of fish/ 100 square Meters	Average Number fish/ 100 square Meters
Walleye pollock	T38	0.000	0.00
Walleye pollock	T48	0.002	0.01
Walleye pollock	T49	0.000	0.00
Walleye pollock	T50	0.000	0.00
Whitespotted greenling	T11B	0.001	0.01
Whitespotted greenling	T38	0.000	0.00
Whitespotted greenling	T48	0.003	0.01
Whitespotted greenling	T49	0.000	0.00
Whitespotted greenling	T50	0.000	0.00
Yoldia	T11B	0.000	0.00
Yoldia	T38	0.000	0.05
Yoldia	T48	0.000	0.00
Yoldia	T49	0.000	0.00
Yoldia	T50	0.000	0.00
anemone	T11B	0.000	0.00
anemone	T38	0.000	0.20
anemone	T48	0.000	0.00
anemone	T49	0.000	0.00
anemone	T50	0.000	0.00
Blackbelly eelpout	T11B	0.001	0.04
Blackbelly eelpout	T38	0.000	0.00
Blackbelly eelpout	T48	0.010	0.24
Blackbelly eelpout	T49	0.040	1.41
Blackbelly eelpout	T50	0.006	0.21
Buffalo sculpin	T11B	0.000	0.00
Buffalo sculpin	T38	0.000	0.00
Buffalo sculpin	T48	0.000	0.00
Buffalo sculpin	T49	0.000	0.00
Butter Clam	T50	0.000	0.00
Butter Clam	T11B	0.000	0.00
Butter Clam	T38	0.000	0.01
Butter Clam	T48	0.000	0.00
Butter Clam	T49	0.000	0.00
Butter Clam	T50	0.000	0.00
Butter sole	T11B	0.000	0.00
Butter sole	T38	0.000	0.00
Butter sole	T48	0.000	0.00
Butter sole	T49	0.000	0.00
Butter sole	T50	0.000	0.00
Cockles	T11B	0.000	0.00
Cockles	T38	0.000	0.08
Cockles	T48	0.000	0.00
Cockles	T49	0.000	0.00

Table 49

Average biomass of fish for 100 square meters trawled.

Investigator: Dr. Colin Levings

Species	Site	Average biomass of fish/ 100 square Meters	Average Number fish/ 100 square Meters
Cockles	T50	0.000	0.00
Copper rockfish	T11B	0.000	0.00
Copper rockfish	T38	0.000	0.00
Copper rockfish	T48	0.000	0.00
Copper rockfish	T49	0.000	0.00
Copper rockfish	T50	0.000	0.01
Dover sole	T11B	0.000	0.00
Dover sole	T38	0.053	0.88
Dover sole	T48	0.000	0.00
Dover sole	T49	0.003	0.05
Dover sole	T50	0.001	0.01
Dungeness crab	T11B	0.042	0.20
Dungeness crab	T38	0.308	2.78
Dungeness crab	T48	0.200	1.67
Dungeness crab	T49	0.128	0.42
Dungeness crab	T50	0.065	0.18
English sole	T11B	0.083	1.03
English sole	T38	0.356	5.95
English sole	T48	0.177	1.94
English sole	T49	0.060	0.51
English sole	T50	0.185	2.47
Eulachon	T11B	0.000	0.00
Eulachon	T38	0.000	0.00
Eulachon	T48	0.000	0.00
Eulachon	T49	0.000	0.00
Eulachon	T50	0.000	0.00
Flathead sole	T11B	0.002	0.01
Flathead sole	T38	0.015	0.10
Flathead sole	T48	0.033	0.53
Flathead sole	T49	0.021	0.49
Flathead sole	T50	0.002	0.16
Greenstriped rockfish	T11B	0.000	0.00
Greenstriped rockfish	T38	0.000	0.00
Greenstriped rockfish	T48	0.000	0.00
Greenstriped rockfish	T49	0.000	0.00
Greenstriped rockfish	T50	0.000	0.00
Kelp greenling	T11B	0.000	0.00
Kelp greenling	T38	0.000	0.00
Kelp greenling	T48	0.000	0.00
Kelp greenling	T49	0.000	0.00
Kelp greenling	T50	0.000	0.00
Longfin smelt	T11B	0.000	0.02
Longfin smelt	T38	0.003	0.19

Table 49

Average biomass of fish for 100 square meters trawled.

Investigator: Dr. Colin Levings

Species	**Site**	**Average biomass of fish/ 100 square Meters**	**Average Number fish/ 100 square Meters**
Longfin smelt	T48	0.001	0.09
Longfin smelt	T49	0.000	0.00
Longfin smelt	T50	0.000	0.00
Longnose skate	T11B	0.000	0.00
Longnose skate	T38	0.000	0.00
Longnose skate	T48	0.000	0.00
Longnose skate	T49	0.000	0.00
Longnose skate	T50	0.000	0.00
Pacific hake	T11B	0.000	0.00
Pacific hake	T38	0.000	0.00
Pacific hake	T48	0.000	0.00
Pacific hake	T49	0.000	0.00
Pacific hake	T50	0.066	2.92
Pacific herring	T11B	0.002	0.09
Pacific herring	T38	0.007	0.22
Pacific herring	T48	0.003	0.05
Pacific herring	T49	0.000	0.00
Pacific herring	T50	0.000	0.00
Pacific sanddab	T11B	0.004	0.04
Pacific sanddab	T38	0.004	0.09
Pacific sanddab	T48	0.000	0.00
Pacific sanddab	T49	0.006	0.03
Pacific sanddab	T50	0.005	0.04

The average biomass may be 0.000 even though a small number of fish were present. This is due to the number of significant figures reported.

Table 50

Age of English sole, as determined from otoliths.

Investigator: Dr. Colin Levings

Fish ID	Length (mm)	Weight (g)	Sex	Age (years)	Site number
990001	262	131	M	8	B49
990002	263	152	F	8	B49
990003	204	63	M	3	B49
990004	200	63	M	3	B49
990005	240	112	M	10	B49
990006	311	261	M	9	B49
990007	215	80	M	9	B49
990008	250	130	M	6	B49
990009	223	98	M	5	B49
990010	218	90	M	5	B49
990011	207	78	M	6	B49
990012	261	158	M	2	B49
990013	243	115	M	5	B49
990014	274	165	F	6	B49
990015	290	220	F	9	B49
990016	251	137	M	9	B49
990017	257	158	M	8	B49
990018	230	103	M	8	B49
990019	227	109	M	8	B49
990020	227	110	M	5	B49
990021	295	193	F	7	B49
990022	263	157	F	6	B49
990023	265	161	F	5	B49
990024	275	160	F	4	B49
990025	260	140	F	4	B49
990026	259	156	F	6	B49
990027	245	133	F	10	B49
990028	265	174	F	7	B49
990029	255	150	F	6	B49
990030	278	171	F	6	B49
990031	223	90	M	8	B11B
990032	218	87	M	7	B11B
990033	262	148	F	6	B11B
990034	311	284	F	11	B11B
990035	272	188	F	9	B11B
990036	325	276	F	10	B11B
990037	254	135	F	5	B11B
990038	256	148	F	7	B11B
990039	232	100	M	7	B11B
990040	243	120	M	5	B11B
990041	273	172	F	9	B11B
990042	229	97	F	5	B11B
990043	216	81	F	5	B11B
990044	235	116	F	5	B11B
990045	247	148	F	7	B11B

Table 50

Age of English sole, as determined from otoliths.

Investigator: Dr. Colin Levings

Fish ID	Length (mm)	Weight (g)	Sex	Age (years)	Site number
990046	240	122	F	9	B11B
990047	228	108	M	7	B11B
990048	227	91	M	6	B11B
990049	217	88	F	6	B11B
990050	217	86	F	6	B11B
990051	258	145	F	7	B11B
990052	237	112	F	7	B11B
990053	241	121	F	8	B11B
990054	227	104	M	4	B11B
990055	236	111	F	4	B11B
990056	228	98	F	5	B11B
990057	226	89	F	4	B11B
990058	228	95	F	4	B11B
990059	230	103	F	4	B11B
990060	218	89	F	4	B11B
990061	257	129	F	7	B38
990062	322	265	F	8	B38
990063	290	184	F	7	B38
990064	285	160	M	11	B38
990065	342	298	F	10	B38
990066	336	312	F	8	B38
990067	289	170	M	15	B38
990068	332	275	F	12	B38
990069	332	301	F	9	B38
990070	215	242	F	11	B38
990071	344	297	F	11	B38
990072	332	313	F	15	B38
990073	228	350	F	9	B38
990074	321	266	F	8	B38
990075	304	204	F	8	B38
990076	306	220	F	10	B38
990077	297	221	F	11	B38
990078	290	168	M	15	B38
990079	295	201	F	6	B38
990080	284	170	F	6	B38
990081	262	137	F	7	B38
990082	283	183	F	8	B38
990083	280	165	M	14	B38
990084	300	220	M	10	B38
990085	271	152	M	10	B38
990086	284	153	M	10	B38
990087	258	139	F	5	B38
990088	258	137	F	6	B38
990089	265	141	F	6	B38
990090	282	202	F	7	B38

Table 50

Age of English sole, as determined from otoliths.

Investigator: Dr. Colin Levings

Fish ID	Length (mm)	Weight (g)	Sex	Age (years)	Site number
990091	302	192	F	10	B48
990092	287	192	F	6	B48
990093	290	190	F	9	B48
990094	271	152	F	6	B48
990095	255	160	F	9	B48
990096	247	125	F	6	B48
990097	289	188	F	7	B48
990098	278	178	F	7	B48
990099	230	97	M	8	B48
990100	266	40	M	11	B48
990101	256	120	M	5	B48
990102	271	176	M	13	B48
990103	285	176	F	10	B48
990104	318	283	F	10	B48
990105	302	235	F	8	B48
990106	275	168	F	5	B48
990107	262	150	F	5	B48
990108	248	126	F	4	B48
990109	255	135	F	5	B48
990110	274	155	F	6	B48
990111	247	126	M	9	B48
990112	252	132	F	7	B48
990113	250	134	F	6	B48
990114	265	146	F	6	B48
990115	297	228	F	6	B48
990116	262	153	F	6	B48
990117	274	177	F	9	B48
990118	274	168	F	8	B48
990119	256	143	F	4	B48
990120		265	F	11	B48
990121	246	113	F	6	B50
990122	295	204	F	12	B50
990123		125	F	6	B50
990124	265	124	M	13	B50
990125	280	166	F	6	B50
990126		95	F	6	B50
990127	235	91	M	8	B50
990128	245	112	F	7	B50
990129	246	120	F	6	B50
990130	243	107	F	4	B50
990131	234	90	M	8	B50
990132	269	142	F	9	B50
990133	228	97	M	8	B50
990134	230	101	M	9	B50
990135	240	105	M	6	B50

Table 50

Age of English sole, as determined from otoliths.

Investigator: Dr. Colin Levings

Fish ID	Length (mm)	Weight (g)	Sex	Age (years)	Site number
990136	233	96	M	10	B50
990137	229	99	F	7	B50
990138	235	94	M	9	B50
990139	224	92	F	7	B50
990140	239	89	M	3	B50
990141	246	93	F	3	B50
990142	234	92	M	11	B50
990143	225	79	M	8	B50
990144	216	61	M	6	B50
990145	237	96	J	7	B50
990146	235	92	M	6	B50
990147	234	99	F	6	B50
990148	230	85	M	9	B50
990149	225	80	F	6	B50
990150	229	85	M	9	B50
990151	285	172	F	3	B49
990152	260	135	M	6	B49
990153	290	178	F	6	B49
990154	292	193	F	5	B49
990155	265	141	F	6	B49
990156	254	145	F	9	B49
990157	290	213	M	6	B49
990158	234	103	M	7	B49
990159	265	155	M	7	B49
990160	227	108	M	6	B49
990161	237	107	F	4	B49
990162	255	132	M	6	B49

Table 51

Stomach contents for English sole from Vancouver Harbour.

Investigator: Dr. Colin Levings

Fish ID	Site	Age	Bivalves	Forams	Mollusc Fragments	Annelids	Annelid Fragments	Nematodes	Amphipods	Unknown Crustacean Fragments	Unknown Crustaceans	Algae	Bark	Unknown Tissue	Stones	Unidentifiable Invertebrate Fragments	Egg capsules
990009	T49	5	34	4	y	7	y	y	4	3	0	y	y	y	n	n	n
990013	T49	5	14	1	y	1	y	y	1	n	0	y	y	y	n	n	n
990014	T49	6	22	6	y	25	y	y	0	n	0	y	y	y	n	n	n
990016	T49	9	40	1	y	24	y	y	0	n	0	y	y	y	n	n	n
990017	T49	8	30	0	y	22	y	y	0	n	0	y	y	y	n	1	n
990018	T49	8	13	5	y	4	y	y	1	n	0	y	y	y	n	n	n
990019	T49	8	34	0	y	25	y	y	2	n	0	y	y	y	n	n	n
990020	T49	5	2	0	y	26	y	y	0	1	1	y	y	y	n	n	n
990021	T49	7	2	2	y	20	y	y	0	n	0	y	y	y	n	2	n
990022	T49	6	9	2	y	18	y	y	0	n	0	y	y	y	n	n	n
990031	T11B	8	6	3	y	9	y	y	0	n	0	y	y	y	n	n	n
990032	T11B	7	16	2	y	6	y	y	0	3	0	y	y	y	n	n	n
990033	T11B	6	5	1	y	3	y	y	1	n	0	y	y	y	n	n	n
990037	T11B	5	1	1	y	13	y	y	0	n	0	y	y	y	n	1	n
990038	T11B	7	2	0	y	45	y	y	4	2	3	y	y	y	n	5	n
990039	T11B	7	9	0	y	26	y	y	1	n	1	y	y	y	n	n	n
990043	T11B	5	4	1	y	9	y	y	0	n	0	y	y	y	n	n	n
990044	T11B	5	7	2	y	15	y	y	0	n	0	y	y	y	n	1	n
990046	T11B	9	2	0	y	21	y	y	0	n	0	y	y	y	n	I	n
990051	T11B	7	8	0	y	6	y	y	0	n	0	y	y	y	n	n	n
990062	T38	8	1	0	y	56	y	y	0	4	1	y	y	y	n	n	2
990063	T38	7	6	0	y	2	y	y	0	n	0	y	y	y	n	n	n
990064	T38	11	4	1	y	67	y	y	0	3	4	y	y	y	n	n	n
990067	T38	15	1	0	y	74	y	y	1	n	0	y	y	y	n	n	n
990068	T38	12	5	0	y	30	y	y	0	n	0	y	y	y	n	n	n
990071	T38	11	0	2	y	62	y	y	0	n	0	y	y	y	n	n	n
990077	T38	11	5	0	y	35	y	y	0	n	0	y	y	y	n	n	n
990081	T38	7	0	0	y	61	y	y	0	1	1	y	y	y	n	n	n
990084	T38	10	0	0	y	6	y	y	0	n	0	y	y	y	n	n	n
990085	T38	10	0	0	y	62	y	y	0	1	0	y	y	y	n	n	n
990091	T48	10	23	0	y	6	n	6	6	4	0	y	y	y	n	n	n

Table 51

Stomach contents for English sole from Vancouver Harbour.

Investigator: Dr. Colin Levings

Fish ID	Site	Age	Bivalves	Forams	Mollusc Fragments	Annelids	Annelid Fragments	Nematodes	Amphipods	Unknown Crustacean Fragments	Unknown Crustaceans	Algae	Bark	Unknown Tissue	Stones	Unidentifiable Invertebrate Fragments	Egg capsules
990009	T49	5	34	4	y	7	y	y	4	3	0	y	y	y	n	n	n
990092	T48	6	1	3	y	19	y	39	0	1	0	y	y	y	n	n	n
990093	T48	9	36	2	y	13	y	11	0	n	0	y	y	y	2	n	n
990095	T48	9	1	0	n	20	y	50	1	1	2	y	y	y	n	3	n
990096	T48	6	14	0	y	14	n	27	0	n	0	y	y	y	n	1	n
990097	T48	7	2	2	y	15	y	58	0	n	0	y	y	y	n	1	n
990098	T48	7	31	10	y	40	y	19	0	y	0	y	y	y	n	9	1
990099	T48	8	36	3	y	6	y	21	7	21	2	y	y	y	n	2	n
990100	T48	11	2	7	y	7	y	21	2	2	0	y	y	y	n	2	n
990101	T48	5	32	2	y	1	n	32	0	5	0	y	y	y	n	19	n
990102	T48	13	1	4	y	4	y	14	0	1	0	y	y	y	n	n	n
990103	T48	10	36	32	y	14	y	122	0	n	1	y	y	y	n	3	n
990104	T48	10	1	0	n	24	y	36	0	n	0	y	y	y	n	3	n
990124	T50	13	37	0	y	6	y	y	4	1	0	y	y	y	n	n	n
990127	T50	8	0	0	y	27	y	y	0	4	1	y	y	y	26	6	n
990129	T50	6	87	0	y	4	y	y	2	1	1	y	y	y	1	n	n
990131	T50	8	14	0	y	4	y	y	4	3	0	y	y	y	n	n	n
990133	T50	8	23	0	y	2	y	y	1	n	1	y	y	y	n	2	n
990134	T50	9	4	2	y	4	y	y	6	9	0	y	y	y	n	3	n
990135	T50	6	64	0	y	15	n	y	1	n	0	y	y	y	n	3	n
990136	T50	10	2	0	y	22	y	y	1	n	1	y	y	y	4	n	n
990138	T50	9	8	0	y	6	y	y	2	n	0	y	y	y	n	n	n
990139	T50	7	6	0	y	4	y	y	3	n	1	y	y	y	6	n	n

Table 52

Length (mm) and wet weight (g) of *Mytilus trossulus*.

Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I1	1	7.8	0.07	0.01
I1	2	7.5	0.05	0.01
I1	3	7.5	0.07	0.01
I1	4	7.0	0.05	0.00
I1	5	6.5	0.04	0.00
I1	6	5.8	0.03	0.00
I1	7	8.0	0.08	0.01
I1	8	8.0	0.08	0.01
I1	9	8.5	0.08	0.01
I1	10	9.1	0.11	0.02
I1	11	7.3	0.07	0.00
I1	12	8.0	0.07	0.01
I1	13	8.4	0.08	0.01
I1	14	8.9	0.11	0.01
I1	15	11.3	0.16	0.03
I1	16	9.4	0.13	0.01
I1	17	8.8	0.11	0.02
I1	18	8.1	0.08	0.01
I1	19	8.0	0.10	0.01
I1	20	10.0	0.15	0.02
I1	21	10.3	0.16	0.02
I1	22	9.2	0.12	0.01
I1	23	10.7	0.15	0.03
I1	24	11.0	0.15	0.03
I1	25	10.0	0.13	0.03
I1	26	11.3	0.19	0.03
I1	27	11.2	0.15	0.03
I1	28	11.4	0.16	0.02
I1	29	10.7	0.18	0.03
I1	30	11.0	0.16	0.03
I1	31	10.3	0.14	0.03
I1	32	10.9	0.14	0.02
I1	33	11.6	0.18	0.03
I1	34	11.8	0.18	0.03
I1	35	12.3	0.21	0.04
I1	36	12.4	0.22	0.04
I1	37	11.4	0.15	0.04
I1	38	11.9	0.22	0.03
I1	39	13.6	0.32	0.06
I1	40	14.4	0.33	0.07
I1	41	12.4	0.29	0.06
I1	42	12.5	0.21	0.04
I1	43	14.8	0.31	0.09
I1	44	12.8	0.20	0.05
I1	45	13.4	0.30	0.07
I1	46	12.8	0.29	0.06
I1	47	12.0	0.19	0.04
I4	52	37.8	4.35	1.16
I4	53	37.6	5.34	1.32
I4	54	18.8	0.62	0.15
I4	55	40.8	4.73	1.20
I4	56	28.3	1.95	0.44
I4	57	9.0	0.06	0.00
I4	58	9.0	0.07	0.00
I4	59	27.5	1.60	0.27
I4	60	10.0	0.12	0.01
I4	61	42.0	4.70	1.20
I4	62	32.4	2.82	0.84
I4	63	7.2	0.03	0.01
I4	64	8.5	0.07	0.01
I4	65	41.8	4.54	1.00
I4	66	13.0	0.27	0.04
I4	67	30.0	2.03	0.35
I4	68	29.4	1.80	0.44
I4	69	26.5	1.37	0.31
I4	70	7.0	0.06	0.00
I4	71	24.3	1.11	0.19
I4	72	33.9	2.84	0.67
I4	73	27.8	1.92	0.40
I4	74	21.6	0.77	0.12
I4	75	30.3	2.08	0.63
I4	76	27.4	1.94	0.39
I4	77	15.0	0.33	0.03
I4	78	7.1	0.04	0.00
I4	79	8.6	0.06	0.00
I4	80	15.5	0.32	0.03
I4	81	10.5	0.13	0.02
I4	82	8.0	0.05	0.01
I4	83	8.0	0.06	0.00
I4	84	26.7	1.34	0.30
I4	85	22.2	1.15	0.19
I4	86	28.6	1.78	0.39
I4	87	23.4	1.12	0.24
I4	88	29.6	2.11	0.48
I4	89	28.7	1.57	0.30
I4	90	22.5	1.05	0.18
I4	91	11.0	0.13	0.01
I4	92	38.1	4.31	1.21
I4	93	27.0	1.70	0.36
I4	94	8.8	0.06	0.00
I4	95	8.6	0.05	0.00
I4	96	37.8	4.69	1.34
I4	97	28.9	2.75	0.49
I4	98	10.1	0.09	0.01

Table 52
Length (mm) and wet weight (g) of *Mytilus trossulus.*
Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)	Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I1	48	14.0	0.34	0.07	I4	99	8.3	0.05	0.01
I1	49	12.8	0.26	0.06	I4	100	7.6	0.05	0.00
I1	50	14.5	0.42	0.09	I5B	1	9.5	0.10	0.01
I1	51	12.4	0.25	0.04	I5B	2	10.5	0.12	0.02
I1	52	12.5	0.23	0.05	I5B	3	9.0	0.08	0.01
I1	53	14.9	0.33	0.08	I5B	4	10.4	0.09	0.01
I1	54	12.9	0.22	0.04	I5B	5	12.6	0.27	0.05
I1	55	21.2	0.96	0.34	I5B	6	14.0	0.27	0.06
I1	56	14.3	0.30	0.06	I5B	7	17.8	0.63	0.15
I1	57	15.6	0.34	0.07	I5B	8	14.7	0.35	0.08
I1	58	22.1	0.92	0.27	I5B	9	16.2	0.37	0.13
I1	59	16.4	0.42	0.10	I5B	10	14.8	0.28	0.06
I1	60	17.8	0.53	0.18	I5B	11	16.3	0.44	0.11
I1	61	18.9	0.60	0.21	I5B	12	14.4	0.24	0.05
I1	62	15.7	0.43	0.10	I5B	13	13.8	0.27	0.06
I1	63	16.5	0.48	0.13	I5B	14	13.5	0.29	0.06
I1	64	16.8	0.44	0.11	I5B	15	17.8	0.56	0.15
I1	65	16.5	0.42	0.11	I5B	16	15.8	0.37	0.09
I1	66	17.8	0.66	0.20	I5B	17	12.6	0.18	0.03
I1	67	18.3	0.69	0.22	I5B	18	17.6	0.53	0.14
I1	68	18.9	0.66	0.21	I5B	19	13.8	0.19	0.11
I1	69	18.9	0.56	0.16	I5B	20	14.8	0.43	0.12
I1	70	19.2	0.67	0.20	I5B	21	17.0	0.34	0.06
I1	71	18.4	0.65	0.21	I5B	22	16.0	0.38	0.08
I1	72	22.2	1.08	0.34	I5B	23	15.0	0.28	0.05
I1	73	22.6	1.04	0.36	I5B	24	16.6	0.43	0.08
I1	74	22.2	0.99	0.36	I5B	25	15.8	0.43	0.08
I1	75	23.4	1.08	0.37	I5B	26	17.3	0.50	0.13
I1	76	26.4	1.46	0.57	I5B	27	17.5	0.51	0.13
I1	77	26.5	1.50	0.58	I5B	28	28.2	0.47	0.11
I1	78	24.6	1.55	0.61	I5B	29	20.4	0.65	0.16
I1	79	21.5	0.87	0.26	I5B	30	21.4	0.91	0.24
I1	80	29.8	1.94	0.68	I5B	31	17.6	0.42	0.10
I1	81	27.0	2.31	0.71	I5B	32	29.5	0.63	0.17
I1	82	28.0	1.62	0.65	I5B	33	22.8	0.91	0.25
I1	83	34.4	2.94	1.08	I5B	34	18.2	0.63	0.14
I1	84	34.7	2.93	0.95	I5B	35	19.9	0.70	0.21
I1	85	36.3	3.71	1.52	I5B	36	21.4	0.85	0.27
I1	86	37.9	3.83	1.45	I5B	37	21.4	0.89	0.26
I1	87	38.3	4.15	1.68	I5B	38	19.8	0.62	0.15
I1	88	41.8	6.65	2.53	I5B	39	19.5	0.65	0.19
I1	89	42.7	6.05	2.28	I5B	40	18.6	0.61	0.18
I1	90	44.4	7.43	2.88	I5B	41	22.0	0.89	0.23
I1	91	46.0	6.85	2.53	I5B	42	19.9	0.55	0.15
I1	92	45.4	6.32	2.26	I5B	43	18.6	0.59	0.17
I1	93	47.7	7.40	3.25	I5B	44	21.7	0.81	0.22
I1	94	47.6	7.91	2.71	I5B	45	20.2	0.71	0.13

Table 52
Length (mm) and wet weight (g) of *Mytilus trossulus.*
Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)	Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I1	95	46.6	7.64	2.88	I5B	46	24.9	1.22	0.33
I1	96	52.8	9.58	2.98	I5B	47	21.8	0.85	0.25
I1	97	55.0	12.27	3.87	I5B	48	22.6	1.00	0.35
I1	98	53.7	8.48	3.46	I5B	49	24.7	1.13	0.34
I1	99	49.9	7.86	3.10	I5B	50	23.5	1.27	0.38
I1	100	50.5	8.32	2.89	I5B	51	26.4	1.65	0.46
I2	1	7.8	0.05	0.01	I5B	52	25.8	1.71	0.69
I2	2	11.9	0.17	0.03	I5B	53	25.8	1.52	0.53
I2	3	12.7	0.18	0.04	I5B	54	26.2	1.61	0.54
I2	4	9.5	0.09	0.01	I5B	55	25.3	1.20	0.39
I2	5	10.9	0.12	0.02	I5B	56	24.5	1.34	0.47
I2	6	12.0	0.16	0.02	I5B	57	28.8	1.90	0.71
I2	7	9.9	0.11	0.02	I5B	58	27.4	1.55	0.56
I2	8	10.9	0.16	0.03	I5B	59	26.0	1.52	0.42
I2	9	12.5	0.21	0.04	I5B	60	30.5	2.05	0.69
I2	10	13.0	0.22	0.05	I5B	61	43.4	4.94	2.20
I2	11	12.4	0.21	0.05	I5B	62	42.8	7.08	2.57
I2	12	12.7	0.22	0.05	I5B	63	43.0	5.87	2.73
I2	13	14.8	0.33	0.09	I5B	64	49.9	6.68	1.89
I2	14	13.8	0.28	0.06	I5B	65	48.3	7.16	3.13
I2	15	16.5	0.48	0.15	I5B	66	49.7	6.84	2.42
I2	16	19.0	0.57	0.16	I5B	67	43.9	9.51	3.93
I2	17	18.5	0.62	0.17	I5B	68	49.2	7.26	3.12
I2	18	17.7	0.52	0.15	I5B	69	49.9	9.51	4.15
I2	19	12.3	0.16	0.03	I5B	70	47.2	8.19	3.59
I2	20	13.3	0.26	0.06	I5B	71	48.8	8.18	3.76
I2	21	16.5	0.49	0.13	I5B	72	48.8	8.22	3.72
I2	22	23.2	1.09	0.44	I5B	73	51.8	9.56	4.01
I2	23	19.8	0.61	0.17	I5B	74	50.7	9.48	4.72
I2	24	20.3	0.63	0.20	I5B	75	53.4	9.11	4.20
I2	25	16.3	0.42	0.12	I5B	76	51.7	8.74	4.12
I2	26	16.0	0.34	0.10	I5B	77	56.7	9.13	3.93
I2	27	17.4	0.57	0.20	I5B	78	51.7	8.28	3.62
I2	28	19.5	0.53	0.15	I5B	79	55.6	10.42	4.28
I2	29	19.5	0.51	0.15	I5B	80	55.6	10.73	5.11
I2	30	17.8	0.59	0.20	I5B	81	56.0	12.05	5.04
I2	31	21.0	0.87	0.26	I5B	82	52.9	9.32	4.23
I2	32	19.7	0.59	0.18	I5B	83	52.9	10.50	4.89
I2	33	22.3	1.03	0.36	I5B	84	54.9	11.09	5.28
I2	34	20.4	0.83	0.26	I5B	85	58.0	11.33	4.95
I2	35	19.7	0.75	0.27	I5B	86	56.9	10.40	4.78
I2	36	18.7	0.61	0.19	I5B	87	56.5	10.42	4.39
I2	37	19.5	0.52	0.18	I5B	88	55.0	9.41	4.21
I2	38	22.8	1.21	0.46	I5B	89	52.4	8.83	3.78
I2	39	20.4	0.66	0.19	I5B	90	54.8	9.95	4.49
I2	40	25.3	1.15	0.42	I5B	91	59.1	12.53	5.59
I2	41	22.4	0.96	0.31	I5B	92	57.0	11.14	5.00

Table 52
Length (mm) and wet weight (g) of *Mytilus trossulus.*
Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)	Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I2	42	21.5	0.79	0.21	I5B	93	62.0	13.52	6.09
I2	43	25.5	1.26	0.35	I5B	94	58.9	10.06	4.93
I2	44	21.4	0.89	0.31	I5B	95	59.8	15.69	7.65
I2	45	21.2	0.81	0.25	I5B	96	61.0	13.79	5.94
I2	46	24.5	1.13	0.38	I5B	97	59.1	12.72	6.60
I2	47	22.9	1.01	0.31	I5B	98	61.8	15.01	7.00
I2	48	25.1	1.28	0.45	I5B	99	59.6	11.99	5.50
I2	49	25.1	1.09	0.43	I5B	100	65.5	13.83	6.11
I2	50	29.9	1.91	0.82	I6	1	9.5	0.10	0.01
I2	51	28.6	1.59	0.63	I6	2	1.0	0.11	0.02
I2	52	24.4	1.12	0.40	I6	3	13.8	0.23	0.05
I2	53	25.8	1.28	0.51	I6	4	14.1	0.22	0.04
I2	54	21.4	0.84	0.30	I6	5	14.0	0.27	0.06
I2	55	22.2	0.97	0.27	I6	6	14.4	0.22	0.03
I2	56	21.3	1.33	0.50	I6	7	14.9	0.28	0.04
I2	57	26.7	1.42	0.61	I6	8	16.5	0.36	0.07
I2	58	28.9	1.59	0.64	I6	9	16.5	0.39	0.09
I2	59	27.5	1.73	0.55	I6	10	15.4	0.32	0.05
I2	60	25.8	1.43	0.59	I6	11	16.8	0.44	0.09
I2	61	33.7	2.71	1.16	I6	12	16.9	0.35	0.07
I2	62	28.3	1.88	0.66	I6	13	15.8	0.30	0.05
I2	63	30.6	2.45	0.84	I6	14	17.6	0.47	0.10
I2	64	30.3	1.80	0.75	I6	15	20.6	0.81	0.19
I2	65	25.6	1.31	0.36	I6	16	19.6	0.54	0.11
I2	66	28.3	1.76	0.63	I6	17	21.5	0.72	0.20
I2	67	26.4	1.35	0.53	I6	18	21.9	0.81	0.19
I2	68	33.8	2.46	1.01	I6	19	22.7	1.33	0.45
I2	69	29.9	1.87	0.79	I6	20	21.1	0.94	0.27
I2	70	29.0	1.82	0.65	I6	21	20.1	0.61	0.18
I2	71	33.4	2.10	0.79	I6	22	22.2	0.85	0.28
I2	72	30.6	2.20	0.70	I6	23	20.9	0.89	0.26
I2	73	38.3	3.21	2.72	I6	24	27.0	1.34	0.36
I2	74	33.9	2.45	0.64	I6	25	25.1	1.28	0.41
I2	75	34.4	3.10	1.09	I6	26	24.6	1.06	0.28
I2	76	37.1	3.16	1.28	I6	27	27.5	1.45	0.46
I2	77	34.4	2.82	1.09	I6	28	34.3	2.74	0.87
I2	78	34.4	2.46	0.90	I6	29	32.2	2.22	0.60
I2	79	31.9	2.39	0.96	I6	30	37.2	4.25	1.28
I2	80	33.3	2.50	0.98	I6	31	35.0	3.15	0.84
I2	81	33.3	3.06	1.44	I6	32	28.3	1.56	0.56
I2	82	33.0	2.51	1.06	I6	33	34.2	2.67	0.81
I2	83	33.0	2.78	0.96	I6	34	26.9	1.31	0.35
I2	84	33.9	2.48	1.06	I6	35	31.4	1.86	0.49
I2	85	35.9	2.88	1.13	I6	36	33.2	3.29	1.00
I2	86	30.6	2.38	0.92	I6	37	32.3	2.58	0.76
I2	87	33.0	2.50	0.87	I6	38	31.0	1.75	0.53
I2	88	34.9	3.10	1.26	I6	39	37.0	3.08	0.98

Table 52

Length (mm) and wet weight (g) of *Mytilus trossulus*.

Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I2	89	34.7	3.24	1.31
I2	90	37.5	3.84	1.83
I2	91	40.3	4.03	1.82
I2	92	42.3	4.02	1.55
I2	93	43.8	4.45	1.88
I2	94	38.8	4.66	2.02
I2	95	46.5	6.25	2.37
I2	96	43.2	4.34	1.88
I2	97	46.0	5.21	2.19
I2	98	48.0	5.53	1.83
I2	99	54.7	8.88	3.33
I2	100	53.4	10.05	3.46
I3A	1	7.5	0.03	0.01
I3A	2	8.8	0.07	0.00
I3A	3	11.4	0.13	0.00
I3A	4	11.4	0.15	0.02
I3A	5	11.4	0.13	0.01
I3A	6	10.7	0.15	0.01
I3A	7	10.5	0.12	0.00
I3A	8	11.5	0.27	0.02
I3A	9	12.1	0.18	0.01
I3A	10	12.5	0.19	0.02
I3A	11	14.8	0.27	0.02
I3A	12	18.6	0.51	0.06
I3A	13	18.0	0.66	0.03
I3A	14	17.0	0.47	0.05
I3A	15	15.4	0.44	0.07
I3A	16	17.0	0.45	0.06
I3A	17	18.0	0.52	0.05
I3A	18	9.4	0.58	0.06
I3A	19	18.3	0.59	0.04
I3A	20	18.2	0.59	0.06
I3A	21	23.4	0.84	0.14
I3A	22	22.6	0.85	0.14
I3A	23	24.9	1.25	0.23
I3A	24	19.7	0.59	0.08
I3A	25	22.7	0.81	0.12
I3A	26	21.6	0.92	0.14
I3A	27	24.0	1.19	0.16
I3A	28	19.9	0.56	0.02
I3A	29	20.7	0.73	0.10
I3A	30	22.9	0.77	0.15
I3A	31	21.9	0.81	0.18
I3A	32	24.5	1.00	0.17
I3A	33	24.6	0.90	0.17
I3A	34	24.9	0.88	0.14
I3A	35	21.6	0.66	0.12

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I6	40	34.9	3.07	0.99
I6	41	34.3	2.89	0.88
I6	42	34.9	2.80	0.78
I6	43	35.5	3.41	1.00
I6	44	39.2	4.05	1.16
I6	45	37.3	3.53	0.95
I6	46	47.8	8.23	2.10
I6	47	37.9	4.11	1.47
I6	48	33.6	2.60	0.80
I6	49	42.5	5.60	1.73
I6	50	46.3	5.12	1.73
I6	51	34.4	3.32	1.15
I6	52	35.9	3.40	1.34
I6	53	32.5	2.49	0.74
I6	54	39.5	4.46	1.47
I6	55	34.0	2.32	0.67
I6	56	36.8	3.47	1.18
I6	57	40.5	4.30	1.19
I6	58	45.4	5.01	1.45
I6	59	41.4	3.97	2.32
I6	60	41.1	5.39	0.83
I6	61	40.0	4.36	1.42
I6	62	43.7	6.71	2.31
I6	63	45.3	7.16	2.67
I6	64	44.9	5.73	1.49
I6	65	39.2	4.31	1.29
I6	66	45.5	5.44	1.74
I6	67	44.4	5.73	2.00
I6	68	45.6	6.74	1.98
I6	69	47.5	6.94	2.52
I6	70	40.5	4.48	1.19
I6	71	51.0	7.27	2.55
I6	72	43.0	6.06	1.92
I6	73	50.3	7.19	1.92
I6	74	50.2	7.15	2.25
I6	75	44.9	4.79	1.50
I6	76	48.0	6.69	2.19
I6	77	44.1	5.81	1.89
I6	78	44.7	5.65	2.08
I6	79	46.0	5.76	2.04
I6	80	48.9	7.25	2.52
I6	81	47.7	8.02	2.88
I6	82	49.8	7.42	2.60
I6	83	43.2	5.87	1.89
I6	84	45.5	5.99	1.99
I6	85	46.9	6.05	1.74
I6	86	47.9	7.08	2.28

Table 52

Length (mm) and wet weight (g) of *Mytilus trossulus.*

Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)	Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I3A	36	24.1	1.00	0.13	I6	87	51.0	8.03	2.07
I3A	37	25.0	1.06	0.13	I6	88	50.3	6.87	2.54
I3A	38	24.1	1.04	0.18	I6	89	52.0	8.29	3.38
I3A	39	22.8	0.86	0.14	I6	90	55.8	8.74	3.18
I3A	40	23.4	1.10	0.19	I6	91	51.0	8.63	2.89
I3A	41	24.8	0.85	0.16	I6	92	56.8	10.39	3.13
I3A	42	23.2	0.89	0.10	I6	93	51.0	7.80	2.81
I3A	43	28.4	1.40	0.33	I6	94	53.1	8.80	2.58
I3A	44	26.1	1.01	0.26	I6	95	51.2	7.58	2.66
I3A	45	26.6	1.23	0.30	I6	96	51.9	9.00	2.79
I3A	46	23.2	0.99	0.14	I6	97	61.8	14.16	5.80
I3A	47	28.6	1.23	0.30	I6	98	54.5	8.65	3.05
I3A	48	27.7	1.45	0.30	I6	99	57.3	9.74	3.74
I3A	49	23.8	1.05	0.26	I6	100	57.4	10.32	3.77
I3A	50	22.6	1.28	0.34	I7	1	34.4	2.74	0.58
I3A	51	24.8	1.02	0.22	I7	2	52.3	10.25	1.90
I3A	52	26.5	1.51	0.34	I7	3	42.0	7.34	1.33
I3A	53	27.4	1.38	0.35	I7	4	53.0	7.88	1.63
I3A	54	27.3	1.28	0.32	I7	5	52.3	7.29	1.75
I3A	55	32.2	2.01	0.55	I7	6	42.4	3.75	0.86
I3A	56	32.3	2.45	0.70	I7	7	42.8	4.60	1.13
I3A	57	33.8	2.14	0.50	I7	8	42.5	4.76	1.44
I3A	58	31.2	1.96	0.55	I7	9	36.4	2.89	0.82
I3A	59	27.3	1.18	0.29	I7	10	42.6	4.63	1.21
I3A	60	30.5	19.80	0.53	I7	11	35.2	2.66	0.75
I3A	61	30.5	1.97	0.51	I7	12	18.8	0.58	0.15
I3A	62	32.4	2.54	0.65	I7	13	57.5	11.79	2.38
I3A	63	26.1	1.12	0.23	I7	14	42.7	6.54	1.59
I3A	64	21.8	1.22	0.28	I7	15	44.2	6.67	1.11
I3A	65	28.1	1.31	0.27	I7	16	38.6	3.80	0.96
I3A	66	32.3	2.13	0.58	I7	17	46.8	5.44	1.18
I3A	67	29.6	1.82	0.57	I7	18	30.1	1.73	0.41
I3A	68	30.0	1.68	0.55	I7	19	39.5	4.15	1.01
I3A	69	28.4	1.74	0.51	I7	20	42.4	4.24	1.03
I3A	70	28.5	1.67	0.44	I7	21	33.6	2.30	0.55
I3A	71	32.5	1.94	0.58	I7	22	31.1	1.87	0.40
I3A	72	28.5	1.89	0.50	I7	23	21.9	1.58	0.29
I3A	73	34.7	2.83	0.75	I7	24	22.2	0.88	0.22
I3A	74	31.3	1.84	0.50	I7	25	29.7	1.71	0.49
I3A	75	31.4	1.48	0.37	I7	26	47.9	7.07	1.42
I3A	76	30.5	1.80	0.27	I7	27	36.9	2.53	0.52
I3A	77	32.5	2.10	0.58	I7	28	43.8	5.15	1.23
I3A	78	34.4	2.66	0.83	I7	29	35.4	2.58	0.62
I3A	79	32.3	2.00	0.48	I7	30	12.8	0.27	0.05
I3A	80	34.9	2.23	0.60	I7	31	36.9	2.78	0.68
I3A	81	34.0	2.71	0.85	I7	32	41.8	4.50	1.08
I3A	82	34.8	2.39	0.67	I7	33	47.9	7.42	1.43

Table 52

Length (mm) and wet weight (g) of *Mytilus trossulus.*

Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I3A	83	33.2	2.97	0.99
I3A	84	34.1	2.24	0.69
I3A	85	36.0	2.74	0.88
I3A	86	36.3	2.82	0.59
I3A	87	39.7	3.87	1.09
I3A	88	37.9	3.87	1.17
I3A	89	38.3	3.84	1.28
I3A	90	36.9	2.94	0.75
I3A	91	38.4	3.69	0.80
I3A	92	38.7	3.68	1.11
I3A	93	40.5	4.52	1.45
I3A	94	42.8	4.49	1.12
I3A	95	37.2	3.64	1.06
I3A	96	40.4	4.10	1.18
I3A	97	44.8	4.60	1.29
I3A	98	43.5	4.96	1.56
I3A	99	39.3	3.75	1.44
I3A	100	45.7	5.31	1.52
I4	1	33.8	2.27	0.60
I4	2	44.4	5.41	1.54
I4	3	33.4	3.70	0.96
I4	4	17.7	0.61	0.12
I4	5	20.0	0.80	0.15
I4	6	26.1	1.76	0.31
I4	7	9.9	0.13	0.00
I4	8	13.0	0.26	0.03
I4	9	28.5	2.03	0.45
I4	10	37.0	4.03	0.98
I4	11	8.1	0.07	0.00
I4	12	10.3	0.10	0.01
I4	13	31.4	2.49	0.60
I4	14	29.0	1.90	0.40
I4	15	36.9	3.93	1.01
I4	16	20.7	0.93	0.19
I4	17	21.0	0.77	0.10
I4	18	32.5	2.57	0.55
I4	19	34.8	3.52	0.66
I4	20	11.4	0.13	0.01
I4	21	22.3	0.91	0.14
I4	22	21.5	0.86	0.15
I4	23	13.8	0.24	0.02
I4	24	10.4	0.15	0.01
I4	25	10.4	0.12	0.01
I4	26	12.3	0.19	0.01
I4	27	15.6	0.33	0.03
I4	28	10.4	0.11	0.01
I4	29	31.4	3.04	0.56

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I7	34	45.3	5.62	1.35
I7	35	35.5	2.81	0.82
I7	36	26.4	1.24	0.29
I7	37	12.6	0.21	0.04
I7	38	12.8	0.21	0.04
I7	39	35.3	2.72	0.55
I7	40	32.8	4.01	0.90
I7	41	44.0	6.08	1.44
I7	42	40.2	3.93	0.90
I7	43	33.9	2.27	0.46
I7	44	39.8	3.91	1.03
I7	45	18.8	0.54	0.15
I7	46	12.3	0.19	0.03
I7	47	23.1	0.92	0.26
I7	48	12.2	0.18	0.03
I7	49	12.8	0.17	0.03
I7	50	17.2	0.61	0.14
I7	51	49.5	8.50	1.84
I7	52	21.6	1.25	0.33
I7	53	36.5	2.49	0.72
I7	54	36.2	2.59	0.78
I7	55	29.8	1.76	0.56
I7	56	29.4	1.81	0.45
I7	57	34.9	2.60	0.78
I7	58	30.4	1.70	0.56
I7	59	41.0	3.87	0.88
I7	60	18.4	0.42	0.09
I7	61	35.2	2.77	0.65
I7	62	40.6	4.16	0.82
I7	63	27.1	1.54	0.29
I7	64	33.3	2.04	0.54
I7	65	24.4	1.24	0.34
I7	66	43.6	4.84	1.17
I7	67	32.9	1.85	0.48
I7	68	24.7	1.01	0.24
I7	69	23.2	0.86	0.17
I7	70	11.9	0.19	0.03
I7	71	15.5	0.32	0.07
I7	72	25.4	1.21	0.30
I7	73	47.9	6.58	1.57
I7	74	52.9	8.71	2.01
I7	75	41.6	4.04	0.84
I7	76	42.3	6.06	0.96
I7	77	49.2	7.30	1.21
I7	78	22.1	0.78	0.18
I7	79	22.4	0.82	0.19
I7	80	17.8	0.47	0.12

Table 52
Length (mm) and wet weight (g) of *Mytilus trossulus*.
Investigator: Ms. Jihyun Yun

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I4	30	28.7	2.06	0.47
I4	31	30.3	2.25	0.50
I4	32	27.3	1.98	0.43
I4	33	27.4	1.75	0.40
I4	34	12.0	0.16	0.01
I4	35	11.0	0.20	0.01
I4	36	40.3	5.47	1.28
I4	37	16.3	0.44	0.06
I4	38	37.0	3.75	0.88
I4	39	27.7	1.82	0.32
I4	40	29.5	2.22	0.48
I4	41	22.6	0.95	0.17
I4	42	11.9	0.18	0.02
I4	43	33.9	3.35	0.71
I4	44	20.3	0.75	0.09
I4	45	22.5	0.95	0.16
I4	46	14.0	0.28	0.03
I4	47	13.3	0.22	0.03
I4	48	14.0	0.27	0.02
I4	49	20.8	0.75	0.11
I4	50	10.0	0.14	0.01
I4	51	21.0	0.90	0.15

Site	Sample Number	Length (mm)	Whole Wt (g)	Meat Wt (g)
I7	81	42.6	4.54	0.98
I7	82	21.5	0.82	0.17
I7	83	15.9	0.40	0.09
I7	84	18.4	0.43	0.10
I7	85	35.8	2.48	0.56
I7	86	40.4	3.84	0.92
I7	87	18.9	0.48	0.12
I7	88	41.9	3.73	1.01
I7	89	47.3	6.07	1.49
I7	90	14.3	0.28	0.06
I7	91	13.3	0.24	0.04
I7	92	12.0	0.18	0.04
I7	93	34.8	2.69	0.63
I7	94	30.0	1.83	0.48
I7	95	30.3	2.04	0.54
I7	96	33.9	2.32	0.51
I7	97	20.5	0.85	0.25
I7	98	26.6	1.18	0.33
I7	99	31.0	1.63	0.43
I7	100	45.5	5.42	1.73

Table 53

Species abundance (indivdiuals/sample) in macrobenthos samples from Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-11B					B-38					B-3A					B-41B					B-48					B-49					B-50				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Nemertinea	Callineridae	Callinera sp.				1						1		1												2		1									
	Lineidae	Cerebratulus sp.					1																														
	Lineidae	Lineus sp.																											2	2							
	Amphiporidae	Amphiporus sp.								1																											
	Tubulanidae	Tubulanus sp.																												1							
Sipuncula	Golfingiidae	Species indet.										1			1		1		1							1	1							1	1	1	1
Ctenophora	Fam. gen. indet.	Species indet.																		1																	
Brachiopoda	Fam. indet.	Species indet.																															1				
Mollusca	Scaphopoda	Species indet.																										3									
	Scaphopoda	Dentalium pretiosum																														1					
	Bivalvia	Acila castrensis										1											2					6	10	4	13	9		2		1	1
	Bivalvia	Axinopsida serricata	1	2	4		13	6	5	5	2	3	42	19	8	11	4						92	76	37	90	58	39	81	126	94	24		16	5	21	6
	Bivalvia	Bivalvia unid.1							1		1			1																							
	Bivalvia	Bivalvia unid.2	1																														1				
	Bivalvia	Bivalvia unid.3											1																								
	Bivalvia	Bivalvia unid.4		1			1						1																						2	2	
	Bivalvia	Bivalvia unid.5					1														1		28	39	12	52	27		1		1	1					
	Bivalvia	Bivalvia unid.6	1			1																						5	4	10	4	5					
	Bivalvia	Bivalvia unid.7																1																			
	Bivalvia	Bivalvia unid.8																																			5
	Bivalvia	Cardiomya aldroydi																																	1		
	Bivalvia	Compsomyax subdiaphana																										2	4	2	2	2					
	Bivalvia	Lucina nuttali	2	1		1																															
	Bivalvia	Lyonsia sp.					1																														
	Bivalvia	Macoma calcarea																1	2				3	6	7	6	8	14	20	26	43	10					
	Bivalvia	Macoma carlottensis			1				1		2	1		9	8	6	2					1															
	Bivalvia	Macoma elimata											8													2	1										
	Bivalvia	Macoma nasuta											9														1										
	Bivalvia	Nucula sp.																																		1	
	Bivalvia	Nucula tenuis									1													5	2	1	1	5	2	2	1	4		4	10	12	
	Bivalvia	Nuculana hamata																							1			2		1	1	4					
	Bivalvia	Tellina capenteri																																	2	9	2
	Bivalvia	Tellina nuculoides				2													2																		
	Bivalvia	Thyasira flexuosa																					2	2	2	1	1									3	
	Bivalvia	Transenella tantilla											69	12	4		4																	1			
	Bivalvia	Yoldia amygalea		1			1																														
	Bivalvia	Yoldia hyperborea								1																			2								
	Gastropoda	Cylichna sp.																																		1	

Table 53

Species abundance (indivdiuals/sample) in macrobenthos samples from Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-11B					B-38					B-3A					B-41B					B-48					B-49					B-50				
			A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
	Gastropoda	Mitrella sp.	2		3		3						1																	5		1		1			
	Gastropoda	Margarites voticiferus												1																							
	Gastropoda	Nasssarius medicus							1			1							1								4										
	Gastropoda	Nasssarius cooperi							1																												
	Gastropoda	Nasssarius perpinguis																1	3	1	1	2	2	2									2				
	Gastropoda	Naticidae unid.																																		1	
	Gastropoda	Gastropoda unid.1																								1											
	Gastropoda	Gastropoda unid.2																								1											
	Gastropoda	Gastropoda unid.3																									1										1
	Gastropoda	Gastropoda unid.4																							1												
	Gastropoda	Gastropoda unid.5																												1							
	Gastropoda	Gastropoda unid.6																	1																		
	Gastropoda	Turbonilla sp.																																3			
Amphipoda	Ampeliscidae	Ampelisca macrocephala				1																															
	Ampeliscidae	Ampelisca eoa																																	1		
	Ampeliscidae	Ampelisca sp.																																	1	2	
	Aoridae	Aoroides secunda																															2				
	Podoceridae	Dulichia monacantha																																		1	
	Lysianassidae	Orchomenella pinguis											1	1	1																						
	Melitidae	Melita sp.			1								1	1	3	1										1										1	2
	Pleustidae	Pleusymtes sp.											1	1	1	1																					
	Photidae	Protomedeia microdactyla			3									2									1														
	Photidae	Protomedeia popovi												1													1										
	Photidae	Protomedeia sp.			11								4				3									1							1			1	
	Photidae	Photis sp. N 1				1									1																						
	Photidae	Photis sp. N 2											1			4																					
	Photidae	Photis sp. N 3												3		1											1										
	Phoxocephalidae	Harpinia sp.																											3	3	2	1				4	1
	Eusiridae	Rhachotropis oculata																																		1	
	Oedicerotidae	Westwoodilla coecula	1		1								2	1	1	1	3								1	2											
	Oedicerotidae	Synchelidium gurjanovae					1						1	1																			1			2	
	Oedicerotidae	Synchelidium sp.																																			1
	Oedicerotidae	Monoculodes sp. N 1																																2			
	Oedicerotidae	Monoculodes sp. N 2																																1			
	Oedicerotidae	Monoculodes sp.																																	1		
	Synopiidae	Tiron acanthurus																					1														
	Tironidae	Syrrhoe sp.																																2			
	??	Varia															0								0		0						0	0			0

Table 53

Species abundance (indivdiuals/sample) in macrobenthos samples from Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-11B					B-38					B-3A					B-41B					B-48					B-49					B-50				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Tanaidacea	Fam. indet.	Species indet.															1																1			17	3
Isopoda	Idoteidae	Synidotea media	1				1								1																						
Cumacea	Leuconidae	Eudorella pacifica						4			2					1																					
	Diastylidae	Diastylus alaskensis														1	2																1				
	Diastylidae	Diastylus sp.																1																		5	1
Copepoda	Fam. indet.	Species indet.																															1				
Decapoda	Crangonidae	Crangon sp.						1																													
	Pinnixidae	Pinnixa rathbunae							1	1		1									2												4	2	9	6	10
	Hippolytidae	Lebbeus sp.													1			1	10																		
	Hippolytidae	Heptacarpus sp.																											1								
Leptostraca	Fam. gen. sp.	Species indet.																																	1		
Hyrudinea	Piscicolidae	Species indet.						1																				1		1							
Polychaeta	Cirratulidae	Chaetozone setosa	2										2										2							1		2		2	3	4	6
	Cirratulidae	Cossura modica																											2		4						
	Cirratulidae	Cossura sp.					1																														
	Cirratulidae	Tharyx multifilis					1	65	40	45	24	45						1	6	5	2	2															
	Cirratulidae	Tharyx sp.																					1	1	3	3	1			2		1					
	Ampharetidae	Melinna ochotica																					1														
	Ampharetidae	Species indet.														1	1						1	1		1											
	Amphictenidae	Cistenides granulata																					1										2		1		
	Aphroditidae	Species indet.																					1													2	
	Aphroditidae	Aphroditidae gen. indet.																															2	1			
	Maldanidae	Euclyminae sp. indet.	12	4	4																							2	3	14	4	4					
	Maldanidae	Praxillella affinis pacifica				12	13																														
	Maldanidae	Praxillella gracilis																												1							
	Maldanidae	Species indet.											1	1	4	2											1							1	2	1	1
	Maldanidae	Micropodarka sp.???															2																				
	Phyllodocidae	Eulalia sp.	1											2															1		2						
	Phyllodocidae	Eulalia bilineata																							1												
	Phyllodocidae	Eteone sp.		1			1																														
	Phyllodocidae	Eteone longa							1															3		1											
	Phyllodocidae	Phyllodoce sp. N 1		1			2																														
	Phyllodocidae	Phyllodoce sp. N 2		1	1																																
	Phyllodocidae	Phyllodoce groenlandica				3																												1	1		
	Glyceridae	Glycera capitata	3	1		3	3						3	3	1		1						6					5	2	8	8	9					
	Glyceridae	Glycera sp.								1														2	2	2								4	4	5	3
	Goniadidae	Glycinde armigera	2	2		2	1	1	2	2		1	4	6	4	5	4	1	2	1		1	2	3	2	2	1	4		1	5	6					3
	Goniadidae	Goniada maculata																											6				2	1	1	2	2

Table 53

Species abundance (indivdiuals/sample) in macrobenthos samples from Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-11B					B-38					B-3A					B-41B					B-48					B-49					B-50				
			A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
	Lumbrineridae	Lumbrineris luti	12	9	6	10	12	9	8	5	8	5	6	11	6	3	6				1		1	3	2		3	10	10	13	7	8	1	5	7	5	10
	Lumbrineridae	Lumbrineris sp. N 1	1																				1							1							
	Capitellidae	Capitella capitata												1																							
	Capitellidae	Mediomastus sp.		1	2	1	1							1					1	1	1										4	5			1		
	Capitellidae	Mediomastus californiensis							2	3	1	2												1				2	2	4	2						
	Capitellidae	Heteromastus sp.						1																													
	Capitellidae	Species indet.																				1	1													1	
	Nephtyidae	Nephtys firruginea	6	4	6	3	12					1		1	1	2	1						14	11	15	4	15				1	1		4	5		6
	Nephtyidae	Nephtys cornuta franciscanum						14	8	5	6	4	1	2	5	4	4	8	8	13	8	7		2		6											
	Nephtyidae	Nephtys cornuta cornuta																										8	5	4	3						
	Nephtyidae	Nephtys longosetosa																													2						
	Nephtyidae	Nephtys sp. N 1																										1					3				
	Nephtyidae	Nephtys sp. N 2																											2								
	Nereidae	Nereis procera														1																					
	Onuphidae	Onuphis sp.	1																																		
	Opheliidae	Ophelina acuminata	10	14	33	24	21						3	5	5	7							1		3	4	3		1		1						
	Opheliidae	Ophelina sp.																																1	1		
	Spionidae	Prionospio lighti	1					1					2	4	4	1				1	1	2															
	Spionidae	Prionospio steenstrupi															3																				
	Spionidae	Dipolydora sp.				1	2	1					2		3	1																					
	Spionidae	Species indet. N 1						8	2	5	12							3	2	4	6	3	3	3	2	2	4										1
	Spionidae	Species indet. N 2																																	1		
	Spionidae	Species indet. N 3																															1		1	4	
	Spionidae	Species indet. N 4																																	1		
	Spionidae	Species indet. N 5																																	3		
	Spionidae	Pigospio sp.											1																								
	Spionidae	Prionospio sp.																		1					1							1				1	1
	Spionidae	Spio sp.												1																							
	Spionidae	Spiophanes berkeleyorum																												2	1						
	Spionidae	Spiophanes sp.																					1											1			
	Spionidae	Laonice cirrata																										1			1	2					
	Sternaspidae	Sternaspis scutata	1													2									1			8	4	16	12	7					
	Eunicidae	Species indet.			2																																
	Terebellidae	Terebellides stroemi																						1						2	1						1
	Terebellidae	Terebellides sp.																																			2
	Terebellidae	Species indet.			1			1					1	1																							
	Polynoidae	Species indet.				1																															
	Disomodae	Disoma sp.					2						4	4	1	3	2								1												

Table 53

Species abundance (indivdiuals/sample) in macrobenthos samples from Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-11B A	B-11B B	B-11B C	B-11B D	B-11B E	B-38 A	B-38 B	B-38 C	B-38 D	B-38 E	B-3A A	B-3A B	B-3A C	B-3A D	B-3A E	B-41B A	B-41B B	B-41B C	B-41B D	B-41B E	B-48 A	B-48 B	B-48 C	B-48 D	B-48 E	B-49 A	B-49 B	B-49 C	B-49 D	B-49 E	B-50 A	B-50 B	B-50 C	B-50 D	B-50 E
	Sigalionidae	Pholoe minuta					2	1					2			3							2				1										
	Hesionidae	Species indet.					2												4																		
	Polynoidae	Species indet.					1								1													1							2		
	Pilargidae	Pilargis sp.																					1	4	2	2	1										
	Pilargidae	Species indet.						1	1																1		1			1	1						
	Dorvilleidae	Dorvilea pseudorubrovitata										1																									
	Dorvilleidae	Dorvilea sp.																																			1
	Dorvilleidae	Species indet.																																			2
	Flabelligeridae	Brada villosa																										3									
	Sabellariidae	Sabellaria sp. (?)																																	1		1
	Sabellidae	Species indet.																																	1		
	Syllidae	Exogone lourei																										3	3								
	Syllidae	Exogone sp.											1																								
	Syllidae	Species indet.																												2		2		1	2		3
	Orbiniidae	Scoloplos armiger											1	1	1												1						4	4	2	2	3
	Onuphidae	Onuphis iridescens																										2	5			1					1
	Onuphidae	Onuphis sp.																																		1	
	Oweniidae	Owenia fusiformis																									1										
Ophiuroidea	Amphiuridae	Amphipholis kochii					1			3		2	1											1	1	1		1			1	1					

A, B, C, D, E refer to indvdiual grab samples. Five grab samples were collected and examined at each site.

Table 54
Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.
Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-11B					B-38				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Nemertinea	Callineridae	Callinera sp.				0.019						0.019
	Lineidae	Cerebratulus sp.					0.35					
	Lineidae	Lineus sp.										
	Amphiporidae	Amphiporus sp.								0.013		
	Tubulanidae	Tubulanus sp.										
Sipuncula	Golfingiidae	Species indet.										0.04
Ctenophora	Fam. gen. indet.	Species indet.										
Brachiopoda	Fam. indet.	Species indet.										
Mollusca	Scaphopoda	Species indet.										
	Scaphopoda	Dentalium pretiosum										
	Bivalvia	Acila castrensis										0.314
	Bivalvia	Axinopsida serricata	0.031	0.054	0.058		0.226	0.138	0.084	0.122	0.034	0.049
	Bivalvia	Bivalvia unid.1							0.086		0.032	
	Bivalvia	Bivalvia unid.2	0.028									
	Bivalvia	Bivalvia unid.3										
	Bivalvia	Bivalvia unid.4		0.021			0.018					
	Bivalvia	Bivalvia unid.5					0.03					
	Bivalvia	Bivalvia unid.6	0.024			0.022						
	Bivalvia	Bivalvia unid.7										
	Bivalvia	Bivalvia unid.8										
	Bivalvia	Cardiomya aldroydi										
	Bivalvia	Compsomyax subdiaphana										
	Bivalvia	Lucina nuttali	0.352	0.066		0.064						
	Bivalvia	Lyonsia sp.					0.036					
	Bivalvia	Macoma calcarea										
	Bivalvia	Macoma carlottensis			0.07				0.504		0.511	0.372
	Bivalvia	Macoma elimata										
	Bivalvia	Macoma nasuta										
	Bivalvia	Nucula sp.										
	Bivalvia	Nucula tenuis									0.089	

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-11B					B-38				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Bivalvia	Nuculana hamata										
	Bivalvia	Tellina capenteri										
	Bivalvia	Tellina nuculoides				0.614						
	Bivalvia	Thyasira flexuosa										
	Bivalvia	Transenella tantilla										
	Bivalvia	Yoldia amygalea		0.254			0.028					
	Bivalvia	Yoldia hyperborea								2.432		
	Gastropoda	Cylichna sp.										
	Gastropoda	Mitrella sp.	0.234		0.552		0.417					
	Gastropoda	Margarites voticiferus										
	Gastropoda	Nasssarius medicus							0.453			0.184
	Gastropoda	Nasssarius cooperi							0.025			
	Gastropoda	Nasssarius perpinguis										
	Gastropoda	Naticidae unid.										
	Gastropoda	Gastropoda unid.1										
	Gastropoda	Gastropoda unid.2										
	Gastropoda	Gastropoda unid.3										
	Gastropoda	Gastropoda unid.4										
	Gastropoda	Gastropoda unid.5										
	Gastropoda	Gastropoda unid.6										
	Gastropoda	Turbonilla sp.										
Amphipoda	Ampeliscidae	Ampelisca macrocephala				0.015						
	Ampeliscidae	Ampelisca eoa										
	Ampeliscidae	Ampelisca sp.										
	Aoridae	Aoroides secunda										
	Podoceridae	Dulichia monacantha										
	Lysianassidae	Orchomenella pinguis										
	Melitidae	Melita sp.			0.05							
	Pleustidae	Pleusymtes sp.										
	Photidae	Protomedeia microdactyla			0.015							

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-11B A	B-11B B	B-11B C	B-11B D	B-11B E	B-38 A	B-38 B	B-38 C	B-38 D	B-38 E
	Photidae	Protomedeia popovi										
	Photidae	Protomedeia sp.			0.03							
	Photidae	Photis sp. N 1				0.005						
	Photidae	Photis sp. N 2										
	Photidae	Photis sp. N 3										
	Phoxocephalidae	Harpinia sp.										
	Eusiridae	Rhachotropis oculata										
	Oedicerotidae	Westwoodilla coecula	0.011		0.006							
	Oedicerotidae	Synchelidium gurjanovae					0.001					
	Oedicerotidae	Synchelidium sp.										
	Oedicerotidae	Monoculodes sp. N 1										
	Oedicerotidae	Monoculodes sp. N 2										
	Oedicerotidae	Monoculodes sp.										
	Synopiidae	Tiron acanthurus										
	Tironidae	Syrrhoe sp.										
	??	Varia										
Tanaidacea	Fam. indet.	Species indet.										
Isopoda	Idoteidae	Synidotea media	0.012				0.009					
Cumacea	Leuconidae	Eudorella pacifica						0.012			0.004	
	Diastylidae	Diastylus alaskensis										
	Diastylidae	Diastylus sp.										
Copepoda	Fam. indet.	Species indet.										
Decapoda	Crangonidae	Crangon sp.						0.05				
	Pinnixidae	Pinnixa rathbunae							0.012	0.02		0.003
	Hippolytidae	Lebbeus sp.										
	Hippolytidae	Heptacarpus sp.										
Leptostraca	Fam. gen. sp.	Species indet.										
Hyrudinea	Piscicolidae	Species indet.						0.003				
Polychaeta	Cirratulidae	Chaetozone setosa	0.011									
	Cirratulidae	Cossura modica										

Table 54
Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.
Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-11B					B-38				
			A	B	C	D	E	A	B	C	D	E
	Cirratulidae	Cossura sp.					0.003					
	Cirratulidae	Tharyx multifilis					0.008	0.35	0.3	0.3	0.25	0.29
	Cirratulidae	Tharyx sp.										
	Ampharetidae	Melinna ochotica										
	Ampharetidae	Species indet.										
	Amphictenidae	Cistenides granulata										
	Aphroditidae	Species indet.										
	Aphroditidae	Aphroditidae gen. indet.										
	Maldanidae	Euclyminae sp. indet.	0.5	0.04	0.025							
	Maldanidae	Praxillella affinis pacifica				0.28	0.34					
	Maldanidae	Praxillella gracilis										
	Maldanidae	Species indet.										
	Maldanidae	Micropodarka sp.???										
	Phyllodocidae	Eulalia sp.	0.002									
	Phyllodocidae	Eulalia bilineata										
	Phyllodocidae	Eteone sp.		0.005			0.001					
	Phyllodocidae	Eteone longa							0.002			
	Phyllodocidae	Phyllodoce sp. N 1		0.008			0.005					
	Phyllodocidae	Phyllodoce sp. N 2		0.018	0.001							
	Phyllodocidae	Phyllodoce groenlandica				0.08						
	Glyceridae	Glycera capitata	3.3	0.1		0.08	0.09					
	Glyceridae	Glycera sp.								0.012		
	Goniadidae	Glycinde armigera	0.08	0.024		0.04	0.025	0.025	0.022	0.03		0.016
	Goniadidae	Goniada maculata										
	Lumbrineridae	Lumbrineris luti	0.09	0.09	0.08	0.08	0.1	0.035	0.03	0.03	0.1	0.025
	Lumbrineridae	Lumbrineris sp. N 1	1.95									
	Capitellidae	Capitella capitata										
	Capitellidae	Mediomastus sp.		0.01	0.015	0.015	0.008					
	Capitellidae	Mediomastus californiensis							0.05	0.003	0.025	0.025
	Capitellidae	Heteromastus sp.						0.006				

Table 54
Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.
Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-11B					B-38				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Capitellidae	Species indet.										
	Nephtyidae	Nephtys firruginea	0.12	0.02	0.1	0.03	0.04					0.07
	Nephtyidae	Nephtys cornuta franciscanum						0.018	0.015	0.018	0.025	0.012
	Nephtyidae	Nephtys cornuta cornuta										
	Nephtyidae	Nephtys longosetosa										
	Nephtyidae	Nephtys sp. N 1										
	Nephtyidae	Nephtys sp. N 2										
	Nereidae	Nereis procera										
	Onuphidae	Onuphis sp.	0.1									
	Opheliidae	Ophelina acuminata	0.11	0.11	0.3	0.18	0.1					
	Opheliidae	Ophelina sp.										
	Spionidae	Prionospio lighti	0.015					0.005				
	Spionidae	Prionospio steenstrupi										
	Spionidae	Dipolydora sp.				0.001	0.01	0.005				
	Spionidae	Species indet. N 1						1.15	0.018	0.45	0.8	
	Spionidae	Species indet. N 2										
	Spionidae	Species indet. N 3										
	Spionidae	Species indet. N 4										
	Spionidae	Species indet. N 5										
	Spionidae	Pigospio sp.										
	Spionidae	Prionospio sp.										
	Spionidae	Spio sp.										
	Spionidae	Spiophanes berkeleyorum										
	Spionidae	Spiophanes sp.										
	Spionidae	Laonice cirrata										
	Sternaspidae	Sternaspis scutata	0.008									
	Eunicidae	Species indet.			0.7							
	Terebellidae	Terebellides stroemi										
	Terebellidae	Terebellides sp.										
	Terebellidae	Species indet.			0.01			0.004				

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-11B					B-38				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Polynoidae	Species indet.				0.005						
	Disomodae	Disoma sp.					0.002					
	Sigalionidae	Pholoe minuta					0.006	0.008				
	Hesionidae	Species indet.					0.01					
	Polynoidae	Species indet.					0.002					
	Pilargidae	Pilargis sp.										
	Pilargidae	Species indet.						0.01	0.002			
	Dorvilleidae	Dorvilea pseudorubrovitata										0.006
	Dorvilleidae	Dorvilea sp.										
	Dorvilleidae	Species indet.										
	Flabelligeridae	Brada villosa										
	Sabellariidae	Sabellaria sp. (?)										
	Sabellidae	Species indet.										
	Syllidae	Exogone lourei										
	Syllidae	Exogone sp.										
	Syllidae	Species indet.										
	Orbiniidae	Scoloplos armiger										
	Onuphidae	Onuphis iridescens										
	Onuphidae	Onuphis sp.										
	Oweniidae	Owenia fusiformis										
Ophiuroidea	Amphiuridae	Amphipholis kochii					0.045			0.25		0.1

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-3A					B-41B				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Nemertinea	Callineridae	Callinera sp.		0.006								
	Lineidae	Cerebratulus sp.										
	Lineidae	Lineus sp.										
	Amphiporidae	Amphiporus sp.										
	Tubulanidae	Tubulanus sp.										
Sipuncula	Golfingiidae	Species indet.			0.05		0.04		0.04			
Ctenophora	Fam. gen. indet.	Species indet.								0.015		
Brachiopoda	Fam. indet.	Species indet.										
Mollusca	Scaphopoda	Species indet.										
	Scaphopoda	Dentalium pretiosum										
	Bivalvia	Acila castrensis										
	Bivalvia	Axinopsida serricata	0.28	0.101	0.08	0.153	0.06					
	Bivalvia	Bivalvia unid.1		0.005								
	Bivalvia	Bivalvia unid.2										
	Bivalvia	Bivalvia unid.3	0.039									
	Bivalvia	Bivalvia unid.4	0.043									
	Bivalvia	Bivalvia unid.5									0.006	
	Bivalvia	Bivalvia unid.6										
	Bivalvia	Bivalvia unid.7						0.04				
	Bivalvia	Bivalvia unid.8										
	Bivalvia	Cardiomya aldroydi										
	Bivalvia	Compsomyax subdiaphana										
	Bivalvia	Lucina nuttali										
	Bivalvia	Lyonsia sp.										
	Bivalvia	Macoma calcarea						0.328	0.126			
	Bivalvia	Macoma carlottensis		0.247	0.295	0.217	0.102					1.112
	Bivalvia	Macoma elimata	5.104									
	Bivalvia	Macoma nasuta	4.035									
	Bivalvia	Nucula sp.										
	Bivalvia	Nucula tenuis										

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-3A					B-41B				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Bivalvia	Nuculana hamata										
	Bivalvia	Tellina capenteri										
	Bivalvia	Tellina nuculoides							0.12			
	Bivalvia	Thyasira flexuosa										
	Bivalvia	Transenella tantilla	0.301	0.094	0.054		0.066					
	Bivalvia	Yoldia amygalea										
	Bivalvia	Yoldia hyperborea										
	Gastropoda	Cylichna sp.										
	Gastropoda	Mitrella sp.	0.16									
	Gastropoda	Margarites voticiferus		0.006								
	Gastropoda	Nasssarius medicus							0.34			
	Gastropoda	Nasssarius cooperi										
	Gastropoda	Nasssarius perpinguis						0.201	0.787	0.066	0.176	0.544
	Gastropoda	Naticidae unid.										
	Gastropoda	Gastropoda unid.1										
	Gastropoda	Gastropoda unid.2										
	Gastropoda	Gastropoda unid.3										
	Gastropoda	Gastropoda unid.4										
	Gastropoda	Gastropoda unid.5										
	Gastropoda	Gastropoda unid.6							0.042			
	Gastropoda	Turbonilla sp.										
Amphipoda	Ampeliscidae	Ampelisca macrocephala										
	Ampeliscidae	Ampelisca eoa										
	Ampeliscidae	Ampelisca sp.										
	Aoridae	Aoroides secunda										
	Podoceridae	Dulichia monacantha										
	Lysianassidae	Orchomenella pinguis	0.003	0.001	0.003							
	Melitidae	Melita sp.	0.008	0.001	0.017	0.003						
	Pleustidae	Pleusymtes sp.	0.002	0.001	0.001	0.001						
	Photidae	Protomedeia microdactyla		0.011								

Table 54
Biomass (g/sample) of macrobenthos collected
in Vancouver Harbour.
Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-3A					B-41B				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Photidae	Protomedeia popovi		0.012								
	Photidae	Protomedeia sp.	0.015				0.006					
	Photidae	Photis sp. N 1			0.001							
	Photidae	Photis sp. N 2	0.001			0.02						
	Photidae	Photis sp. N 3		0.003		0.001						
	Phoxocephalidae	Harpinia sp.										
	Eusiridae	Rhachotropis oculata										
	Oedicerotidae	Westwoodilla coecula	0.008	0.006	0.015	0.005	0.015					
	Oedicerotidae	Synchelidium gurjanovae	0.001	0.001								
	Oedicerotidae	Synchelidium sp.										
	Oedicerotidae	Monoculodes sp. N 1										
	Oedicerotidae	Monoculodes sp. N 2										
	Oedicerotidae	Monoculodes sp.										
	Synopiidae	Tiron acanthurus										
	Tironidae	Syrrhoe sp.										
	??	Varia					0.03					
Tanaidacea	Fam. indet.	Species indet.					0.001					
Isopoda	Idoteidae	Synidotea media			0.03							
Cumacea	Leuconidae	Eudorella pacifica				0.011						
	Diastylidae	Diastylus alaskensis				0.01	0.009					
	Diastylidae	Diastylus sp.						0.001				
Copepoda	Fam. indet.	Species indet.										
Decapoda	Crangonidae	Crangon sp.										
	Pinnixidae	Pinnixa rathbunae									0.2	
	Hippolytidae	Lebbeus sp.			0.012			0.003	0.92			
	Hippolytidae	Heptacarpus sp.										
Leptostraca	Fam. gen. sp.	Species indet.										
Hyrudinea	Piscicolidae	Species indet.										
Polychaeta	Cirratulidae	Chaetozone setosa	0.012									
	Cirratulidae	Cossura modica										

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-3A A	B-3A B	B-3A C	B-3A D	B-3A E	B-41B A	B-41B B	B-41B C	B-41B D	B-41B E
	Cirratulidae	Cossura sp.										
	Cirratulidae	Tharyx multifilis						0.002	0.02	0.012	0.025	0.01
	Cirratulidae	Tharyx sp.										
	Ampharetidae	Melinna ochotica										
	Ampharetidae	Species indet.				0.07	0.012					
	Amphictenidae	Cistenides granulata										
	Aphroditidae	Species indet.										
	Aphroditidae	Aphroditidae gen. indet.										
	Maldanidae	Euclyminae sp. indet.										
	Maldanidae	Praxillella affinis pacifica										
	Maldanidae	Praxillella gracilis										
	Maldanidae	Species indet.	0.005	0.02	0.05	0.015						
	Maldanidae	Micropodarka sp.???					0.05					
	Phyllodocidae	Eulalia sp.		0.003								
	Phyllodocidae	Eulalia bilineata										
	Phyllodocidae	Eteone sp.										
	Phyllodocidae	Eteone longa										
	Phyllodocidae	Phyllodoce sp. N 1										
	Phyllodocidae	Phyllodoce sp. N 2										
	Phyllodocidae	Phyllodoce groenlandica										
	Glyceridae	Glycera capitata	0.25	0.092	0.05		0.018					
	Glyceridae	Glycera sp.										
	Goniadidae	Glycinde armigera	0.05	0.038	0.05	0.15	0.04	0.05	0.12	0.02		0.018
	Goniadidae	Goniada maculata										
	Lumbrineridae	Lumbrineris luti	0.02	0.055	0.06	0.022	0.07				0.01	
	Lumbrineridae	Lumbrineris sp. N 1										
	Capitellidae	Capitella capitata		0.002								
	Capitellidae	Mediomastus sp.		0.015					0.015	0.005	0.008	
	Capitellidae	Mediomastus californiensis										
	Capitellidae	Heteromastus sp.										

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-3A A	B-3A B	B-3A C	B-3A D	B-3A E	B-41B A	B-41B B	B-41B C	B-41B D	B-41B E
	Capitellidae	Species indet.										0.011
	Nephtyidae	Nephtys firruginea		0.019	0.03	0.025	0.02					
	Nephtyidae	Nephtys cornuta franciscanum	0.003	0.002	0.015	0.01	0.012	0.022	0.025	0.03	0.025	0.021
	Nephtyidae	Nephtys cornuta cornuta										
	Nephtyidae	Nephtys longosetosa										
	Nephtyidae	Nephtys sp. N 1										
	Nephtyidae	Nephtys sp. N 2										
	Nereidae	Nereis procera				0.005						
	Onuphidae	Onuphis sp.										
	Opheliidae	Ophelina acuminata	0.011	0.009	0.03	0.05						
	Opheliidae	Ophelina sp.										
	Spionidae	Prionospio lighti	0.018	0.015	0.023	0.002				0.003	0.01	0.008
	Spionidae	Prionospio steenstrupi					0.009					
	Spionidae	Dipolydora sp.	0.012		0.012	0.003						
	Spionidae	Species indet. N 1						0.04	0.05	0.65	0.15	0.1
	Spionidae	Species indet. N 2										
	Spionidae	Species indet. N 3										
	Spionidae	Species indet. N 4										
	Spionidae	Species indet. N 5										
	Spionidae	Pigospio sp.	0.002									
	Spionidae	Prionospio sp.								0.003		
	Spionidae	Spio sp.		0.005								
	Spionidae	Spiophanes berkeleyorum										
	Spionidae	Spiophanes sp.										
	Spionidae	Laonice cirrata										
	Sternaspidae	Sternaspis scutata				0.018						
	Eunicidae	Species indet.										
	Terebellidae	Terebellides stroemi										
	Terebellidae	Terebellides sp.										
	Terebellidae	Species indet.	0.37	0.15								

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-3A					B-41B				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Polynoidae	Species indet.										
	Disomodae	Disoma sp.	0.05	0.004	0.008	0.004	0.02					
	Sigalionidae	Pholoe minuta	0.01			0.011						
	Hesionidae	Species indet.							0.04			
	Polynoidae	Species indet.			0.002							
	Pilargidae	Pilargis sp.										
	Pilargidae	Species indet.										
	Dorvilleidae	Dorvilea pseudorubrovitata										
	Dorvilleidae	Dorvilea sp.										
	Dorvilleidae	Species indet.										
	Flabelligeridae	Brada villosa										
	Sabellariidae	Sabellaria sp. (?)										
	Sabellidae	Species indet.										
	Syllidae	Exogone lourei										
	Syllidae	Exogone sp.	0.002									
	Syllidae	Species indet.										
	Orbiniidae	Scoloplos armiger	0.001	0.012	0.001							
	Onuphidae	Onuphis iridescens										
	Onuphidae	Onuphis sp.										
	Oweniidae	Owenia fusiformis										
Ophiuroidea	Amphiuridae	Amphipholis kochii	0.05									

Table 54
Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.
Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-48					B-49					B-50				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Nemertinea	Callineridae	Callinera sp.				0.03		0.01									
	Lineidae	Cerebratulus sp.															
	Lineidae	Lineus sp.							0.12	0.02							
	Amphiporidae	Amphiporus sp.															
	Tubulanidae	Tubulanus sp.								0							
Sipuncula	Golfingiidae	Species indet.				0.06	0.01							0	0	0.05	0.002
Ctenophora	Fam. gen. indet.	Species indet.															
Brachiopoda	Fam. indet.	Species indet.											0.2				
Mollusca	Scaphopoda	Species indet.						0.03									
	Scaphopoda	Dentalium pretiosum										0.18					
	Bivalvia	Acila castrensis	0.45					6.59	10.9	4.22	14	11.3		1.41		0.03	1.058
	Bivalvia	Axinopsida serricata	1.45	1.28	0.73	1.27	0.82	0.9	1.87	2.09	1.45	0.31		0.16	0.12	0.33	0.026
	Bivalvia	Bivalvia unid.1															
	Bivalvia	Bivalvia unid.2											0.01				
	Bivalvia	Bivalvia unid.3															
	Bivalvia	Bivalvia unid.4													0.23	0.2	
	Bivalvia	Bivalvia unid.5	0.24	0.41	0.23	0.53	0.3		0.06		0.05	0.06					
	Bivalvia	Bivalvia unid.6						0.62	0.69	0.89	0.44	0.35					
	Bivalvia	Bivalvia unid.7															
	Bivalvia	Bivalvia unid.8															0.227
	Bivalvia	Cardiomya aldroydi													0.3		
	Bivalvia	Compsomyax subdiaphana						43.2	58.9	15.3	55.4	50.3					
	Bivalvia	Lucina nuttali															
	Bivalvia	Lyonsia sp.															
	Bivalvia	Macoma calcarea	0.38	2.81	2.77	1.47	3.01	0.63	11.3	1.02	1.77	0.43					
	Bivalvia	Macoma carlottensis															
	Bivalvia	Macoma elimata				0.33	0.14										
	Bivalvia	Macoma nasuta					0.13										
	Bivalvia	Nucula sp.														0.01	
	Bivalvia	Nucula tenuis		0.13	0.08	0.05	0.06	0.26	0.11	0.1	0.06	0.16		0.12	0.43	0.42	

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-48					B-49					B-50				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Bivalvia	Nuculana hamata			0.04			0.2		0.07	0.04	0.13					
	Bivalvia	Tellina capenteri													0.34	0.53	0.072
	Bivalvia	Tellina nuculoides															
	Bivalvia	Thyasira flexuosa	0.2	0.06	0.09	0.01	0.02									0.21	
	Bivalvia	Transenella tantilla												0.02			
	Bivalvia	Yoldia amygalea															
	Bivalvia	Yoldia hyperborea							0.64								
	Gastropoda	Cylichna sp.														0.01	
	Gastropoda	Mitrella sp.								0.12		0.01		0.1			
	Gastropoda	Margarites voticiferus															
	Gastropoda	Nasssarius medicus					2.22										
	Gastropoda	Nasssarius cooperi															
	Gastropoda	Nasssarius perpinguis	0.18	0.06									0.5				
	Gastropoda	Naticidae unid.														0.01	
	Gastropoda	Gastropoda unid.1				0.1											
	Gastropoda	Gastropoda unid.2				0.14											
	Gastropoda	Gastropoda unid.3					0.1										0.019
	Gastropoda	Gastropoda unid.4			0.11												
	Gastropoda	Gastropoda unid.5								0.13							
	Gastropoda	Gastropoda unid.6															
	Gastropoda	Turbonilla sp.												0.03			
Amphipoda	Ampeliscidae	Ampelisca macrocephala															
	Ampeliscidae	Ampelisca eoa													0		
	Ampeliscidae	Ampelisca sp.													0.05	0	
	Aoridae	Aoroides secunda											0.01				
	Podoceridae	Dulichia monacantha														0	
	Lysianassidae	Orchomenella pinguis															
	Melitidae	Melita sp.				0										0	0.01
	Pleustidae	Pleusymtes sp.															
	Photidae	Protomedeia microdactyla	0.01														

Table 54
Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.
Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-48					B-49					B-50				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Photidae	Protomedeia popovi					0.01										
	Photidae	Protomedeia sp.				0							0			0	
	Photidae	Photis sp. N 1															
	Photidae	Photis sp. N 2															
	Photidae	Photis sp. N 3					0										
	Phoxocephalidae	Harpinia sp.							0.02	0.01	0	0.01				0.01	0.002
	Eusiridae	Rhachotropis oculata														0.02	
	Oedicerotidae	Westwoodilla coecula			0.01	0.01											
	Oedicerotidae	Synchelidium gurjanovae											0			0	
	Oedicerotidae	Synchelidium sp.															0.002
	Oedicerotidae	Monoculodes sp. N 1												0.03			
	Oedicerotidae	Monoculodes sp. N 2												0			
	Oedicerotidae	Monoculodes sp.													0.01		
	Synopiidae	Tiron acanthurus	0.01														
	Tironidae	Syrrhoe sp.												0			
	??	Varia			0		0						0	0			0.05
Tanaidacea	Fam. indet.	Species indet.											0.01			0.01	0.012
Isopoda	Idoteidae	Synidotea media															
Cumacea	Leuconidae	Eudorella pacifica															
	Diastylidae	Diastylus alaskensis											0				
	Diastylidae	Diastylus sp.														0.06	0.003
Copepoda	Fam. indet.	Species indet.											0				
Decapoda	Crangonidae	Crangon sp.															
	Pinnixidae	Pinnixa rathbunae											0	0	0	0.03	0.003
	Hippolytidae	Lebbeus sp.															
	Hippolytidae	Heptacarpus sp.							0.05								
Leptostraca	Fam. gen. sp.	Species indet.													0.01		
Hyrudinea	Piscicolidae	Species indet.						0		0							
Polychaeta	Cirratulidae	Chaetozone setosa	0.01							0.01		0.01		0.01	0.02	0.03	0.044
	Cirratulidae	Cossura modica							0.02		0.03						

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-48 A	B-48 B	B-48 C	B-48 D	B-48 E	B-49 A	B-49 B	B-49 C	B-49 D	B-49 E	B-50 A	B-50 B	B-50 C	B-50 D	B-50 E
	Cirratulidae	Cossura sp.															
	Cirratulidae	Tharyx multifilis															
	Cirratulidae	Tharyx sp.	0.01	0.01	0.02	0.01	0.01			0		0.01					
	Ampharetidae	Melinna ochotica	0.04														
	Ampharetidae	Species indet.	0.01	0		0.02											
	Amphictenidae	Cistenides granulata	0.04										0.02		0.02		
	Aphroditidae	Species indet.	0.01													0.01	
	Aphroditidae	Aphroditidae gen. indet.											0.01	0			
	Maldanidae	Euclyminae sp. indet.						0.02	0.02	0.08	0.03	0.03					
	Maldanidae	Praxillella affinis pacifica															
	Maldanidae	Praxillella gracilis								0.02							
	Maldanidae	Species indet.					0.05							0.03	0.03	0.02	0.05
	Maldanidae	Micropodarka sp.???															
	Phyllodocidae	Eulalia sp.							0.01		0.02						
	Phyllodocidae	Eulalia bilineata			0.01												
	Phyllodocidae	Eteone sp.															
	Phyllodocidae	Eteone longa		0.04		0.04											
	Phyllodocidae	Phyllodoce sp. N 1															
	Phyllodocidae	Phyllodoce sp. N 2															
	Phyllodocidae	Phyllodoce groenlandica												0.02	0.01		
	Glyceridae	Glycera capitata	1.3					0.08	0.05	0.36	0.1	0.21					
	Glyceridae	Glycera sp.		2.1	4.25	0.22								0.08	0.06	0.04	0.011
	Goniadidae	Glycinde armigera	0.1	0.02	0.02	0.1	0.08	0.23		0.03	0.07	0.1					0.01
	Goniadidae	Goniada maculata							0.2				0.03	0.01	0.03	0.02	0.03
	Lumbrineridae	Lumbrineris luti	0.01	0.1	0.12		0.02	0.6	0.04	0.07	0.03	0.02	0.02	0.01	0.04	0.03	0.055
	Lumbrineridae	Lumbrineris sp. N 1	0.4							0.14							
	Capitellidae	Capitella capitata															
	Capitellidae	Mediomastus sp.									0.01	0.03			0		
	Capitellidae	Mediomastus californiensis		0.03				0	0.02	0.01	0.03						
	Capitellidae	Heteromastus sp.															

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

			B-48					B-49					B-50				
Group	**Class, order or family**	**Species**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
	Capitellidae	Species indet.	0.01													0.02	
	Nephtyidae	Nephtys firruginea	0.4	0.26	0.35	0.11	0.36				0.02	0.03		0.02	0.03		0.041
	Nephtyidae	Nephtys cornuta franciscanum		0.01		0.02											
	Nephtyidae	Nephtys cornuta cornuta						0.3	0.03	0.02	0.01						
	Nephtyidae	Nephtys longosetosa									0.03						
	Nephtyidae	Nephtys sp. N 1						1.02					0.02				
	Nephtyidae	Nephtys sp. N 2							0.04								
	Nereidae	Nereis procera															
	Onuphidae	Onuphis sp.															
	Opheliidae	Ophelina acuminata	0		0.02	0.02	0.01		0		0.01						
	Opheliidae	Ophelina sp.												0	0.01		
	Spionidae	Prionospio lighti															
	Spionidae	Prionospio steenstrupi															
	Spionidae	Dipolydora sp.															
	Spionidae	Species indet. N 1	0.15	0.29	0.05	0.1	0.2										0.012
	Spionidae	Species indet. N 2													0		
	Spionidae	Species indet. N 3											0.01		0.01	0.02	
	Spionidae	Species indet. N 4													0		
	Spionidae	Species indet. N 5													0.02		
	Spionidae	Pigospio sp.															
	Spionidae	Prionospio sp.			0.01							0.01				0	0.008
	Spionidae	Spio sp.															
	Spionidae	Spiophanes berkeleyorum								0.01	0.01						
	Spionidae	Spiophanes sp.	0.01											0.01			
	Spionidae	Laonice cirrata						0.75			0.03	2.4					
	Sternaspidae	Sternaspis scutata			0.01			0.7	0.5	0.75	0.47	0.8					
	Eunicidae	Species indet.															
	Terebellidae	Terebellides stroemi		0.21						0.04	0.32						0.12
	Terebellidae	Terebellides sp.															0.045
	Terebellidae	Species indet.															

Table 54

Biomass (g/sample) of macrobenthos collected in Vancouver Harbour.

Investigators: Dr. Jong Jeel Je and Dr. Tatyana Belan

Group	Class, order or family	Species	B-48					B-49					B-50				
			A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
	Polynoidae	Species indet.															
	Disomodae	Disoma sp.			0.2												
	Sigalionidae	Pholoe minuta	0.01				0.01										
	Hesionidae	Species indet.															
	Polynoidae	Species indet.						0.01							0.01		
	Pilargidae	Pilargis sp.	0	0.27	0.02	0.03	0.01										
	Pilargidae	Species indet.			0.01		0.01			0.01	0.02						
	Dorvilleidae	Dorvilea pseudorubrovitata															
	Dorvilleidae	Dorvilea sp.															0.008
	Dorvilleidae	Species indet.															0.012
	Flabelligeridae	Brada villosa						0.1									
	Sabellariidae	Sabellaria sp. (?)													0.02		0.04
	Sabellidae	Species indet.													0.03		
	Syllidae	Exogone lourei						0.05	0.06								
	Syllidae	Exogone sp.															
	Syllidae	Species indet.								0.02		0.01		0	0.02		0.007
	Orbiniidae	Scoloplos armiger					0.02						0.25	0.19	0.13	0.03	0.026
	Onuphidae	Onuphis iridescens						0.39	0.38			0.36					0.2
	Onuphidae	Onuphis sp.														0.28	
	Oweniidae	Owenia fusiformis					0.02										
Ophiuroidea	Amphiuridae	Amphipholis kochii		0.05	0.05	0.15		0.23			0.1	0.01					

Table 55

Harmful Algal Bloom Study: Wet weight, dry weight, and average lethal time of mice injected with an extraction of shellfish samples.

Investigator: Dr. Tian Yan

Sample Number	Genus	Species	Collection Date	Site	Wet Weight (g)	Dry Weight (g)	Ratio (ww/dw)	Average Lethal time (hours)
1	*Mytilus*	*trossulos*	5/27/99	I1	94.1	16	5.9	12
2	*Mytilus*	*trossulos*	5/27/99	I1	83.4	14.5	5.8	1.5
3	*Clinocardium*	*nuttallii*	5/27/99	B49	20.5	3	6.8	nm
4	*Mytilus*	*trossulos*	5/28/99	I3A	103.6	17.5	5.9	12
5	*Mytilus*	*trossulos*	5/28/99	I3A	89.5	14.8	6	24
6	*Mytilus*	*trossulos*	5/29/99	I5B	101.4	22.2	4.5	nm
7	*Mytilus*	*trossulos*	5/29/99	I5B	106.5	26	4	nm
8	*Mytilus*	*trossulos*	5/29/99	I6	78.3	16.5	4.7	nm
9	*Mytilus*	*trossulos*	5/29/99	I6	76.5	15.7	4.9	nm
10	*Ruditapes*	*philippinarium*	5/29/99	I6	90.1	17.2	5.2	nm
11	*Clinocardium*	*nuttallii*	5/29/99	T38	117.7	18.9	8.1	nm
12	*Clinocardium*	*nuttallii*	5/29/99	T38	29.6	4.2	7	nm
13	*Yoldia*	sp.	5/29/99	T38	5.3	0.9	5.9	nm
14	*Mytilus*	*trossulos*	5/30/99	I4	117.1	8.9	6.2	>24
15	*Mytilus*	*trossulos*	5/30/99	I4	97.3	17.2	5.7	>24
16	*Venerupis*	*staninea*	5/30/99	I4	98.3	16.1	6.1	nm
17	*Venerupis*	*staninea*	5/30/99	I4	93.7	16	5.9	nm
18	*Mytilus*	*trossulos*	6/1/99	I2A	97.3	14.9	6.5	>24
19	*Mytilus*	*trossulos*	6/1/99	I2A	98	15.2	6.4	1.1
20	*Mytilus*	*trossulos*	6/2/99	I7	81.9	16.9	4.8	nm
21	*Mytilus*	*trossulos*	6/2/99	I7	56.7	11.3	5	nm

nm = no mouse mortality

Table 56

Harmful Algal Bloom Study: Concentrations of Paralytic Shellfish Poison measured.

Investigator: Dr. Tian Yan

Sample*	**Sample Type**	**Average Lethal time**	**PSP in Extract** (eqv. STX microg/ml)	**PSP in Mussel** (eqv. STX microg/100g ww)
STX	0.294 microg/ml	9.5 min		
I1	mussel	16.5 h	0.15-0.2	15-20
I2A	mussel	12 h	0.15-0.2	15-20
STX	0.147 microg/ml	15 h		
I3A	mussel	18 h	<0.15	<15
I4	mussel	>24 hr**	<0.15	<15

*sample refers to reference material (STX) or to the site where mussels were collected.
**(>24hr) showed classical PSP symptoms, such as paralyzed legs, slow but deep respiration, and trembling head, yet the mouse survived after 24 h.

STX = saxitoxin
PSP = Paralytic shellfish poison

Table 57

Harmful Algal Bloom Study: Artemia Assay Results

Investigator: Dr. Tian Yan

Site	**Date**	**Result**
I1	5/27/99	-
I2A	6/1/99	-
I3A	5/28/99	+
I4	5/30/99	-
I5b	5/29/99	-
I6	5/29/99	-
I7	6/2/99	-

- = negative result
+ = swimming behavior of Artemia was inhibited, and the 24h LC50 of Artemia was about 50%.