Appendix 3: Final Report for selenium concentration in pilchard from Albany (Jones, 2011).

FINAL REPORT

Selenium in Pilchards from Albany

Summary
Samples of pilchards from along the south coast of Western Australia obtained by the Department of Fisheries with the assistance of industry and the Albany Port Authority have established that pilchards from King George Sound are no higher in Selenium than pilchards from elsewhere on the south coast of Western Australia, nor are they different from the selenium levels reported for the same pilchard species caught off South Africa. Levels of Se in pilchards are naturally high, but are not as high as in other pelagic tunas caught in the open ocean.

Introduction
In February 2011 the Fish Health Unit, Department of Fisheries received advice from Dr Nick Dunlop of the Conservation Council, that Selenium (Se) in feathers of Little Penguins (*Eudyptula minor)* from the Mistaken Island colony were significantly higher (almost double) than those from both the Penguin Island and Woody Island colonies. From this Dr Dunlop concluded that penguins foraging on schooling planktivorous fishes within King George Sound were being exposed to elevated levels of dietary Se.

The Conservation Council therefore arranged for sampling of schooling planktivorous species in Princess Royal Harbour and Oyster Harbour in early March 2011. The samples obtained using a beach-seine net included Hardyheads (*Pranesus ogilbyi*) (Princess Royal Harbour n=10, Oyster Harbour n=10). Australian Anchovies (*Engraulis australis*, n=3) and Blue Sprats (*Spratelloides robustus, n=?*). In addition, pilchard (*Sardinops sagax*, n=10) samples captured in King George Sound in early March 2011 by commercial purse-seine were analysed. The draft report concluded that "the Se concentrations observed in planktivorous fish from all the Albany waterways were significantly higher than expected from Australian commercial fish from 'unpolluted' environments (mean = 1.13mg/ kg dry weight)".

This finding was of concern to the Department, the Port Authority and to the purse-seine fishing industry. One of the difficulties with the Conservation Council report was that fish obtain selenium from their diet, and levels vary by fish species, season and area (Satovic et al. 2003; Bhattacharya et al. 2003). Pilchards are known to be "high" in this essential element (Hayase et al. 2009). An additional difficulty presented by pelagic fish is that they school by size and condition, thus sampling needs to be stratified to avoid bias.

Therefore, a larger sample of pilchards was obtained by the Department with the assistance of industry and the Albany Port Authority to independently assess the data provided by the Conservation Council.

Methods

The sampling design was to collect 75 pilchards (25 fish from each of 3 schools) from each of three areas (King George Sound Albany, Esperance and Bremer Bay. In the event, only two schools were sampled from Esperance. Fish were measured (fork length), weighed, minced, dried, and reweighed before submitting to Chemistry Centre for analysis.

In interpreting the literature, the following formulae were used for estimation of dry weight (dw) from wet weight and for estimation of whole body Se from Se concentrations in muscle:

$$Dry\ weight = wet\ weight \times 100/(100\text{-}percent\ moisture)$$

percent moisture was assumed to be 75% based on figures in Table A1 of Tetra Tech (2008)

Se in fish muscle to whole body (Tetra Tech (2008))

$$Se_{wholebody} = exp(0.1331+(0.8937 \times ln(Se_{muscle})))$$

Results

An initial 40 samples were submitted to the Chemistry Centre, and a further 10 (larger Albany pilchards from King George Sound) were subsequently submitted after analysis showed that the Albany fish were generally smaller than the pilchards from Bremer Bay. The 40 samples consist of 15 samples from Seal Island (King George Sound); and 25 fish from two control areas (Bremer Bay n=15; Esperance n=10). The mean and standard deviation Se level for KGS was 3.5 ± 0.5 mg/kg dw, n=15 and for the controls 3.4 ± 0.7 mg/kg dw, n=25. A comparison of the length to the weight showed that there was a good correlation between the two parameters (Figure 1) showing that weight is a good approximation for length. As expected, there was considerable variation between sample weights (and thus length) within areas and between areas (Table 1). However, because the selenium levels (mg/kg dry weight), showed no correlation with wet weight (Figure 2), the variation in sample weights could be ignored. The mean and standard deviation (SD) for Se from the samples are provided in Table 2.

Table 1. Wet weight data (g) by sample and area.

Weight summary

	Sample	mean	count	SD
Albany	1	28.33	5	4.74
	2	17.61	5	3.06
	3	38.22	15	9.06
Bremer Bay	1	33.62	5	4.37
	2	48.54	5	8.68
	3	46.45	5	15.46
Esperance	1	19.77	5	6.92
	2	22.47	5	2.54
Albany	total	32.12	25	11.12
Bremer Bay	total	42.87	15	11.92
Esperance	total	21.12	10	5.21

Table 1. Selenium measurements (mg/kg dry weight) in fish samples.

Selenium

	Sample	mean	count	SD
Albany	1	3.44	5	0.76
	2	3.44	5	0.41
	3	3.63	5	0.56
Bremer Bay	1	2.6	5	0.19
	2	3.84	5	0.63
	3	3.06	5	0.72
Esperance	1	3.98	5	0.30
	2	3.54	5	0.54
Albany	total	3.56	25	0.57
Bremer Bay	total	3.17	15	0.74
Esperance	total	3.76	10	0.47

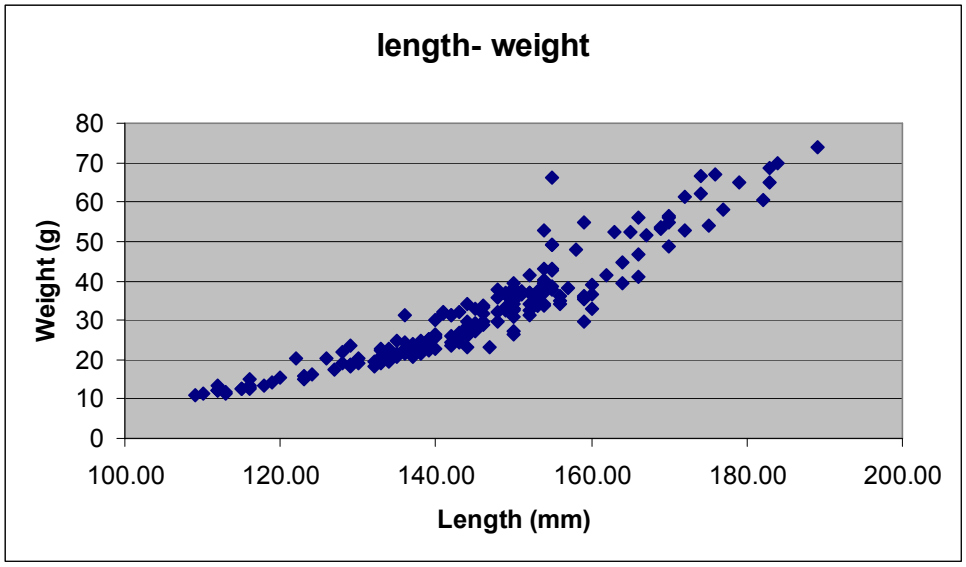

Figure 1. Plot of length against wet weight for all of the pilchards sampled.

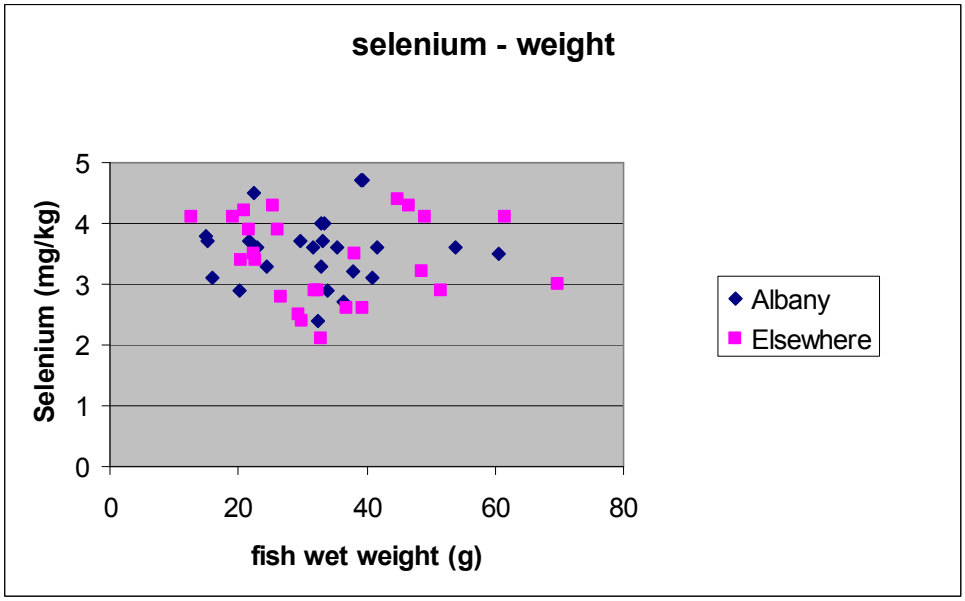

Figure 2. Plot of the selenium values (mg/kg dry weight) against wet weight (g) of pilchards.

Discussion

The results show that though there is variation between samples, the KGS samples are not statistically different from those from Bremer Bay and Esperance. The data also show that there is no correlation between fish length and Se concentrations. As expected, there is significant variation between dry weight of samples within areas (data not shown)

Selenium is an essential element in animal nutrition, including fish (Kaneko & Ralston 2007) but is toxic at high concentrations. . Most of the aquatic toxicity literature up until about 2000 gives data only for freshwater or anadromous fish. For example, Mance (1987) does not give any Se toxicity data for marine teleosts and this absence of marine fish data was also commented on by Anon. (2008). However, Kifer & Payne (1968) cite levels in fish meals as ranging from 1.0-4.0 mg/kg dw. Brix et al. (2000) in a review of toxicity data for selenium (again based only on freshwater or estuarine fish) proposed a whole body dry weight tissue based toxicity threshold of 6-9 mg/kg for selenium.

Kaneko & Ralston (2007) measured selenium in 15 species of pelagic fish from the central north Pacific near Hawaii, and found that the mcg/g (= mg/kg) wet weight values for selenium in muscle of yellowfin tuna were 1.25 + 0.27 ; skipjack 1.57 +0.92; and albacore 0.88+0.19. These are equivalent (assuming a 75% moisture content) to 5.0; 6.28 and 3.52 mg/kg respectively. Šatovic et al. (2003) found that Se levels in muscle of pilchards (*Clupea pilchardus*) in the Adriatic sea vary by location and season of catch, with an average of 0.580 mcg/g ww (about 2.4 mg/kg dw on whole body basis), but a spring value of 0.712 ± 0.0237 mcg/g ww (2.9 mg/kg dw on a whole body basis). Closer to home, Oceania advertise that their canned pilchards (*Sardinops sagax*) from South Africa have an average Se level of 1198mcg/100g serving (equivalent to 4.79 mg/kg dw).

Thus the King George Sound pilchards are no higher in Se than pilchards from elsewhere on the south coast of Western Australia, nor are they different from the same species found in South Africa. Levels of Se in pilchards are high, but are not as high as in other pelagic tunas caught in the open ocean.

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