Marine Pollution Bulletin 109 (2016) 661–666

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Contaminant (PAHs, OCs, PCBs and trace metals) concentrations are declining in axial tissue of sand flathead (*Platycephalus bassensis*) collected from an urbanised catchment (Port Phillip Bay, Australia)

Marthe Monique Gagnon [a,*], Jarrad Kyle Baker [a], Sara M. Long [b], Kathryn L. Hassell [c], Vincent J. Pettigrove [c]

[a] *Department of Environment and Agriculture, Curtin University, P.O. Box U1987, Perth, Western Australia 6845, Australia*
[b] *Centre for Aquatic Pollution Identification and Management (CAPIM), Bio21 Molecular Science and Biotechnology Institute, The University of Melbourne, Parkville, Victoria 3010, Australia*
[c] *Centre for Aquatic Pollution Identification and Management (CAPIM), The University of Melbourne, Parkville, Victoria 3010, Australia*

ARTICLE INFO

Article history:
Received 18 April 2016
Received in revised form 29 April 2016
Accepted 3 May 2016
Available online 18 May 2016

Keywords:
Fish
Port Phillip Bay
Contaminants
Trace metals
Organochlorines
PCBs

ABSTRACT

Concentrations of PAHs, OCs, PCBs and trace metals were determined in the white muscle of sand flathead *Platycephalus bassensis* collected at 6 locations in Port Phillip Bay during 2015. No PAHs, OCs or PCBs were detected in the white muscle of sand flathead at any of the locations, however measurable levels of As, Cu, Hg, Se and Zn were detected at all sites. Only As and Hg exhibited regional difference in white muscle concentrations, with As present only in a non-toxic organic form and Hg measured at levels that are comparable to levels reported in reference sites in other studies. All contaminants detected in the white muscle of sand flathead collected in Port Phillip Bay in 2015 were below Australian Food Standards guideline values, and by world standards, the Port Phillip Bay sand flathead population is considered minimally contaminated. Furthermore, tissue contaminant concentrations appear to be decreasing over time.

Most major cities of the world are located near sheltered embayments which facilitate transport of goods by sea, provide recreation and amenity and offer protection from open coastal weather extremes. However, embayments are susceptible to environmental pollution via industrial use of their banks and urbanisation of their catchment area. Port Phillip Bay is an example of a typical urban embayment. The catchment includes large urban areas from the Cities of Melbourne and Geelong with a population exceeding four million. The Bay is 1930 km^2 with a coastline length of 264 km (Sampson et al., 2014) and is relatively shallow with half of the 26 km^3 volume occupying areas <8 m deep and the narrow southern entrance, resulting in a flushing time of up to 12 months (Victoria EPA, 2011). The land catchment covers an area of 9790 km^2 and includes industrial zones that contribute heavy metals, organic contaminants and industrial chemicals, as well as urban and rural areas which provide nutrient and biocide inputs into the Bay.

Initial studies of toxicants in the Bay, in the early 1970s, focussed on nutrients but subsequent studies in the late 1970s included measurements of metals of concern, namely cadmium, mercury, zinc and copper which were elevated in molluscs (Phillips et al., 1992). Later investigations in the 1980s included organic contaminants, and established that elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) were found in parts of the Bay (Phillips et al., 1992). Of special concern was the discharge of Kororoit Creek into the northern side of the bay, carrying significant loads of mercury (Hg), copper (Cu) and chromium (Cr) from industrial discharges (Scott and Christoff, 1988). Monitoring programs concerned with the deteriorating ecological health of the Bay were established, and contaminant levels were measured in various environmental compartments including water, sediments and fish. The first comprehensive study of Port Phillip Bay included the study of physical and ecological processes governing the Bay as well as nutrient and toxicant inputs. Harris et al. (1996) found that overall found that overall the Bay was relatively unpolluted but hot spots of contamination were identified in highly industrialised/urbanised areas, with major inputs via direct effluent discharge from large industries or via the Yarra River flowing through Melbourne. Important measures were taken to protect Port Phillip Bay from detrimental effects of contamination: firstly, a system of licensing discharges which improved the quality of urban and industrial effluents entering the Bay was instated, and secondly the creation of management zones for specific tasks such as wildlife protection and aquaculture (Phillips et al., 1992). The water quality of the Yarra River and of Kororoit Creek has been further improved through increased sewering of catchments and diversion of industrial discharges into the sewerage system (Sampson et al., 2014; Scott and Christoff, 1988).

A key bioindicator species that has been used to monitor pollution in Port Phillip Bay is the sand flathead (*Platycephalus bassensis*), which is an iconic and recreationally important fish species. Sand flathead are

* Corresponding author.
E-mail address: m.gagnon@curtin.edu.au (M.M. Gagnon).

http://dx.doi.org/10.1016/j.marpolbul.2016.05.003
0025-326X/

long-lived carnivorous ambush predators that conceal themselves in fine sediments and are not strong swimmers and therefore believed to be representative of the area from where they are collected (Fabris et al., 1992). During the late 1970′s, sand flathead collected in Port Phillip Bay had a mean mercury concentration of 0.5 mg/kg in edible white muscle but this level had declined to 0.23 mg/kg in the early 1990s, and to 0.16 mg/kg by the mid-1990s (Fabris, 1995). Whilst in the early 1990s, levels of organochlorine pesticides, PAHs and PCBs were mostly below the detection limits in the white muscle of sand flathead collected from various parts of Port Phillip Bay. Nevertheless, a study conducted in 1999 in urbanised areas of the Bay reported measurable levels of PAH metabolites in sand flathead biliary secretions, which are suggestive of recent exposure to petroleum hydrocarbons of pyrolytic origin (Gagnon and Holdway, 2002). Since Port Phillip Bay is a major seafood source for the city of Melbourne (Hirst et al., 2014) it is imperative to have ongoing monitoring of the Bay's health status.

In the past decade, the continuous improvement of wastewater management by the city of Melbourne aimed at preserving water quality and ecological integrity in the Bay, however substantial population growth on the shorelines of Port Phillip Bay could intensify pollution inputs in the future. To evaluate the current health status of sand flathead in Port Philip Bay, a comprehensive study was undertaken in 2015 which included the measurement of a suite of physiological and biochemical parameters (Baker et al., in prep.) complemented by the determination of contamination levels in the white muscle of sand flathead. The suite of contaminants analysed included polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCs), PCB congeners (PCBs) and ten metals commonly found as pollutants in urban or industrialised environments. It is expected that the information reported here will be useful for long term monitoring and management of the Port Phillip Bay environment.

Skinless white muscle samples were collected from 96 sand flathead originating from six separate locations within Port Phillip Bay during February 2015 (Fig. 1.), as per the Department of Environment and Primary Industries permit No. RP1216. The fish were captured by hook and line and kept in aerated live tanks on board the boat, then brought back to the laboratory where they were sacrificed by iki jime (Robb et al., 2000) as per Curtin University Animal Ethics Approval # AEC-2015-05. Physiological parameters were recorded and biopsies of blood, liver, bile, brain and gonads were collected for biomarker analyses, and otoliths were retained for age determination. All tissues were collected within 10 min of death. Fish were immediately filleted, and a white muscle sample was placed in HPLC-grade methanol rinsed aluminium foil and stored at −20 °C prior to chemical analysis. Pooled samples of white muscle from 3 fish of similar size and sex (collected within one location) were submitted for chemical analysis.

Determination of OCs pesticides and PCBs in muscle tissue was conducted by the National Measurement Institute (NMI, North Ryde, New South Wales), according to the US EPA methods 3540C and 3620B (US EPA, 1996a, 1996b). Briefly, homogenised tissue samples were mixed with anhydrous sodium sulphate and extracted using a hexane:acetone mix. The extract was cleaned up by gel permeation chromatography (GPC) and the final extract was analysed by GC-ECD (dual column).

PAHs were also analysed by NMI, according to the US EPA method 8270D (US EPA, 1998). Homogenised muscle samples were extracted with dichloromethane/acetone, cleaned up using GPC and silica gel, then analysed by gas chromatography with a mass selective detector (MSD) using electron impact-selective ion monitoring.

Trace metal analysis of homogenised white muscle was conducted by NMI for the following elements: total arsenic (TotAs); inorganic arsenic (InorAs); total mercury (TotHg); copper (Cu); zinc (Zn); cadmium (Cd); chromium (Cr); nickel (Ni); silver (Ag) and selenium (Se). These elements were analysed according to the US EPA methods 6010C (US EPA, 2000) and 6020A (US EPA, 1998) and to the AOAC methods 986.15 (AOAC International, 2002) and 974.14 (AOAC International, 2002, 2002a). The homogenised samples were acid-digested then analysed for trace metals using inductively coupled plasma-mass spectrometry (ICP-MS) and/or inductively coupled plasma-atomic emission spectrometry (ICP-AES).

Inorganic arsenic was measured using the hydride generation ICP-MS technique, which measures total acid extractable As^{+3} and As^{+5} from inorganic arsenic compounds plus arsenic from the partial

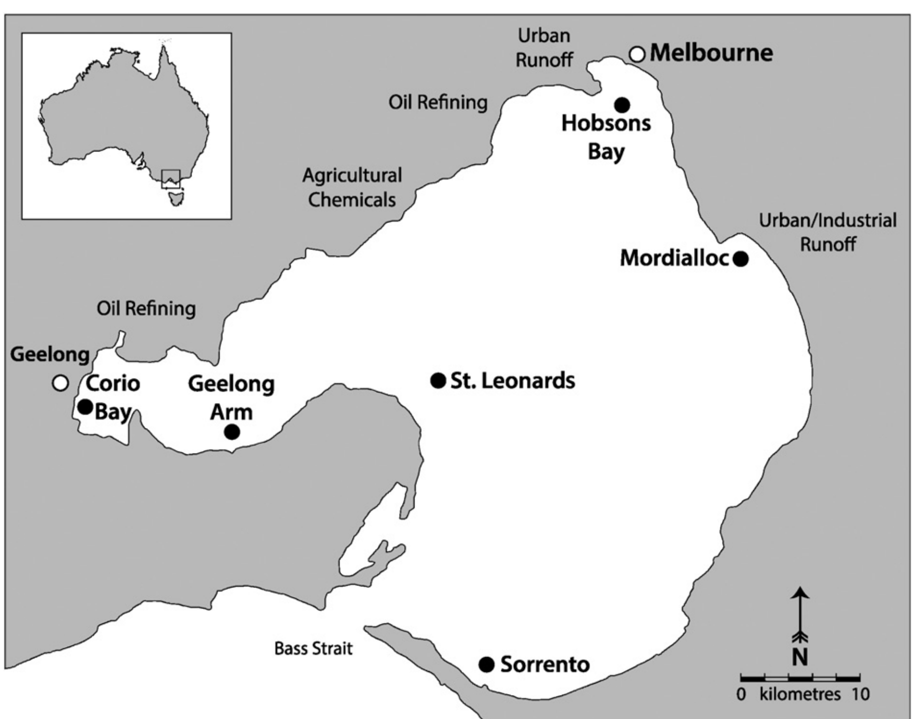

Fig. 1. Sampling locations in Port Phillip Bay, 2015.