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Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

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Agenda item 4

PLANNING OF GESAMP ACTIVITIES: GLOBAL TRENDS IN POLLUTION OF COASTAL ECOSYSTEMS

Report of the Chair of Working Group 39

1 The goal of WG 39 is to contribute to the reduction of stress in coastal ecosystems by providing stakeholders, scientists and society with an objective and global assessment of pollution trends during the last century in sensitive coastal ecosystems. At the request of IAEA, WG 39 looks at the establishment of trends in global pollution in coastal environments.

2 The Working Group (WG) met for the first time back-to-back with the International Symposium on Isotopes in Hydrology, Marine Ecosystems, and Climate Change Studies in Monaco at the beginning of April 2011. Terms of Reference (ToR) were provided and members agreed on the working methodology and distribution of tasks among them. The main activity was to conduct a literature survey on temporal trends of pollution of coastal ecosystems following a list of priority substances, and to classify the information according to the geographical definitions of the Large Marine Ecosystems (LMEs). A bibliographic database was designed in MSExcel to organize the information extracted from the collected documents. The database and the document collection management was made through the file-sharing website DropBox. WG members engaged to intersessional work on the compilation of documents and population of the database. In the 38th session of GESAMP (2011) a report of the WG 39 inception meeting was submitted and it was noted that financial support was needed to continue working with the tasks included in the ToRs. In the 39th session of GESAMP (2012) it was stressed that the WG did not have a meeting since its first meeting in 2011, due to other priorities at the IAEA in relation to the Fukushima accident in March 2011, and thus progress had not been achieved. During the GESAMP 40th session (2013), it was reported that 304 scientific papers had been compiled and recorded in the WG 39 bibliographic database (see annex 1). A pilot web platform was presented and developed at no cost by UNINMAR at the Institute of Marine Sciences and Limnology, National Autonomous University of Mexico (ICML-UNAM), with the aim to host and manage the information contained in the WG 39 database. It was again noted that financial support was needed for data preparation for trend analysis of the contaminants, especially for the digitization of core profile figures from the papers contained in the data base.

3 The second meeting of WG 39 was held at the Environment Laboratories of the International Atomic Energy Agency (IAEA) in Monaco in May, 2014. An improved version of the web-based analysis tool was presented, which has the capability to assess the pollution trends in the temporal series obtained from the literature. The analysis routine was carefully explained, step by step, so WG 39 members were able to perform trend analysis in their assigned LMEs. As a pilot study, the relevant figures of LME 03 California Current were digitized by UNAM, at no cost to the leading organizations. WG 39 members worked in the quantification of temporal trends from selected papers, pollutants were grouped, statistical tests were performed, a preliminary LME dataset was integrated, pollutant concentrations were compared to the NOAA-SQUIRT benchmarks to evaluate potential risk of harmful effects to the coastal resources, and a preliminary report on LME 03 California Current was produced. The WG 39 working methodology was revised according to the experience gained by all WG 39 members during i) the literature search and

review (Task 1) and ii) the pilot pollution trend analysis performed in session 2 of this meeting. During the meeting, WG 39 members delineated and agreed on future work and task assignment. After the examination of the pilot study, members agreed that the methodology designed, the existing tools and available data would warrant a high quality and high impact product. The WG 39 members stressed again that financial support was needed to continue with WG 39 tasks. At the end of the meeting, the main results were presented to IAEA-EL Director and IAEA-EL staff recognized the quality and relevance of the work done and further emphasized the IAEA interest and commitment to the objectives of WG 39. He mentioned that IAEA would look for funding in order to continue the work of WG 39, notably the digitization of all data and gathering of information for the final report.

4 A report of the second meeting of WG39 was submitted to the 41st session of GESAMP (2014). It was reported that all data analysis results would be carefully described and interpreted in a detailed report for each LME, and submitted for review by the GESAMP members before publication. The meeting stressed again that, in order to continue with WG 39 activities, it was necessary to complete the digitization of core profile figures from the papers in the bibliographic database. It was agreed that the supporting agencies would look for appropriate funding with the aim to implement the pending WG 39 activities (e.g. digitization of paper graphs, maps production, third meeting of the WG 39 to review the final report) during the intersessional period. However, the timeline for completion of the work depended on the availability of funds.

5 During the 42nd session of GESAMP (2015) it was informed that, during the third quarter of 2015, IAEA and the Executive Committee of GESAMP had agreed to provide the needed funds to support the pending work of WG 39. UNINMAR-UNAM had committed to provide the final report of the digitization within one year, upon receipt of the resources (in June 2015).

6 During the 43rd session of GESAMP (2016) it was informed that UNINMAR-UNAM had completed the digitization and capture of the available literature within the current total of 66 LMEs (328 articles from 50 LMEs; 16 LMEs do not have available publications), the digitization of graphs (871 time series) and the compilation a total of 58,006 geo-chrono-referenced data. The information for each time series (Table 1, below) includes the metadata corresponding to the bibliographic source, sampling location (coordinates and depth), contaminant (family, subfamily and contaminant type) and the contaminant concentrations versus age provided by sediment dating. The information is available at UNINMAR where it can be visualized and analyzed by the members of GESAMP WG 39 (http://www.icmyl.unam.mx/uninmar/mapa.jsf#zoom=2&lat=21.70167&lon=0&layers=B00TT).

7 Data analysis is currently ongoing and in a very advanced stage. Results are being integrated into individual reports by LME (see an example in annex 2), with the purpose to facilitate expert assessment. The individual reports include the following sections:

.1 a brief description of the biogeochemical and socioeconomic characteristics of the LME (summarized from the LME Briefs, in http://www.lme.noaa.gov; and the individual factsheets of TWAP LMEs assessment, in http://onesharedocean.org/lmes);

.2 bibliography reviewed: information on the number of papers per LME which could be used according to the analysis methodology, the number of contaminant profiles (per family and subfamily);

.3 trend analysis: presents the number of contaminant profiles analyzed (bar plot), which presented a statistically significant trend ($p<0.05$) per period of study (1900-1950, 1950-1975 and 1975-2015) or along the whole period (within 1900-2015). This section also presents the classification of the trends (increasing, reducing or neutral); and

.4 maximum levels: presents a comparison of the maximum contaminant concentrations found with the Probable Effect Level from the SQUIRT (Buchman, 2008).

8 The individual reports now require the intervention of the WG 39 members for discussion and conclusions derived from these analyses.

Action requested of GESAMP

9 GESAMP is invited to consider the information provided and take action as appropriate.

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Table 1. Information available from the literature analysis and graph digitization, by LME[1]

Large Marine Ecosystem	***ARTICLES***	***LOCATION***	***TIME SERIES***	***ANALYTE NUMBER***	***DATA NUMBER***	***FAMILIES***
01 East Bearing Sea	1	2	2	1	24	1
02 Gulf of Alaska	1	2	2	1	25	1
03 California Current	12	33	134	50	2696	2
04 Gulf of California	10	16	49	15	1216	4
05 Gulf of Mexico	7	26	55	17	1006	3
06 Southeast U.S. Continental Shelf	1	1	4	4	30	1
07 Northeast U.S. Continental Shelf	8	21	56	22	750	5
10 Insular Pacific Hawaiian	2	4	24	12	879	2
11 Pacific Central-American Coastal	4	4	14	13	281	4
12 Caribbean Sea	5	14	37	16	543	5
13 Humboldt Current	5	33	36	4	454	4
14 Patagonian Shelf	2	3	11	8	234	3
15 South Brazil	22	46	139	45	2324	6
16 East Brazil Shelf	2	8	20	6	134	3
17 North Brazil Shelf	3	7	10	3	141	2
18 West Greenland Shelf	8	35	71	24	979	4
19 East Greenland Shelf	3	10	19	3	123	2
20 Barents Sea	11	27	40	11	510	4
21 Norwegian Sea	4	16	33	11	255	3
22 North Sea	6	14	48	31	533	3
23 Baltic Sea	38	98	590	237	8291	5
24 Celtic - Biscay Shelf	4	6	36	19	653	3
25 Iberian Coastal	11	56	230	20	3698	4
26 Mediterranean Sea	31	116	412	56	5970	6
27 Canary Current	4	6	35	10	464	4
28 Guinea Current	2	6	34	6	123	1
29 Benguela Current	2	2	4	4	64	3
32 Arabian Sea	6	20	73	10	2163	4
33 Red Sea	1	1	4	4	64	1
34 Bay of Bengal	3	22	94	10	1218	3
35 Gulf of Thailand	3	7	37	16	1107	4
36 South China Sea	30	68	351	92	10428	6
38 Indonesia Sea	3	3	13	7	218	1
40 Norheast Australian Shelf	7	3	26	7	411	2
41 East-Central Australian Shelf	1	3	15	5	91	2
42 Southeast Australian Shelf	2	2	11	7	217	1
43 Southwest Australian Shelf	2	2	3	2	24	1
44 West-Central Australian Shelf	2	4	11	4	84	3
46 New Zealand Shelf	3	8	18	8	205	3
47 East China Sea	7	10	23	17	653	4
48 Yellow Sea	12	18	67	22	1981	3

Large Marine Ecosystem	**ARTICLES**	**LOCATION**	**TIME SERIES**	**ANALYTE NUMBER**	**DATA NUMBER**	**FAMILIES**
49 Kuroshio Current	11	35	201	92	3161	6
50 Sea of Japan East Sea	7	9	135	99	1747	5
54 Chukchi Sea	5	14	29	10	515	3
55 Beaufort Sea	1	3	6	2	90	1
58 Kara Sea	1	1	1	1	15	1
60 Faroe Plateau	2	2	5	5	66	3
61 Antarctic	4	9	33	17	446	4
62 Black Sea	4	5	13	10	519	2
66 Canadian High Arctic	2	10	19	3	183	2

[1]LMEs not listed do not have any study report available

ANNEX 1

WG 39 BIBLIOGRAPHIC DATABASE

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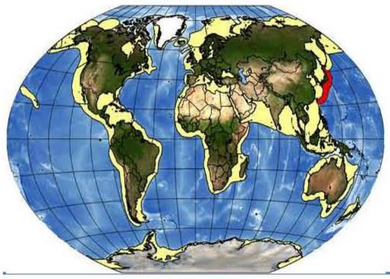
ANNEX 2

Example of individual LME report



LME 49
Kuroshio Current

The Kuroshio Current LME extends from the Philippines to the Japanese Archipelago's northernmost island, Hokkaido. It has a surface area of about 1.3 million km^2, of which 0.33% is protected, and contains 1.29% of the world's coral reefs, and 9 major estuaries. The region has a generally mild, temperate climate; and the Kuroshio Current LME is considered a moderately high productivity ecosystem. The LME is an important spawning and nursery ground for many important pelagic fishes such as clupeoids, horse mackerel, scomber and saury. The number of collapsed and overexploited stock account for 80% of the commercially exploited stocks, with only half of the reported landings supplied by fully exploited stocks (Belkin et al., 2017 and references therein). The coastal fringe of the Kuroshio current LME stretches over 260,980 km^2. The population reported in 2010 was 111 318 thousand, with a density of 426 persons per km^2, and about 17% of coastal population living in rural areas (TWAP, 2015). Fisheries are a major economic activity in Japan, which relies on the sea for its supply of fish, seaweed and other marine resources. Japan's rapid economic development after World War II impacted its marine environment. On the Pacific side, there is air pollution from power plant emissions, resulting in acid rain; lakes and reservoirs are acidified, resulting in a decrease in water quality and a threat to aquatic life. Among the major pollution issues in the marine areas surrounding Japan are sewage and non-biodegradable pollution in Tokyo/Yokosuka and Hakodate/Otsuchi areas; oil spills and incidents caused by land-based activities, drifting oil and wastes produced by shipping activities; as well as red tides and blue tide (caused by upwelling of blue-green oxygen-depleted turbid waters observed in Tokyo Bay from early summer to autumn) (Belkin et al., 2017 and references therein).
This LME falls in the cluster of LMEs that exhibit medium to high numbers of collapsed and overexploited fish stocks, high levels of demersal non-destructive low bycatch fishing, as well as very high shipping pressure. This LME is most vulnerable to climate change. Other key stressors include commercial shipping, ocean based pollution, invasive species, and all three types of demersal commercial fishing (demersal destructive, non-destructive low-bycatch, and non-destructive high-bycatch) (TWAP, 2015).

Bibliography reviewed

In LME49, 11 papers were originally selected, and 11 were used for analysis after initial screening. Information on 187 time series was extracted, meeting the requirements of the proposed methodology. The selected bibliography contained information on 88 contaminants included in 19 subfamilies (Al, C, Cr, Cu, Ni, N, P, Pb, V, Zn, PCBs, Cd, Hg, Sn, Pu, AR, Dioxins, Furans, ^{137}Cs) and 6 families (Metals, Nutrients, Industrial organic chemicals, Radionuclides, Sediments, Industrial organic byproducts). The studies cover the time period 1574 – 2011, although only data from 1900 were used for trend analysis. As examples, Pb and PCBs time series are shown in Figures LME49.1 and LME49.2.

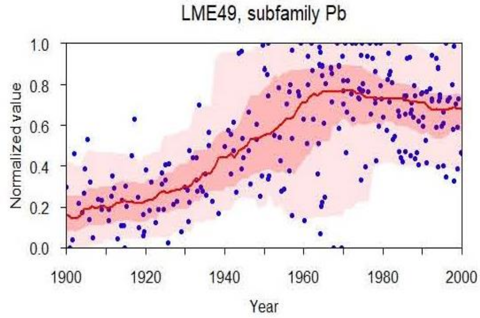


Figure LME49.1. Pb time series. The red line shows a decadal moving average, the shaded areas represent the 25-75% (red) and 5-95% (pink) quantiles.

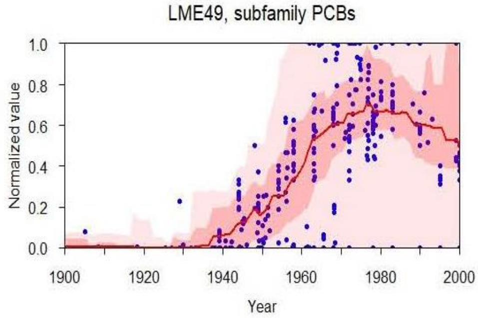


Figure LME49.2. PCBs time series. The red line shows a decadal moving average, the shaded areas represent the 25-75% (red) and 5-95% (pink) quantiles.

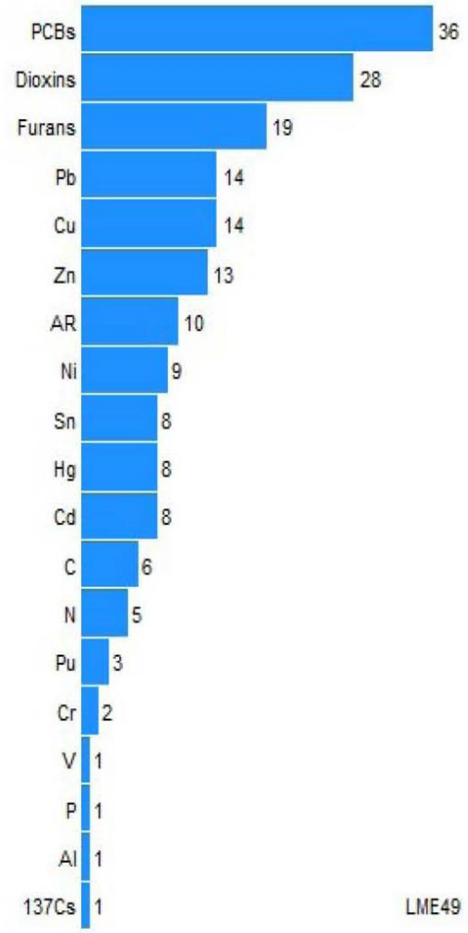


Figure LME49.3: Number of time series per contaminant.

Trend analysis

The number of time series by contaminant is shown in Figure LME49.1. According to the methodology, time series trends were calculated for the periods 1900-2015, 1900-1950, 1950-1975 and 1975-2015. In total, 69 trends were determined and 37 were statistically significant ($p<0.05$, Table LME49.1).

For Al, the calculated trends (in units of percentage of variation per decade) were n.a. during 1900 - 1950, neutral during 1950 - 1975, n.a. during 1975 - 2015, and neutral during the whole period. For Cd, the calculated trends (in units of percentage of variation per decade) were neutral during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 4.3 during the whole period. For Cr, the calculated trends (in units of percentage of variation per decade) were neutral during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 3 during the whole period. For Cu, the calculated trends (in units of percentage of variation per decade) were 9.1 during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 5.7 during the whole period. For Hg, the calculated trends (in units of percentage of variation per decade) were neutral during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 2.9 during the whole period.

Table LME49.1. Summary of LME49 trends per contaminant.

Contaminant	1900-1950		1950-1975		1975-2015		1900-2015	
	N	Trend	N	Trend	N	Trend	N	Trend
Al	3	n.a.	7	neutral	2	n.a.	12	neutral
Cd	28	neutral	26	neutral	45	neutral	99	4.3
Cr	12	neutral	13	neutral	16	neutral	40	3
Cu	52	9.1	57	neutral	96	neutral	204	5.7
Hg	27	neutral	27	neutral	50	neutral	103	2.9
Ni	30	neutral	37	neutral	45	neutral	112	neutral
Pb	87	7.8	72	neutral	111	neutral	269	5.4
Sn	27	neutral	26	neutral	50	10.3	103	5.1
V	4	n.a.	6	neutral	2	n.a.	12	neutral
Zn	50	13.6	52	neutral	95	neutral	195	6.3
137Cs	4	n.a.	8	neutral	14	-8.9	25	-4.3
Pu	13	1.4	55	-22.8	87	-1.4	155	-4.9
PCBs	80	5.6	142	25.9	123	-10.3	344	9.9
Dioxins	88	5.6	129	11	168	-14.6	385	8.4
Furans	38	6.6	67	9.3	109	-16.5	214	8.9
C	18	7.2	22	neutral	29	17.4	69	7.1
N	17	neutral	18	neutral	31	15.4	66	6.1
P	3	n.a.	5	neutral	3	n.a.	11	7.7
AR	26	8.3	24	neutral	51	neutral	101	6.1

N = number of data; Trend = percentage of variation per decade; n.d. = no data; n.a. = not analysed; n.s. = not significant; u.r. = under review

For Ni, the calculated trends (in units of percentage of variation per decade) were neutral during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and neutral during the whole period. For Pb, the calculated trends (in units of percentage of variation per decade) were 7.8 during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 5.4 during the whole period. For Sn, the calculated trends (in units of percentage of variation per decade) were neutral during 1900 - 1950, neutral during 1950 - 1975, 10.3 during 1975 - 2015, and 5.1 during the whole period. For V, the calculated trends (in units of percentage of variation per decade) were n.a. during 1900 - 1950, neutral during 1950 - 1975, n.a. during 1975 - 2015, and neutral during the whole period. For Zn, the calculated trends (in units of percentage of variation per decade) were 13.6 during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 6.3 during the whole period.

For ^{137}Cs, the calculated trends (in units of percentage of variation per decade) were n.a. during 1900 - 1950, neutral during 1950 - 1975, -8.9 during 1975 - 2015, and -4.3 during the whole period. For Pu, the calculated trends (in units of percentage of variation per decade) were 1.4 during 1900 - 1950, -22.8 during 1950 - 1975, -1.4 during 1975 - 2015, and -4.9 during the whole period. For PCBs, the calculated trends (in units of percentage of variation per decade) were 5.6 during 1900 - 1950, 25.9 during 1950 - 1975, -10.3 during 1975 - 2015, and 9.9 during the whole period. For Dioxins, the calculated trends (in units of percentage of variation per decade) were 5.6 during 1900 - 1950, 11 during 1950 - 1975, -14.6 during 1975 - 2015, and 8.4 during the whole period. For Furans, the calculated trends (in units of percentage of variation per decade) were 6.6 during 1900 - 1950, 9.3 during 1950 - 1975, -16.5 during 1975 - 2015, and 8.9 during the whole period. For C, the calculated trends (in units of percentage of variation per decade) were 7.2 during 1900 - 1950, neutral during 1950 - 1975, 17.4 during 1975 - 2015, and 7.1 during the whole period. For N, the calculated trends (in units of percentage of variation per decade) were neutral during 1900 - 1950, neutral during 1950 - 1975, 15.4 during 1975 - 2015, and 6.1 during the whole period. For P, the calculated trends (in units of percentage of variation per decade) were n.a. during 1900 - 1950, neutral during 1950 - 1975, n.a. during 1975 - 2015, and 7.7 during the whole period. For AR, the calculated trends (in units of percentage of variation per decade) were 8.3 during 1900 - 1950, neutral during 1950 - 1975, neutral during 1975 - 2015, and 6.1 during the whole period.

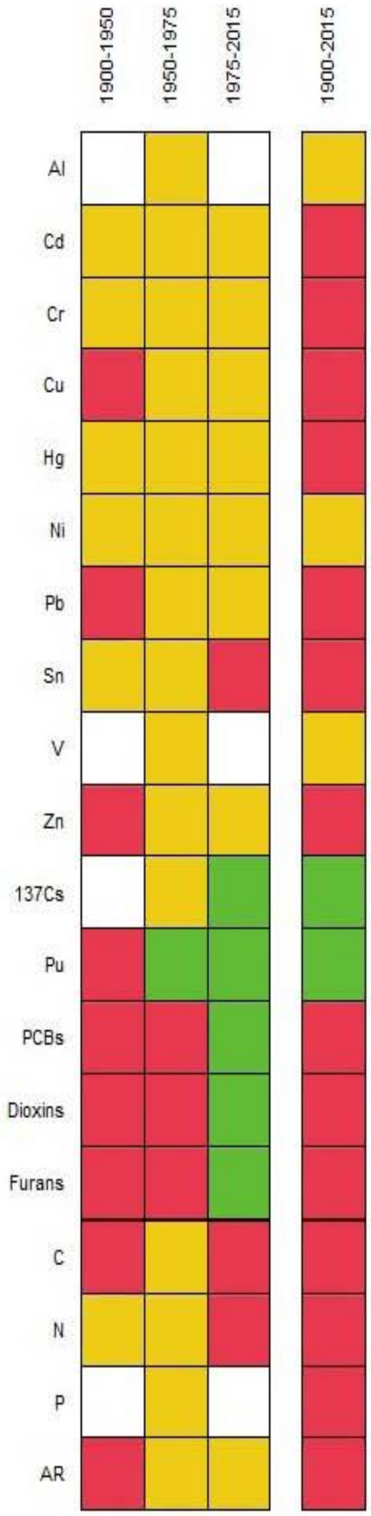


Figure LME49.4. Chart of temporal trends.

Maximum levels

In LME49, metal concentrations were compared to the Probable Effect Level (PEL) in marine sediments (Table.LME49.2). This value represents the concentration above which adverse biological effects frequently occur, and it is suggested as a preliminary screening concentration to identify substances which may threaten natural resources (Buchman, 2008). Maximum concentrations of four metals (Hg, Ni, Pb, Zn) were above PEL, and for Hg it was 212 times larger.

Table LME49.2. Comparison of maximum concentrations with the Probable Effect Level (PEL).

Metal	Number of time series	Maximum concentration (ppm)	PEL (ppm)
Cd	4	2.44	4.21
Cr	2	144	160
Cu	10	95.6	108
Hg	4	148.15	0.7
Ni	5	46.87	42.8
Pb	10	112.4	112
Zn	9	780.25	271

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