The Development of a Common set of Water and Sediment Quality Guidelines for the Coastal Zone of the BCLME

Project BEHP/LBMP/03/04

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This report also includes feedback that was received from key stakeholders attending the Work sessions that were held in each of the three countries:

Namibia: 25 and 26 January 2005
Angola: 7 and 8 February 2005
South Africa: 10 and 11 February 2005

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EXECUTIVE SUMMARY

(RECOMMENDED WATER AND SEDIMENT QUALITY GUIDELINES FOR THE BCLME REGION IN A NUTSHELL)

The United Nations Office for Project Services ("UNOPS") commissioned the CSIR (South Africa) to conduct this project, of which the main purpose was to obtain:

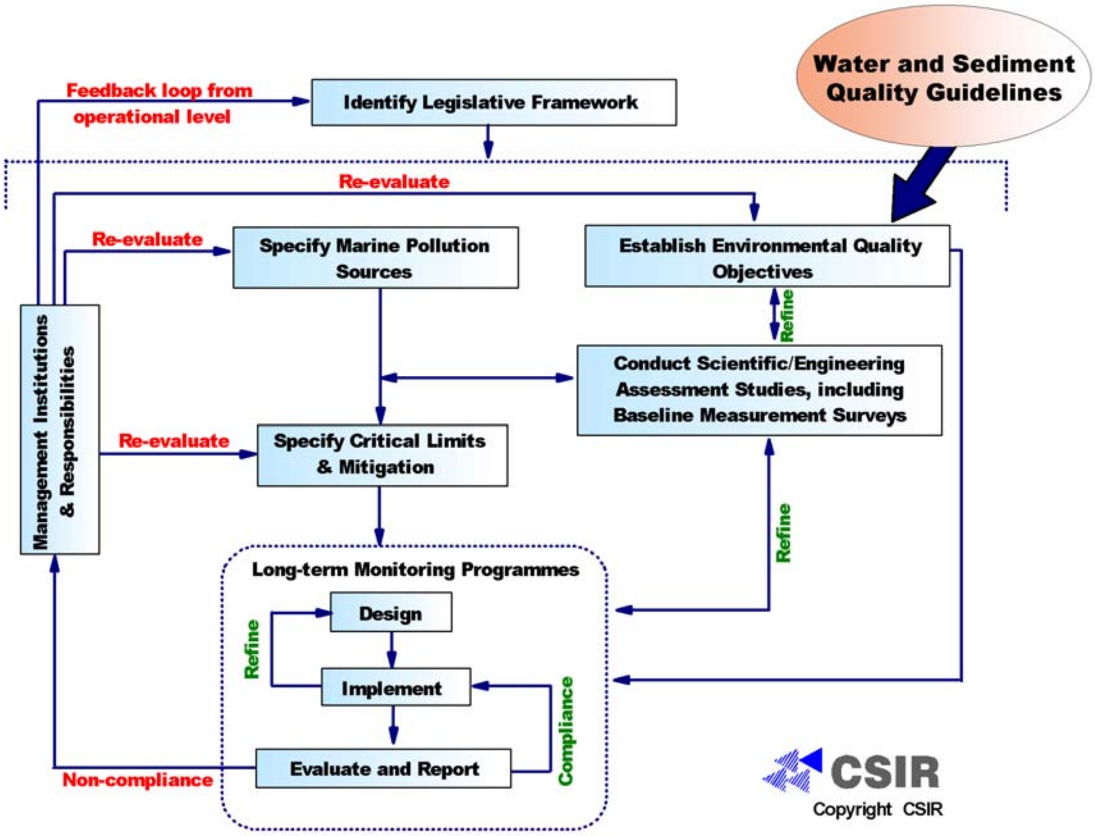
- A set of recommended water and sediment quality guidelines for a range of biogeochemical and microbiological quality variables, in order to sustain natural ecosystem functioning, as well as to support designated beneficial uses, in coastal areas of the BCLME region
- Best Practice Protocols for the implementation (or application) of these quality guidelines in the management of the coastal areas in the BCLME region.

An important secondary objective was to get acceptance from key stakeholders in the three countries on the proposed guidelines and protocols. This was achieved through work sessions and training workshops held in each of the three countries to which key stakeholders were invited. The outputs from this project were also incorporated into an updatable web-based information system (temporary web address: www.wamsys.co.za/bclme).

The ultimate goal in marine water quality management is to keep the marine environment suitable (or fit) for all designated uses. To achieve this goal, the quality objectives set for a particular marine environment should be aimed at protecting the biodiversity and functioning of marine aquatic ecosystems, as well as designated uses of the marine environment (also referred to as beneficial uses). It is proposed that three designated uses of marine waters be recognised for the BCLME region, namely:

- Marine aquaculture (including collection of seafood for human consumption)
- Recreational use
- Industrial uses.

The recommended water and sediment quality guidelines, as part of this section, provide guidance to managers, local governing authorities and scientists to set site-specific environmental quality objectives within a study area for the protection of marine aquatic ecosystems and other designated uses. Therefore, in the larger integrated and ecosystem-based framework, within which marine water quality is managed, water and sediment quality guidelines play a major role in setting environmental quality objectives, as illustrated below:



Below is a summary of the constituent categories for which recommended water and sediment quality are provided for different designated uses as part of this study:

TYPE OF QUALITY GUIDELINE		MARINE AQUATIC ECOSYSTEMS	MARINE AQUACULTURE	RECREATION	INDUSTRIAL USES
Water	Objectionable Matter/ Aesthetics	Yes	Refer to Marine Aquatic Ecosystem Guidelines	Yes	Based on site-specific requirements of industrial use in the area
	Physico-chemical variables	Yes		Refer to Drinking Water Guidelines	
	Nutrients	Yes			
	Toxic substances	Yes			
	Microbiological indicators	-	Yes	Yes	
	Tainting substances	-	Yes	-	
Sediment	Toxic Substances	Yes	Refer to Marine Aquatic Ecosystem Guidelines	-	

As a rule of thumb, it is recommended that the following simple application rules apply:

1. Compliance with quality guideline values for the *Protection of marine aquatic ecosystems* should be aimed at in all coastal waters, except in approved sacrificial zones, e.g. near wastewater discharges and certain areas within harbours.

2. In addition to (1), the classification system recommended for *Marine aquaculture* should be applied in areas where shellfish are collected or cultured for human consumption so as to manage human health risks. The assumption is that the health of the organisms is catered for under the *Protection of Marine Aquatic Ecosystems* (referring to 1).

3. In addition to (1), the aesthetic quality guidelines, as well as the classification system ranking waters in terms of human health risks for *Recreational use,* should be applied in related areas. With reference to toxic substances, it is recommended that suitable *Drinking water quality guidelines* be consulted to make preliminary risk assessments, where these substances are expected to present at levels that could pose a risk to human health (following the example of the WHO, 2003).

4. In addition to (1), site specific water quality guidelines, based on the requirements of local *Industries,* should be applied, where and if applicable.

The recommended quality guidelines and protocols for implementation, as listed below, have been drawn from a review of international water and sediment quality guidelines. As information is developed further for specific conditions in the BCLME region, these may be modified, following the principle of adaptive management.

Recommended Water and Sediment Quality Guidelines: Protection of Marine Aquatic Ecosystems

Water quality guidelines for the protection of aquatic ecosystems are recommended for the following constituent categories:

- Objectionable matter
- Physico-chemical variables
- Nutrients
- Toxic substances.

Sediment quality guideline values are generally specified only for the protection of aquatic ecosystems, in particular for toxic substances.

Recommended water quality guidelines for objectionable matter (aesthetic):

PROPOSED GUIDELINE
Water should not contain litter, floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance. Water should not contain materials from non-natural land-based sources which will settle to form objectionable deposits. Water should not contain submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use. Water should not contain substances producing objectionable colour, odour, taste, or turbidity.

Recommended water quality guidelines for physico-chemical variables:

VARIABLE	PROPOSED WATER QUALITY GUIDELINE
Temperature	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value should be determined as the range defined by the 20%ile and 80%ile of the seasonal distribution for the reference system. Test data: Median concentration for the period
Salinity	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value should be determined as the 20%ile or 80%ile of the reference system(s) distribution, depending upon whether low salinity or high salinity effects are being considered. Test data: Median concentration for the period
pH	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value range should be determined as the range defined by the 20%ile and 80%ile of the seasonal distribution for the reference system. pH changes of more than 0.5 pH unit from the seasonal maximum or minimum defined by the reference systems should be fully investigated. Test data: Median concentration for the period
Turbidity Suspended solids	Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline values should be determined as the 80%ile of the reference system(s) distribution. Additionally, the natural euphotic depth (Z_{eu}) should not be permitted to change by more than 10%. Test data: Median concentration for period
Dissolved oxygen	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value should be determined as the 20%ile of the reference system(s) distribution. Where possible, the guideline value should be obtained during low flow and high temperature periods when DO concentrations are likely to be at their lowest. Test data: Median DO concentration for the period, calculated using the lowest diurnal DO concentrations.

Recommended water quality guidelines for nutrients:

VARIABLE	PROPOSED WATER QUALITY GUIDELINE
Chlorophyll a	Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80%ile of the reference system(s) distribution.
Nutrients	Nutrient concentrations in the water column should not result in chlorophyll a, turbidity and/or dissolved oxygen levels that are outside the recommended water quality guideline range (see above). This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, nutrient concentrations can be derived using the Reference system data approach: Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80%ile of the reference system(s) distribution.

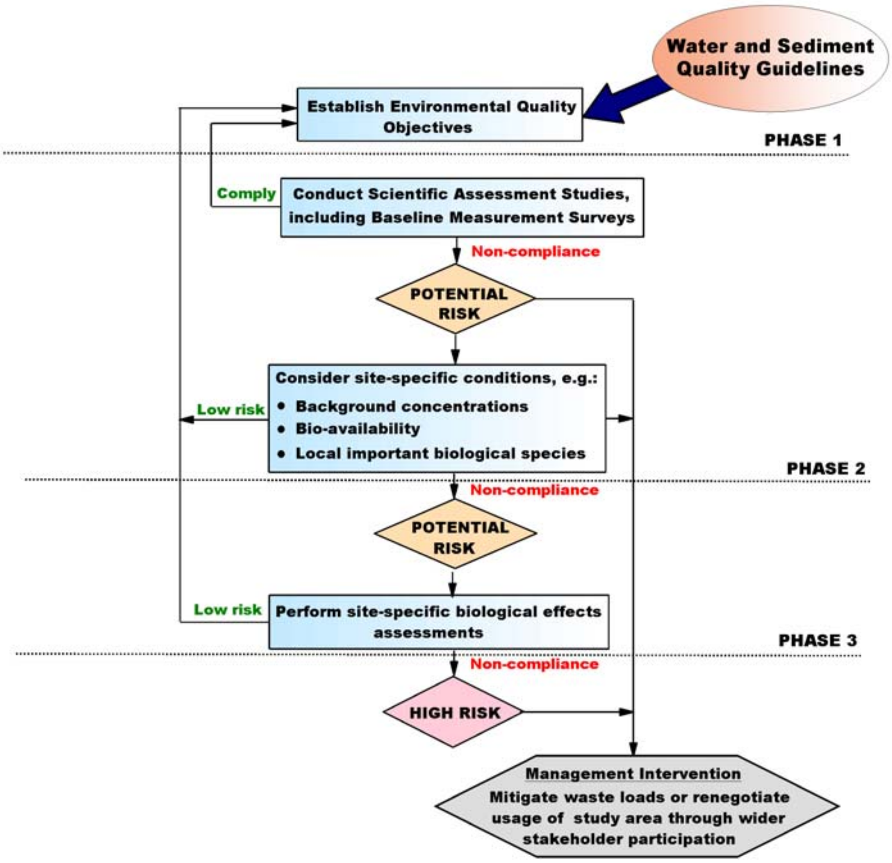
Recommended water quality guidelines for toxic substances:

TOXIC SUBSTANCES	RECOMMENDED GUIDELINE VALUE in µg/ℓ
Total Ammonia-N	910
Total Residual Chlorine-Cl	3
Cyanide (CN^-)	4
Fluoride(F^-)	5 000
Sulfides (S^-)	1
Phenol	400
Polychlorinated Biphenyls (PCBs)	0.03*
Trace metals (as Total metal):	
Arsenic	As(III) - 2.3; As(V) - 4.5
Cadmium	5.5
Chromium	Cr (III) - 10; Cr (VI) - 4.4
Cobalt	1
Copper	1.3
Lead	4.4
Mercury	0.4
Nickel	70
Silver	1.4
Sn (as Tributyltin)	0.006
Vanadium	100
Zinc	15
Aromatic Hydrocarbons (C6-C9 simple hydrocarbons - volatile):	
Benzene (C6)	500
Toluene (C7)	180
Ethylbenzene (C8)	5
Xylene (C8)	Ortho - 350; Para - 75; Meta - 200
Naphthalene (C9)	70
Poly-Aromatic Hydrocarbons (< C15 - acute toxicity with short half-life in water)	
Anthracene (C14)	0.4
Phenanthrene (C14)	4
Poly-Aromatic Hydrocarbons (> C15, chronic toxicity, with longer half-life in water)	
Fluoranthene (C15)	1.7
Benzo(a)pyrene (C20)	0.4
Pesticides:	
DDT	0.001
Dieldrin	0.002
Endrin	0.002

Recommended sediment quality guidelines for toxic substances:

TOXIC SUBSTANCES	RECOMMENDED GUIDELINE VALUE	PROBABLE EFFECT CONCENTRATION
TRACE METALS (mg/kg dry weight)		
Antimony	-	-
Arsenic	7.24	41.6
Cadmium	0.68	4.21
Chromium	52.3	160
Copper	18.7	108
Lead	30.2	112
Mercury	0.13	0.7
Nickel	15.9	42.8
Silver	0.73	1.77
Tin as Tributyltin-Sn	0.005	0.07
Zinc	124	271
TOXIC ORGANIC COMPOUNDS (µg/kg dry weight normalized to 1% organic carbon)		
Total PAHs	1684	16770
Low Molecular PAHs	312	1442
Acenaphthene	6.71	88.9
Acenaphthalene	44	640
Anthracene	46.9	245
Fluorene	21.2	144
2-methyl naphthalene	-	-
Naphthalene	34.6	391
Phenanthrene	86.7	544
High Molecular Weight PAHs	655	6676
Benzo(a)anthracene	74.8	693
Benzo(a) pyrene	88.8	763
Dibenzo(a,h)anthracene	6.22	135
Chrysene	108	846
Fluoranthene	113	1494
Pyrene	153	1398
Toxaphene	-	-
Total DDT	3.89	51.7
p p DDE	2.2	27
Chlordane	2.26	4.79
Dieldrin	0.72	4.3
Total PCBs	21.6	189

Recommended water and sediment quality guidelines for the protection of marine aquatic ecosystems should be applied as benchmarks, following a risk assessment or phased approach as illustrated below:



Where scientific assessment studies or monitoring results reveal that recommended quality guideline values are exceeded, this should trigger the incorporation of additional information or further investigation to determine whether or not a real risk to the ecosystem exists, and, where necessary, to adjust the guideline values for site-specific conditions.

Quality guideline values should be compared with the median of the measured or simulated data set. Where a guideline value was based on professional judgement, the rationale for the selection of such a value should be provided and a process should be put in place whereby the adopted value is reviewed and supported or modified in light of emerging information, following the principle of adaptive management.

Recommended Water and Sediment Quality Guidelines: Marine Aquaculture

In terms of water quality guidelines for marine aquaculture (including the collection and harvesting of living stock for human consumption), the following are important considerations:

- Protection of the health of the aquatic ecosystem so as to ensure sustainable production and quality of products
- Protection of the health of human consumers
- Tainting of seafood products.

With reference to the protection of aquatic organisms used in the culture and harvesting of seafood, it is recommended that the water quality guidelines proposed for the *Protection of aquatic ecosystems* be applied, rather than developing a separate series of quality guidelines.

With reference to the protection of human consumers, it is proposed that the allowable limits of toxic substances and human pathogens in food products be controlled through legislation.

In terms of shellfish growing areas, microbiological recommended water quality guidelines aimed at mitigating human health risks are as follows:

INDICATOR	PROPOSED WATER QUALITY GUIDELINE
Faecal coliform	Median concentrations should not exceed 14 Most Probable Number (MPN) per 100 ml with not more than 10% of the samples exceeding 43 MPN per 100 ml for a 5-tube, 3-dilution method.

Estimated threshold concentrations for tainting substances are listed below:

TAINTING SUBSTANCE	THRESHOLD CONCENTRATIONS ABOVE WHICH TAINTING IS LIKELY TO OCCUR (mg/ℓ)
Acenaphthene	0.02
Acetophenone	0.5
Acrylonitrile	18
Copper	1
m-cresol	0.2
o-cresol	0.4
p-cresol	0.12
Cresylic acids (meta, para)	0.2
Chlorobenzene	-
n-butylmercaptan	0.06
o-sec. butylphenol	0.3
p-tert. butylphenol	0.03
2-chlorophenol	0.001
3-chlorophenol	0.001
3-chlorophenol	0.001
o-chlorophenol	0.001
p-chlorophenol	0.01
2,3-dinitrophenol	0.08
2,4,6-trinitrophenol	0.002
2,3 dichlorophenol	0.00004
2,4-dichlorophenol	0.001
2,5-dichlorophenol	0.023
2,6-dichlorophenol	0.035
3,4-dichlorophenol	0.0003

TAINTING SUBSTANCE	THRESHOLD CONCENTRATIONS ABOVE WHICH TAINTING IS LIKELY TO OCCUR (mg/ℓ)
2-methyl-4-chlorophenol	0.75
2-methyl-6-cholorophenol	0.003
3-methyl-4-chlorophenol	0.02 – 3
o-phenylphenol	1
Pentachlorophenol	0.03
Phenol	1
2,3,4,6-tetrachlorophenol	0.001
2,4,5-trichlorophenol	0.001
2,3,5-trichlorophenol	0.001
2,4,6-trichlorophenol	0.003
2,4-dimethylphenol	0.4
Dimethylamine	7
Diphenyloxide	0.05
B,B-dichlorodiethyl ether	0.09
o-dichlorobenzene	< 0.25
p-dichlorobenzene	0.25
Ethylbenzene	0.25
Momochlorobenzene	0.02
Ethanethiol	0.24
Ethylacrylate	0.6
Formaldehyde	95
Gasoline/Petrol	0.005
Guaicol	0.082
Kerosene	0.1
Kerosene plus kaolin	1
Hexachlorocyclopentadiene	0.001
Isopropylbenzene	0.25
Naphtha	0.1
Naphthalene	1
Naphthol	0.5
2-Naphthol	0.3
Nitrobenzene	0.03
a-methylstyrene	0.25
Oil, emulsifiable	15
Pyridine	5
Pyrocatechol	0.8
Pyrogallol	0.5
Quinoline	0.5
p-quinone	0.5
Styrene	0.25
Toluene	0.25
Outboard motor fuel as exhaust	0.5
Zinc	5

It is recommended that a classification system for shellfish growing areas be adopted for the BCLME region and that a dedicated task team be convened to decide on the final approach for the classification system. In the interim, it is recommended that the classification be based on the results for Sanitary Surveys that consist of:

- Identification and evaluation of all potential and actual pollution sources (Shoreline Survey)
- Monitoring of growing waters and shellfish to determine the most suitable classification for the shellfish harvesting area (Bacteriological Survey).

The recommended classification system for the BCLME region that is provided is as follows:

CLASS	DESCRIPTION
Approved	Approved areas need to be free from pollution and shellfish from such areas are suitable for direct human consumption of raw shellfish.
Conditionally approved/restricted	Where areas are subjected to limited, intermittent pollution caused by discharges from wastewater treatment facilities, seasonal populations, non-point source pollution, or boating activity, they can be classified as conditionally approved or conditional ly restricted. However, it must be shown that the shellfish harvesting area will be open for the purposes of harvesting shellfish for a reasonable period of time and the factors determining this period are known, predictable and are not so complex as to preclude a reasonable management approach. When 'open' for shellfish harvesting for direct human consumption, the water quality in the area must comply with the limits as specified for 'Approved' area. When 'closed' for direct consumption but 'open' to harvesting for relaying or depuration, the requirements of 'Restricted' area must be met. At times when the area is 'closed' for all harvesting, then the requirements of 'Prohibited Areas' apply.
Restricted	Restricted areas are subject to a limited degree of pollution. However, the level of faecal pollution, human pathogens and toxic or deleterious substances are at such a level) that shellfish can be made fit for human consumption by either relaying or depuration.
Prohibited	An area is classified as 'Prohibited' for shellfish harvesting if no comprehensive survey has been conducted or where a survey finds that the area is: • adjacent to a sewage treatment plant outfall or other point source outfall with public health significance • contaminated by (an) unpredictable pollution source(s) • contaminated with faecal waste so that the shellfish may be vectors for disease micro-organisms • affected by algae which contain biotoxin(s) sufficient to cause a public health risk • contaminated with poisonous or deleterious substances whereby the quality of shellfish may be affected. NOTE: Where an event such as a flood, storm or marine biotoxin outbreak occurs in either 'Approved' or 'Restricted' areas, these can also be classified as temporarily 'Prohibited' area.

Requirements associated with each class in the recommended (interim) classification system are:

CLASS	REQUIREMENTS
Approved	A sanitation survey must be completed according to specification and be reviewed annually. The area shall not be contaminated with faecal coliform (as listed) and shall not contain pathogens or hazardous concentrations of toxic substances or marine biotoxins (an approved shellfish growing area may be temporarily made a prohibited area, e.g. when a flood, storm or marine biotoxin event occurs). Evidence of potential pollution sources such as sewage lift station overflows, direct sewage discharges, septic tank seepage, etc., is sufficient to exclude the growing waters from the approved category. Faecal coliform median/geometric mean of water sample results must not exceed 14/100 ml and the estimated 90th percentile must not exceed 21/100 ml (using Membrane Filtration) or 14/100 ml and the estimated 90th percentile must not exceed 43/100 ml for a 5-tube decimal dilution test, or 49/100 ml for a 3-tube decimal dilution test (using Most Probable Number [MPN]). Total coliform median/geometric mean of water sample results must not exceed 70/100 ml and the estimated 90th percentile must not exceed 230/100 ml for a 5-tube decimal dilution test, or 330/100 ml for a 3-tube decimal dilution test (using MPN).
Conditionally approved/restricted	Factors determining this period are known, predictable and are not so complex as to preclude a reasonable management approach. A management plan must be developed for every conditionally approved/restricted area. When 'open' for shellfish harvesting for direct human consumption, the water quality in the area must comply with the limits as specified for 'Approved' area. When 'closed' for direct consumption but 'open' to harvesting for relaying or depuration, the requirements of 'Restricted' area must be met. At times when the area is 'closed' for all harvesting, then the requirements of 'Prohibited Areas' apply.
Restricted	Faecal coliform median/geometric mean of water sample results must not exceed 70/100 ml and the estimated 90th percentile must not exceed 85/100 ml (using Membrane Filtration) or 88/100 ml and the estimated 90th percentile must not exceed 260/100 ml for a 5-tube decimal dilution test, or 300/100 ml for a 3-tube decimal dilution test (using MPN). Total coliform median/geometric mean of water sample results must not exceed 700/100 ml and the estimated 90th percentile must not exceed 2300/100 ml for a 5-tube decimal dilution test, or 3300/100 ml for a 3-tube decimal dilution test (using MPN).
Prohibited area	No requirements specified.

It is, however, recommended that a dedicated task team, consisting of marine aquaculture specialists and responsible authorities from the different countries in the BCLME region, be convened to decide on the final approach to the classification of shellfish growing areas in the region. This process has already been initiated as part of another project in the BCLME Programme (Project EV/HAB/04/Shellsan – Development of a shellfish sanitation programme model for application in consort with the microalgal toxins component).

Recommended Water and Sediment Quality Guidelines: Recreation

In terms of water quality, the following key aspects are important in relation to recreational use of coastal waters:

- Aesthetics
- Protection of human health relating to toxic substances
- Protection of human health relating to microbiological contaminants.

For recreational areas, the water quality guidelines related to aesthetics are similar to those listed under *objectionable matter* in the *Protection of Marine Aquatic Ecosystems (see above).*

With reference to toxic substances, it is recommended that suitable *Drinking water quality guidelines* be consulted to make preliminary risk assessments in areas where these substances are expected to be present at levels that pose a risk to human health.

As for microbiological indicators, it is recommended that both *E. coli* and Enterococci (faecal streptococci) be used as indicator organisms. It is also recommended that instead of using 'single' target values that classify a beach as either 'safe' or 'unsafe', a range of target values be derived corresponding to different levels of risk:

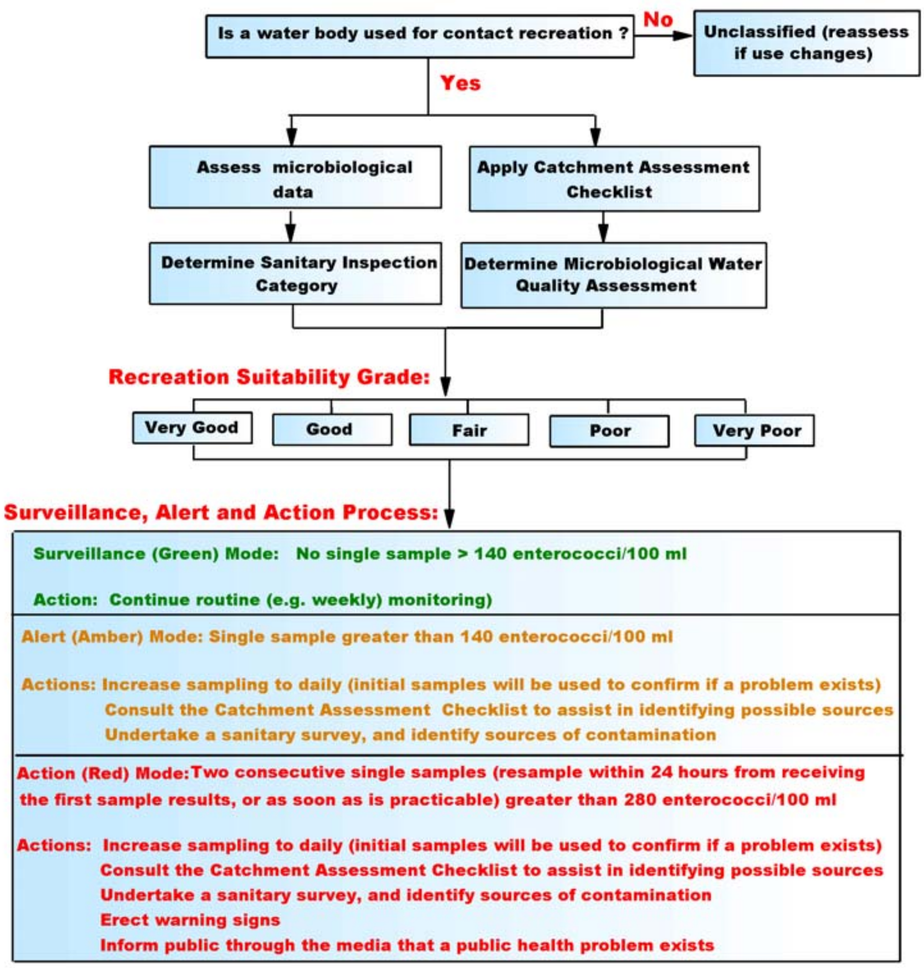
CATEGORY	95th PERCENTILE OF ENTEROCOCCI per 100 ml*	ESTIMATED RISK PER EXPOSURE
A	<40	<1% gastrointestinal (GI)illness risk <0.3% acute febrile respiratory (AFRI) risk
B	40 – 200	1–5% GI illness risk 0.3–1.9% AFRI risk
C	201 – 500	5–10% GI illness risk 1.9–3.9% AFRI risk
D	> 500	>10% GI illness risk >3.9% AFRI risk

It is recommended that the BCLME region adopt a beach classification system, rather than the traditional approach of classifying recreational waters as either safe or unsafe. With reference to water quality, the classification should be based on both a sanitary survey as well as routine microbiological surveys. The classification rating should be re-evaluated on an annual basis.

Recommended classification system for recreational areas:

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="5">Microbiological Quality Assessment Category
(95th percentile enterococci/100 ml – see Table above)</td></tr>
<tr><td>A
(<40)</td><td>B
(41-200)</td><td>C
(201-500)</td><td>D
(>500)</td><td>Exceptional circumstances</td></tr>
<tr><td rowspan="6">Sanitary Inspection Category</td><td>Very Low</td><td>Very good</td><td>Very good</td><td>Fair</td><td>Follow-up</td><td rowspan="5">Action</td></tr>
<tr><td>Low</td><td>Very good</td><td>Good</td><td>Fair</td><td>Follow-up</td></tr>
<tr><td>Moderate</td><td>Good</td><td>Good</td><td>Fair</td><td>Poor</td></tr>
<tr><td>High</td><td>Good</td><td>Fair</td><td>Poor</td><td>Very poor</td></tr>
<tr><td>Very high</td><td>Follow-up</td><td>Fair</td><td>Poor</td><td>Very poor</td></tr>
<tr><td>Exceptional circumstances</td><td colspan="5">Action</td></tr>
</table>

The implementation of the classification system, as well as the proposed day-to-day management system, is schematically illustrated below:



The Way Forward

- The recommended guidelines still need to be **officially approved and adopted** by responsible authorities in each of the three countries. It is recommended that the output of this project be used as a starting point for such initiatives.

- The quality guidelines and protocols developed as part of this project form an **integral part of the management framework for land-based marine pollution sources** (developed as part of another BCLME project – BEHP/LBMP/03/01).

  In the interim, until such time as a management framework and quality guidelines have been incorporated in official government policy, it is proposed that the quality guidelines developed as part of this project, together with the proposed management framework, be applied as preliminary tools towards improving the management of the water quality in coastal areas of the BCLME region.

- As part of the official water and sediment quality guidelines to be adopted in each of the three countries, it is recommended that the preferred **analytical methods** for the different chemical and microbiological variables also be included.

- The **updatable web-based information system** (temporary web address www.wamsys.co.za/bclme) that was developed as part of this project can be a very useful decision-support and educational tool provided that it is maintained and updated regularly. In the short to medium term, it is recommended that one or more of the BCLME offices within the three countries takes on this responsibility.

- To facilitate wider capacity building in the BCLME region of the management of marine pollution in coastal areas, it is strongly recommended that the output of this project be included in a **training course**. In this regard, the *Train-Sea-Coast/Benguela Course Development Unit* is considered the ideal platform from which to develop and present such training (www.ioisa.org.za/tsc/index.htm).

RESUMO EXECUTIVO

(LINHAS MESTRAS RECOMENDADAS PARA A QUALIDADE DA ÁGUA E SEDIMENTOS PARA DA REGIÃO DO BCLME EM SUMÁRIO)

o Gabinete das Nações Unidas Para Prestação de Serviços "UNOPS") contratou o CSIR (África do Sul) para executar este projecto, cujo objectivo principal era o de obter:

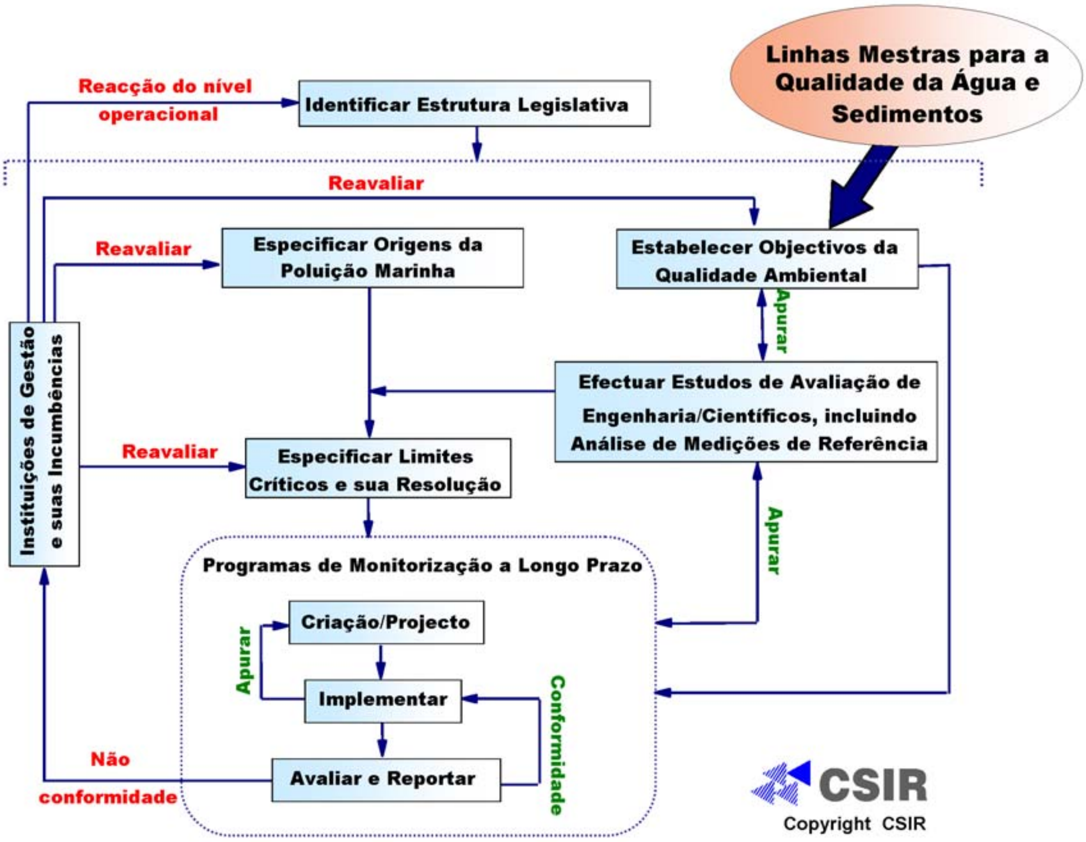
- Um conjunto de linhas mestras sobre qualidade da água e sedimentos para uma gama de variáveis de qualidade biogeoquímicas e microbiológicas, de modo a sustentar o funcionamento de um ecossistema natural, assim como apoiar os usuários nas áreas costeiras da região do BCLME.
- Protocolos de Boa Prática para a implementação (ou aplicação) destas linhas mestras no que se refere à gestão das áreas costeiras na região do BCLME.

O objectivo secundario de relevo foi a aceitação pelos "stakeholders" dos três paises das linhas mestras propostas e dos protocolos. Isto foi levado a efeito atravéz das sessões de trabalhos e "workshops"de treino nos tres paises aos quais os mesmos "stakeholders" foram convidados. Os productos deste projecto foram integrados num sistema informatico da "web" que poderá ser actualizado (endereço web temporário: www.wamsys.co.za/bclme).

O objectivo primario na gestão da qualidade da água marinha é o de manter o ambiente marinho adequado (ou saudável) para todos os usos apontados. Para atingir este fim, os objectivos estabelecidos para um ambiente marinho em particular devem apontar para a protecção à biodiversidade e funcionamento dos ecosistemas aquático-marinhos, bem como para os usos designados do ambiente marinho (também referidos como usos de benefício). É proposto que três usuários para a região do BCLME sejam reconhecidos a saber:

- Aquacultura marinha (incluindo recolha de marisco para consumo humano)
- Uso recreativo
- Usos industriais

As linhas mestras sobre qualidade de água e sedimentos recomendadas, como parte desta secção, fornecem orientações aos gestores, autoridades de governo locais e cientistas de modo a definirem objectivos de qualidade ambiental específicos numa área de estudo para a protecção dos ecossistemas aquático- marinhos e outros usos designados. Consequentemente, nos grandes sistemas integrados e ecossistemas onde a qualidade da água do mar é gerida, as linhas mestras da qualidade da água e sedimentos desempenham um papel importante na implementação dos objectivos da qualidade ambiental como ilustrado abaixo:



Indica-se abaixo um resumo das categorias constituintes para as quais a qualidade da água e sedimentos recomendadas, são fornecidos para diferentes usuários como parte do presente estudo:

TIPO DE LINHAS MESTRAS PARA A QUALIDADE DE ÁGUA		**ECOSISTEMAS AQUÁTICO MARINHOS**	**AQUACULTURA MARINHA**	**RECREAÇÃO**	**FINS INDUSTRIAIS**
Água	Matéria objectável /Estética	Sim	Refere-se a orientações do ecossistema aquático-marinho	Sim	Baseado em requisitos específicos de fins industriais na zona
	Variáveis físico-químicas	Sim		Refere-se a orientações para água potável	
	Nutrientes	Sim			
	Substâncias tóxicas	Sim			
	Indicações microbiológicas	-	Sim	Sim	
	Substâncias contaminantes	-	Sim	-	
Sedimentos	Substâncias tóxicas	Sim	Refere-se a orientações do ecossistema aquático-marinho	-	

Como regras básicas, recomenda-se que sejam aplicadas as seguintes regras simples:

1. A conformidade com os valores orientativos de qualidade para Protecção dos ecosistemas aquático-marinhos deve ser um dos objectivos em todas as águas costeiras, excepto em certas zonas já aprovadas, ou seja, junto a áreas de descarga de águas residuais e certas áreas junto aos portos.
2. Adicionalmente ao ponto (1), a classificação do sistema recomendado para aquacultura marinha deve ser aplicada em áreas onde existe recolha de marisco ou em cultivo para consumo humano, de modo a gerir os riscos de saúde para o ser humano. Assume-se que a condição sanitária dos organismos é devidamente tida em conta, ao abrigo da *Protecção dos Ecosistemas Aquático-marinhos* (referindo ponto 1).
3. Adicionalmente ao ponto (1), as linhas mestras de qualidade estética, bem como o sistema de classificação que categorizam as águas para uso de recriação relativamente aos riscos de saúde para o ser humano devem ser aplicadas nas respectivas áreas. Quanto a substâncias tóxicas, recomenda-se a consulta das *Linhas mestras para qualidade de água potável*, a fim de ser efectuada uma análise de risco preliminar, onde se espera que tais substâncias apresentem níveis que possam colocar a saúde pública em risco (seguindo o exemplo da OMS [WHO, 2003]).
4. Em adição ao ponto (1), as orientações da qualidade específica da água, baseada nos requisitos das indústrias locais, devem ser usadas sempre que aplicáveis.

As orientações e protocolos de qualidade recomendados para implementação, como se indica abaixo, foram criadas a partir de uma revisão de orientações para a qualidade da água e sedimentos a nível internacional. Uma vez que a informação se desenvolve a partir de condições específicas na região do BCLME, podem as mesmas ser alteradas, seguindo o princípio de gestão adaptável.

Linhas Mestras Recomendadas para a Qualidade da Água e Sedimentos: Protecção dos Ecosistemas Aquático-Marinhos

São recomendadas as seguintes orientações de qualidade para a água dos ecosistemas, dentro das várias áreas:

- Matéria objectável
- Variáveis físico-químicas
- Nutrientes
- Substâncias tóxicas.

Os valores da qualidade de sedimentos são normalmente especificados apenas para a protecção de ecosistemas aquáticos, em particular para <u>substâncias tóxicas</u>.

Linhas mestras recomendadas para a qualidade da água no que respeita a matéria objectável (estética):

DIRECTRIZ PROPOSTA
A água não deve conter lixos, partículas de matérias flutuantes, detritos, óleo, gordura, cera, escuma, espuma ou materiais e resíduos flutuantes similares provenientes de fontes terrestres em concentrações que poderão causar incómodos. A água não deverá conter materiais provenientes de fontes terrestres não naturais os quais assentarão para formar depósitos objectáveis. A água não deverá conter objectos submersos e outros riscos na subsuperfície que sejam de origem não natural e os quais podem constituir perigo, causar riscos ou interferir com qualquer uso designado/reconhecido. A água não deverá conter substâncias produtoras de cor, odor, sabor ou turvação objectáveis.

Linhas mestras recomendadas para a qualidade da água no que respeita a variáveis físico-químicas:

VARIÁVEL	DIRECTRIZ PROPOSTA PARA A QUALIDADE DE ÁGUA
Temperatura	Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição sazonal para o sistema de referência. Teste de dados: Concentração mediana (ou média) para o período.
Salinidade	Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição do(s) sistema(s) de referência, dependendo se os efeitos de baixa ou alta salinidade estão a ser considerados. Teste de dados: Concentração mediana (ou média) para o período.
pH	Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição do(s) sistema(s) de referência Mudanças de pH superiores a 0.5 unidades de pH do máximo ou mínimo sazonal definidos pelos sistemas de referência deverão ser investigados por inteiro. Teste de dados: Concentração mediana (ou média) para o período
Turvação Sólidos suspensos	Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição do(s) sistema(s) de referência Adicionalmente, não deve ser permitido mudar a profundidade natural (Z_{eu}) em mais de 10%. Teste de dados: Concentração mediana (ou média) para o período
Oxigénio dissolvido	Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição do(s) sistema(s) de referência. Quando possível o valor directriz deverá ser obtido durante períodos de baixa corrente e alta temperatura quando as concentrações de OD têm maior probabilidade de

VARIÁVEL	DIRECTRIZ PROPOSTA PARA A QUALIDADE DE ÁGUA
	apresentar os seus valores mais baixos. Teste de dados: Concentração mediana de OD para o período, calculada, usando as concentrações diurnas mais baixas de OD

Linhas mestras recomendadas para a qualidade da água no que respeita a nutrientes:

VARIÁVEL	DIRECTRIZ PROPOSTA PARA A QUALIDADE DE ÁGUA
Clorofila a	Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição do(s) sistema(s) de referência.
Nutrientes	Concentrações de nutrientes na coluna de água não devem resultar em clorofila a, turvidade e/ou níveis de oxigénio dissolvido fora do intervalo recomendado na directriz de qualidade de água (ver acima). Tal deverá ser estabelecido utilizando técnicas de modelagem estatísticas ou matemáticas apropriadas. Em alternativa, onde uma abordagem de modelação pode ser difícil de implementar, a concentração de nutrientes pode ser derivada utilizando uma abordagem de sistema de dados Referenciais: Quando um sistema ou sistemas de referência apropriados estão disponíveis, e existem dados suficientes para o sistema de referência, o valor directriz da distribuição sazonal deverá ser definido pelo valor de 20% e 80% da distribuição do(s) sistema(s) de referência.

Linhas mestras recomendadas para a qualidade da água no que respeita a susbtâncias tóxicas:

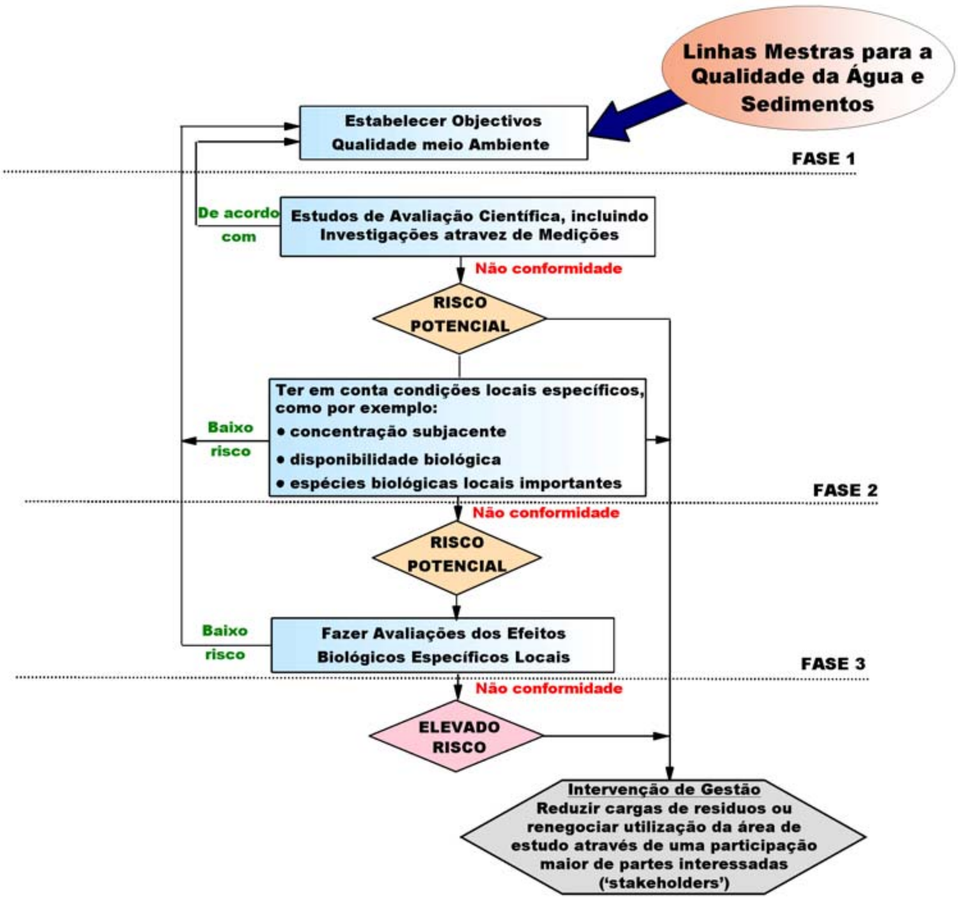
SUBSTÂNCIAS	VALOR DIRECTRIZ RECOMENDADO em µg/ℓ
Total Amoníaco-N	910
Total Residual Cloro-Cl	3
Cianeto (CN^-)	4
Fluoreto(F^-)	5 000
Sulfuro (S^-)	1
Fenol	400
Poli Cloretos *Biphenyls* (PCBs)	0.03
Vestígios metálicos (em metal Total):	
Arsénico	As(III) - 2.3; As(V) - 4.5
Cádmio	5.5
Crómio	Cr (III) - 10; Cr (VI) - 4.4
Cobalto	1
Cobre	1.3
Chumbo	4.4
Mercúrio	0.4
Níquel	70
Prata	1.4
Sn (tal como *Tributyltin)*	0.006
Vanádio	100
Zínco	15
Hidrocarbonetos Aromáticos (C6-C9 hidrocarbonetos simples - volátil):	
Benzeno (C6)	500
Toluene (C7)	180
Etilbenzeno (C8)	5
Xylene (C8)	Ortho - 350; Para - 75; Meta - 200
Naftaleno (C9)	70
Hidrocarbonetos Poli-Aromáticos (< C15 – toxicidade elevada com baixa duração de vida em água)	
Antraceno (C14)	0.4
Fenantreno (C14)	

SUBSTÂNCIAS	VALOR DIRECTRIZ RECOMENDADO em µg/ℓ
Hidrocarbonetos Poli-Aromáticos (> C15, toxicidade crónica, com maior duração de vida na água)	
Fluoranteno (C15)	1.7
Benzo(a) pireno (C20)	0.4
Pesticidas:	
DDT	0.001
Dieldrina	0.002
Endrina	0.002

Linhas mestras recomendadas para a qualidade dos sedimentos no que respeita a substâncias tóxicas:

SUBSTÂNCIAS TÓXICAS	VALOR DE DIRECTRIZ RECOMENDADO	EFEITO DE CONCENTRAÇÃO PROVÁVEL
VESTÍGIOS METÁLICOS (mg/kg peso em seco)		
Antimónio	-	-
Arsénico	7.24	41.6
Cádmio	0.68	4.21
Crómio	52.3	160
Cobre	18.7	108
Chumbo	30.2	112
Mercúrio	0.13	0.7
Níquel	15.9	42.8
Prata	0.73	1.77
Estanho tal como *Tributyltin*-Sn	0.005	0.07
Zínco	124	271
COMPOSTOS ORGÂNICOS TÓXICOS (µg/kg peso seco normalizado para 1% carvão orgânico)		
Total PAHs	1684	16770
Baixo Valor Molecular PAHs	312	1442
Acenafteno	6.71	88.9
Acenaftaleno	44	640
Antraceno	46.9	245
Fluoreto	21.2	144
2-metilo naftaleno	-	-
Naftaleno	34.6	391
Fenantreno	86.7	544
Alto Peso Molecular PAHs	655	6676
Benzo(a) antraceno	74.8	693
Benzo(a) pireno	88.8	763
Dibenzo(a,h)antraceno	6.22	135
Criseno	108	846
Fluoranteno	113	1494
Pireno	153	1398
Toxofilo	-	-
Total DDT	3.89	51.7
p p DDE	2.2	27
Cloreto	2.26	4.79
Dieldrina	0.72	4.3
Total PCBs	21.6	189

As linhas mestras recomendadas para a qualidade da água e sedimentos para protecção dos ecossistemas aquático - marinhos devem ser aplicados como referências, no seguimento de uma avaliação de risco ou aproximação por fases, como ilustrado abaixo:



Sempre que os estudos de avaliação científica ou os resultados da verificação revelem que os valores de qualidade recomendados são excedidos, dever-se á produzir informação suplementar ou efectuar-se mais investigação, a fim de determinar se existe ou não um factor de risco real para o ecossistema e, sempre que necessário, ajustar esses valores para condições locais específicas.

Os valores de qualidade orientativos devem ser comparados com os dados medidos ou simulados. Se um valor orientativo tiver tido por base um julgamento profissional, a fundamentação lógica para a selecção desse valor deve ser fornecida e deve ser implementado um processo, onde o valor adoptado seja revisto e apoiado ou modificado, à luz da informação ora emergente, seguindo o princípio de gestão adaptável.

Linhas mestras recomendadas para a qualidade da água e sedimentos: aquacultura marinha

No que diz respeito às orientações da qualidade da água para aquacultura marinha (incluindo a recolha de seres vivos para consumo humano), estas são considerações importantes:

- Protecção do estado de saúde do ecosistema aquático, de modo a assegurar uma produção sustentável e produtos de qualidade
- Protecção do estado de saúde dos consumidores humanos
- Contaminação de marisco.

Fazendo referência à protecção de organismos aquáticos utilizados na cultura e recolha de pescado, recomenda-se que as orientações da qualidade da água propostas para a *Protecção dos ecosistemas aquáticos* sejam aplicadas, em vez de recorrer a uma série de orientações separadas.

Quanto à protecção dos consumidores humanos, propõe-se que os limites admitidos de substâncias tóxicas e micróbios patogénicos em produtos alimentares sejam controlados através de legislação.

No que concerne as áreas de crescimento de marisco, as orientações microbiológicas recomendadas procuram reduzir os riscos de saúde humano como se indica:

INDICADOR	DIRECTRIZ PROPOSTA PARA A QUALIDADE DE ÁGUA
Coliforme fecal	Concentrações medianas não deverão exceder 14 Número Mais Provável (NMP) por 100 ml com não mais de 10% das amostras a exceder 43 NMP por 100 ml por um tubo de 5, método de diluição 3.

Concentrações limite estimadas para substâncias contaminadoras são dadas abaixo:

SUBSTÂNCIA CONTAMINADORA	LIMIARES DE CONCENTRAÇÕES ACIMA DOS QUAIS A CONTAMINAÇÃO É PROVÁVEL ACONTECER (mg/ℓ)
Acenafeteno	0.02
Acetofenona	0.5
Acrilonitrilo	18
Cobre	1
m-cresol	0.2
o-cresol	0.4
p-cresol	0.12
Ácidos cresílicos (meta, para)	0.2
Clorobenzina	-
n-butilmercaptano	0.06

SUBSTÂNCIA CONTAMINADORA	LIMIARES DE CONCENTRAÇÕES ACIMA DOS QUAIS A CONTAMINAÇÃO É PROVÁVEL ACONTECER (mg/ℓ)
o-sec. butilfenol	0.3
p-tert. butilfenol	0.03
2-clorofenol	0.001
3- clorofenol	0.001
3- clorofenol	0.001
o- clorofenol	0.001
p- clorofenol	0.01
2,3-dinitrofenol	0.08
2,4,6-trinitrofenol	0.002
2,3 diclorofenol	0.00004
2,4-diclorofenol	0.001
2,5- diclorofenol	0.023
2,6- diclorofenol	0.035
3,4- diclorofenol	0.0003
2-metil-4-clorofenol	0.75
2-metil-6-clorofenol	0.003
3-metil-4-clorofenol	0.02 – 3
o-fenifenol	1
Pentaclorofenol	0.03
Fenol	1
2,3,4,6-tetraclorofenol	0.001
2,4,5-triclorofenol	0.001
2,3,5-triclorofenol	0.001
2,4,6-tricorofenol	0.003
2,4-dimetilfenol	0.4
Dimetilamina	7
Difenilóxido	0.05
B,B-diclorodietil éter	0.09
o-diclorobenzeno	< 0.25
p-diclorobenzeno	0.25
Etilbenzeno	0.25
Momoclorobenzeno	0.02
Etanatiol	0.24
Etilacrilato	0.6
Formaldeide	95
Gasolina	0.005
Guaicol	0.082
Querosene	0.1
Querosene plus caolín	1
Hexaclorociclopentadieno	0.001
Isopropilbenzeno	0.25
Nafta	0.1
Naftaleno	1
Naftol	0.5
2-Naftol	0.3
Nitrobenzeno	0.03
a-metilestireno	0.25
Óleo, emulsificável	15
Piridino	5
Pirocatecol	0.8
Pirogalol	0.5
Quinolino	0.5
p-quinona	0.5
Estireno	0.25
Tolueno	0.25
Combustão de fuel em motores fora de bordo	0.5
Zinco	5

Recomenda-se que seja adoptado pela região do BCLME um sistema de classificação para as áreas de crescimento de marisco e que um grupo de trabalho dedicado seja nomeado, a fim de tomar decisões quanto à abordagem final a ter no que respeita ao sistema de classificação. Neste entretanto, recomenda-se que essa classificação assente nos resultados das Análises Sanitárias, que consistem em:

- Identificação e avaliação de todas as origens potenciais e reais de poluição (investigação costeira)
- Avaliação de águas em crescimento e marisco para determinar a classificação mais adequada para as áreas de recolha de marisco (Análise bacteriológica).

O sistema de classificação recomendado para a região do BCLME é a seguinte:

CLASSE	DESCRIÇÃO
Aprovado	As áreas aprovadas devem estar isentas de poluição e o marisco daí oriundo é próprio para consumo humano directo de marisco em cru.
Aprovado condicionalmente /restringido	Nas áreas sujeitas ou limitadas a poluição intermitente causada por descargas de tratamentos de águas residuais, populações sazonais, poluição não identificada, ou actividades náuticas, podem ser classificadas como "aprovadas condicionalmente" e/ou restringidas. No entanto, deve ser elucidado que a área de recolha e apanha do marisco estará aberta para a apanha de marisco durante um período de tempo razoável e que os factores que determinam este período são conhecidos, previsíveis e não são complexos ao ponto de ir contra uma gestão razoável. Quando "abertas" para a apanha de marisco para consume humano directo, a qualidade da água na área deve estar de acordo com os limites tal como especificados para "Áreas aprovadas". Quando "fechadas" para consumo directo, mas "abertas" para a apanha devido a reposição ou depuração, devem ser cumpridos os requisitos de "Área restringida". Alturas há em que a área está "fechada" para qualquer tipo de recolha e nesse caso aplicar-se-ão os requisitos de "Áreas proibidas".
Restringido	As áreas restringidas estão sujeitas a um grau de poluição limitado. No entanto, o nível de poluição fecal, micróbios patogénicos humanos e substâncias tóxicas ou perniciosas atingem um tal nível que o marisco pode estar bom para consumo humano, ou por recolocação ou por depuração.
Proibido	Uma área é classificada como "Proibida" se não tiver sido efectuada uma análise profunda ou sempre que uma análise verifique a existência de: • Unidade adjacente de tratamentos de águas residuais ou outra origem semelhante com repercussões significativas na saúde pública • Contaminação devido a causas de poluição imprevisíveis • Contaminação por restos fecais, fazendo com que o marisco seja vector de doenças micro-orgânicas • Algas que contenham biotoxinas suficientes para causar risco de saúde pública • Contaminação com substâncias venenosas ou nocivas que possam afectar o marisco. NOTA: Quando ocorrer uma cheia, tempestade ou contaminação marítima por biotoxinas em áreas "Aprovadas" ou "Restringidas", estas podem ser também classificas temporariamente como áreas "Proibidas".

Os requisitos associados a cada classe nos sistemas de classificação recomendados (no entretanto) são:

CLASSE	REQUISITOS
Aprovado	Deve ser feita um levantamento sanitário de fundo, segundo as especificações, a qual deve ser revista anualmente. A área não deve estar contaminada com resíduos fecais coliformes (como listados) e não deve ter micróbios patogénicos ou concentrações perigosas de substâncias tóxicas ou biotoxinas marinhas (uma área de marisco aprovada pode ser temporariamente declarada "área proibida" quando, por ex., houver cheias, tempestades ou contaminação por biotoxinas). A evidência de causas de poluição potencial, tais como provenientes de estações de tratamentos de esgotos, descargas de esgotos directas, de tanques sépticos, etc, é mais do que razão para excluir qualquer área da categoria de "aprovado". Os resultados das amostras de coliformes fecais medianas/geométricas não devem exceder os 14/100 ml e o percentil 90 estimado não deve ser superior a 21/100 ml (usando Membrana de Filtragem) ou 14/100 ml e o percentil 90 estimado não deve ser superior a 43/100ml para um ensaio de diluição decimal a-5-tubos, ou 49/100 ml para um ensaio de diluição decimal a-3-tubos (usando Número Mais Provável (MPN)).
Aprovado condicionalmente /restringido	Os factores que determinam este período são conhecidos e não são tão complexos ao ponto de impossibilitar uma abordagem de gestão razoável. Deve ser desenvolvido um plano de gestão para cada área condicionalmente aprovada/restringida. Quando "abertas" para a apanha de marisco para consume humano directo, a qualidade da água na área deve estar de acordo com os limites tal como especificados para "Áreas aprovadas". Quando "fechadas" para consumo directo, mas "abertas" para a apanha devido a reposição ou depuração, devem ser cumpridos os requisitos de "Área restringida". Alturas há em que a área está "fechada" para qualquer tipo de recolha e nesse caso aplicar-se-ão os requisitos de "Áreas proibidas".
Restringido	Os resultados das amostras de coliformes fecais medianos/geométricos não devem exceder 70/100 ml e o percentil 90 estimado não deve ser superior a 85/100 ml (usando Membrana de Filtragem) ou 881/00 ml e o percentil 90 estimado não deve ser superior a 260/100 ml para um ensaio de diluição decimal a-5-tubos, ou 300/100 ml para um ensaio de diluição decimal a-3-tubos (usando Número Mais Provável (MPN)). Os resultados das amostras de coliformes fecais medianos/geométricos não devem exceder 700/100 ml e o percentil 90 estimado não deve ser superior s 2300/100 ml para um ensaio de deluição decimal a-5-tubos, ou 3300/100 para um ensaio de diluição decimal a-3-tubos (usando Número Mais Provável (MPN)).
Área proibida	Sem requisitos especificados

Contudo, recomenda-se que uma equipa técnica, formada por especialistas em aquacultura e autoridades responsáveis dos diferentes países na região do BCLME, seja formada para decidir no tipo de abordagem final para a classificação das áreas de cultivo de marisco nesta região. Este processo foi já iniciado, como parte de um outro Programa do BCLME (Projecto EV/HAB/04/Shellsan - Development of a shellfish sanitation – *Desenvolvimento de cuidados sanitários para cultivo de marisco*), um modelo de aplicação em conjunto com componente de toxinas de microalgas.

Linhas mestras recomendadas para a qualidade da água e sedimentos: actividades de recreio

Em termos de qualidade da água, os pontos chave seguintes são importantes no que se refere à utilização recreativa das águas costeiras:

- Estética
- Protecção da saúde pública face a substâncias tóxicas
- Protecção da saúde pública face a contaminantes microbiológicos.

Para áreas de recreio, as orientações da qualidade da água que se prendem com o aspecto estético são semelhantes às apresentadas na lista sob o título *matérias objectáveis*, em *Protecção dos ecosistemas aquático-marinhos* (ver acima).

Quanto a substâncias tóxicas, recomenda-se a consulta das *orientações para a qualidade da água potável*, de modo a fazer-se uma avaliação preliminar dos riscos nas áreas onde tais substâncias podem apresentar-se a níveis que ponham em causa a saúde pública.

Quanto a indicadores microbiológicos, recomenda-se que tanto o *E.coli* e o Enterococci (faecal streptococci) sejam usados como organismos indicadores. Recomenda-se, por outro lado, que em vez de utilizar valores-alvo "singulares" que classifiquem uma praia de "segura" ou "não segura", seja feita uma derivativa de valores-alvo que correspondam a níveis de risco diferentes:

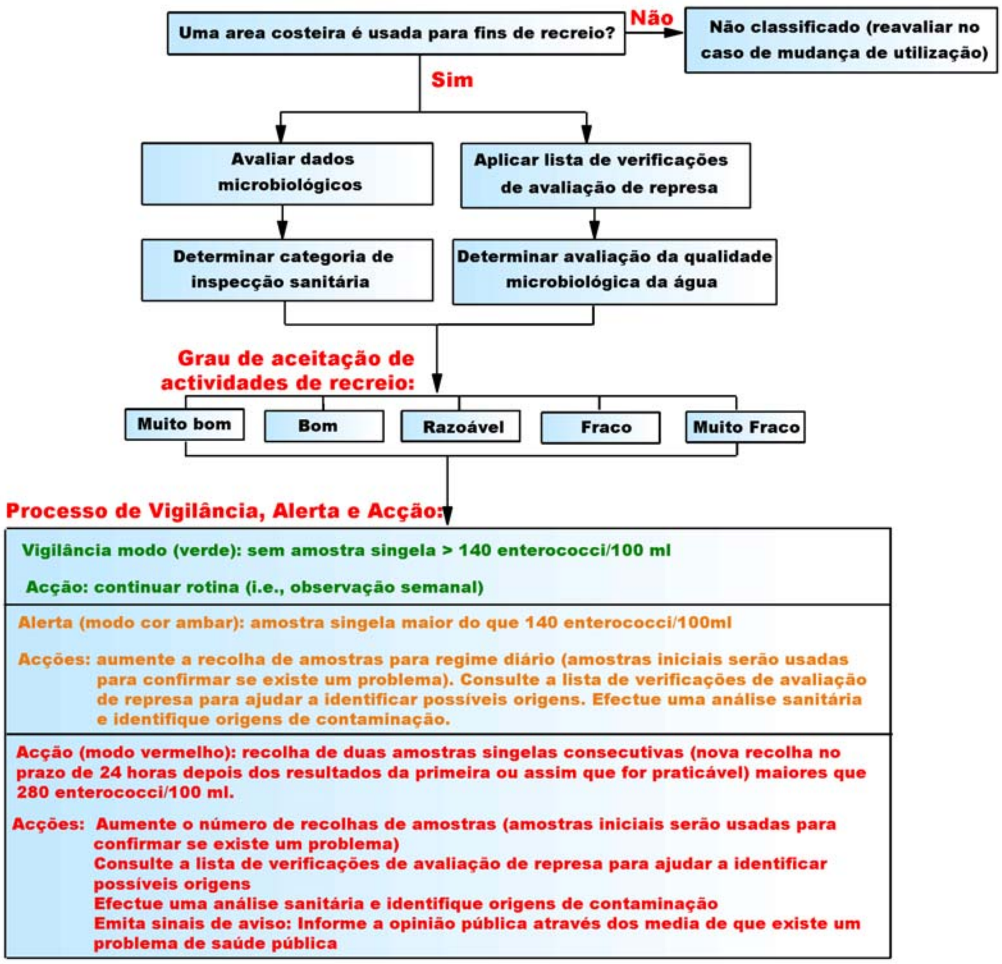
CATEGORIA	95° PERCENTIL DE ENTEROCOCCI por 100 ml	RISCO ESTIMADO POR EXPOSIÇÃO
A	<40	<1% risco de doença gastrointestinal (GI) <0.3% risco de febre respiratória aguda (AFRI)
B	40 – 200	1–5% risco de doença GI 0.3–1.9% risco de AFRI
C	201 – 500	5–10% risco de doença GI 1.9–3.9% risco de AFRI
D	> 500	>10% risco de doença GI >3.9% risco de AFRI

Recomenda-se que a região do BCLME adopte um sistema de classificação de praias em vez de fazer a abordagem tradicional de classificação de águas para a prática de actividades de recreio como sendo seguras ou não seguras. Reportando-nos à qualidade da água, a classificação deve ser baseada tanto na análise sanitária como nas análises microbiológicas de rotina. O índice de classificação deve ser reavaliado anualmente.

Sistema de classificação recomendado para áreas de recreio:

		Categoria de Avaliação Qualidade Microbiológica (percentile 95 enterococci/100 ml – ver Tabela acima de)				
		A (<40)	B (41-200)	C (201-500)	D (>500)	Circunstâncias excepcionais
Categoria de Inspecção sanitária	Muito baixa	Muito boa	Muito boa	Razoável	A seguir	Acção
	Baixa	Muito boa	Boa	Razoável	A seguir	
	Moderada	Boa	Boa	Razoável	Fraca	
	Alta	Boa	Razoável	Fraca	Muito fraca	
	Muito alta	A seguir	Razoável	Fraca	Muito fraca	
	Circunstâncias excepcionais	Acção				

A implementação do sistema de classificação, bem como do sistema de gestão dia-a-dia proposto, é esquematizado abaixo:



O caminho a seguir

- As linhas mestras recomendadas necessitam todavia de serem **oficialmente aprovadas e adoptadas** pelas autoridades responsáveis em cada um dos três países. Recomenda-se que o resultado deste projecto seja usado como ponto de partida de tais iniciativas.

- As linhas mestras de qualidade e protocolos desenvolvidos como fazendo parte deste projecto formam parte integral da estrutura de gestão das origens da poluição marinha (concebido como parte de um outro projecto BCLME - o **BEHP/LBMP/03/01).**

- Neste entretanto, até que a estrutura de gestão e as orientações de qualidade tenham sido incorporadas na política oficial do governo, propõe-se que essas linhas mestras concebidas como parte do projecto, em conjunto com a estrutura de gestão proposta, sejam aplicadas como ferramentas preliminares com vista à melhoria da gestão da qualidade da água nas áreas costeiras da região do BCLME.

- Como parte das orientações oficiais da qualidade da água e sedimentos a serem adoptadas em cada um dos três países, recomenda-se que também sejam incluídos os **métodos analíticos** de eleição para as diferentes variáveis químicas e microbiológicas.

- O **sistema de informação actualizável com suporte na Internet** (endereço web temporário: www.wamsys.co.za/bclme) criado como parte deste projecto pode ser útil para apoiar a tomada de decisão e como ferramenta educativa, desde que mantido e actualizado com regularidade. A curto e médio prazo, recomenda-se que um ou mais escritórios do BCLME no âmbito dos três países seja por esse facto responsável.

- A fim de facilitar uma maior e mais vasta capacidade de construção no seio da região do BCLME no que respeita à gestão da poluição marinha nas áreas costeiras, é fortemente recomendado que os resultados deste projecto sejam incluídos num **curso de formação**. Assim sendo, a Unidade de Desenvolvimento do Curso (*Train-Sea-Coast/Benguela Course Development Unit)* é tido como a plataforma ideal para desenvolver e a presentar essa formação (www.ioisa.org.za/tsc/index.htm).

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ACRONYMS, SYMBOLS AND ABBREVIATIONS

ACR	Acute-Chronic Ratio
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZFA	Australia New Zealand Food Authority
AQUIRE	Aquatic Toxicity Information Retrieval Database
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASSAC	Australian Shellfish Sanitation Advisory Committee
AWRC	Australian Water Resources Council
BCF	Bio-Concentration Factor
BCLME	Benguela Current Large Marine Ecosystem
BOD	Biochemical Oxygen Demand
CCC	Criteria Continuous Concentration
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
CEC	Council of European Community
CF	Conversion Factor
CMC	Criteria Maximum Concentration
COD	Chemical Oxygen Demand
CWA	Clean Water Act, United States
DEAT	Department of Environmental Affairs and Tourism (South Africa)
DWAF	Department of Water Affairs and Forestry (South Africa)
EC	European Community
EC_{50}	Effective concentration the dosage at which the desired response is present for 50 % of the population
EqP	Equilibrium Partitioning
ERL	Effect Range Low
ERM	Effect Range Median
FEE	Foundation for Environmental Education
IRIS	Integrated Risk Information System
LC_{50}	Concentration that is lethal to 50% of the test organisms
LOEC	Lowest Observable Effects Concentration

MAF	Ministry of Agriculture and Fisheries (New Zealand)
MATC	Maximum Acceptable Toxicant Concentration
MHSPE	Ministry for Housing, Spatial Planning and Environment, Netherlands
NHMRC	National Health and Medical Research Council (Australia)
NOAA	National Oceanic and Atmospheric Administration (United States)
NOEC	No Observable Effect Concentration
NSSP	National Shellfish Sanitation Program
PAH	Polyaromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEL	Probable Effect Level
OECD	Organisation for Economic Co-Operation and Development
RSA	Republic of South Africa
SQG	Sediment Quality Guidelines
TEL	Threshold Effect Level
UNEP	United Nations Environmental Program
US-EPA	United States Environmental Protection Agency
US-FDA	United States Food and Drug Administration
WQG	Water Quality Guideline
WHO	World Health Organisation
WRc	Water Research Centre

INTRODUCTION

1. SCOPE OF WORK

The United Nations Office for Project Services ("UNOPS”) commissioned the CSIR (South Africa) to develop a common set of quality guidelines for the coastal areas in the BCLME region.

The main purpose of this project is to obtain:

- A set of recommended water and sediment quality guidelines for a range of biogeochemical and microbiological quality variables, in order to sustain natural ecosystem functioning, as well as to support designated beneficial uses, in coastal areas of the BCLME region
- Best Practice Protocols for the implementation (or application) of these quality guidelines in the management of the coastal areas in the BCLME region.

The above were achieved through a critical review of:

- International and national water and sediment quality guidelines and their applicability to the BCLME region, as well as the approach and methodology followed in setting such guidelines
- International best practice in terms of the implementation of quality guidelines in the management of coastal areas.

In the **Introduction** to this Report, the *Scope of Work* (Chapter 1) is followed by a chapter on the *Project Approach and Methodology* (Chapter 2), providing an overview of the standing and role of quality guidelines, as well as the approach that was followed in developing the recommended water and sediment quality guidelines for the BCLME region. Chapter 3 (*Current Status in the BCLME Region*) provides an overview of existing practices in the countries within the BCLME region.

The critical reviews of international sediment and quality guidelines are provided in Sections 1 to 6):

- **Section 1:** International review on water quality guidelines for the protection of marine aquatic ecosystems
- **Section 2**: International review on sediment quality guidelines for the protection of marine aquatic ecosystems

- **Section 3:** International review on water quality guidelines for Marine Aquaculture
- **Section 4**: International review on water quality guidelines for Recreation
- **Section 5:** International review on water quality guidelines for Industrial use

Each of these sections provides an overview of the approach and methodology that were used by different countries in the development of quality guidelines, as well as an overview of international implementation practices. The preferred approach and methodology for the BCLME regions, as well as the preferred implementation practices, are also substantiated in each of these sections.

Section 6 provides an overview of the recommended quality guidelines and recommended protocols for implementation proposed for the coastal zone in the BCLME region.

Appendices to this Report contain the following:

- **Appendix A**: Summary of International Marine Water Quality Guideline Values for the Protection of Marine Aquatic Ecosystems
- **Appendix B**: Summary of International Sediment Quality Guideline Values for the Protection of Marine Aquatic Ecosystems
- **Appendix C**: Summary of International Marine Water Quality Guideline Values for Marine Aquaculture.
- **Appendix D**: User Manual for the Web-based Information System (temporary web address: www.wamsys.co.za.

2. PROJECT APPROACH AND METHODOLOGY

The ultimate goal in the management of marine (coastal) water resources is to keep the environment suitable for all designated uses – both existing and future uses (this includes the 'use' of designated areas for biodiversity protection and ecosystem functioning).

Such uses can usually only be maintained if the aquatic marine ecosystem is also protected from degradation. In turn, the integrity of aquatic marine ecosystems depends on a number of factors, including:

- *Water and sediment quality* (referring to the biogeochemical status)

- Water flows (referring to river inflows)
- Physical habitat (referring to water circulation processes, sediment type and climatic conditions)
- Availability of suitable migrations or recruitment routes
- Food web integrity and availability.

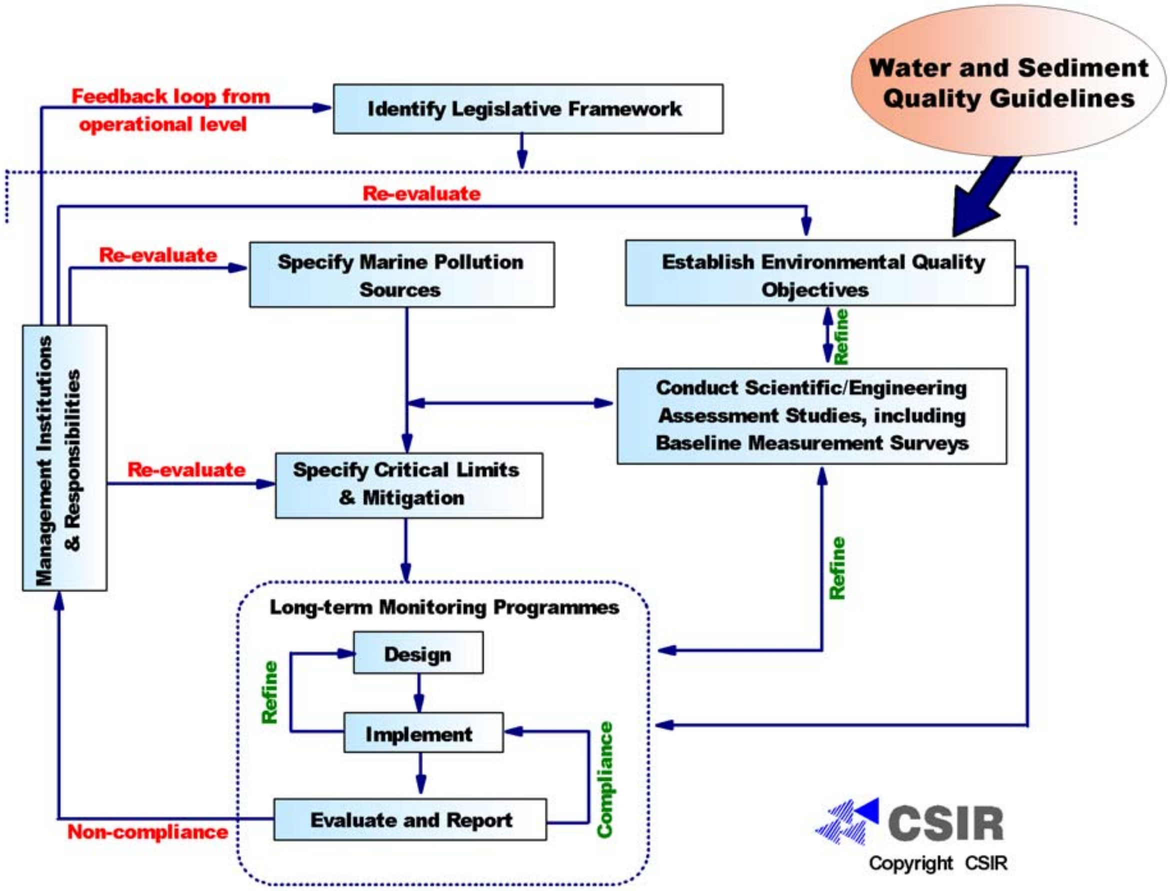
Important uses of coastal waters that also rely on suitable water quality are, for example, recreation and marine aquaculture. However, it should be noted that water quality is but one of numerous factors that influences suitability. For example, the suitability of coastal areas for recreation is also influenced by:

- Beach safety
- Climatic conditions (cold, heat and sunlight)
- Contamination of beach sand
- Dangerous aquatic organisms.

Therefore, in order to effectively manage coastal marine ecosystems so that they remain suitable for designated use, measurable targets or objectives should be set for each of the above-mentioned parameters. In this regard, water and sediment quality guidelines are developed to provide guidance to managers and local governing authorities in setting site-specific *quality objectives* for *water and sediment quality*, where such parameters are identified as being of potential concern.

A water (or sediment) quality guideline is a numerical concentration limit or narrative statement that is recommended for the support and maintenance of a designated water use. *They are not standards* (i.e. legally enforceable values), and should not be regarded as such.

Within the larger management framework for marine pollution, water and sediment quality guidelines are therefore typically used to assist in the derivation of site-specific environmental quality objectives for a particular study area, as illustrated below:



This above-mentioned framework is discussed in detail in another BCLME project, namely, Baseline Assessment of Sources and Management of Land-based Marine Pollution in the BCLME Region (Project BEHP/LBMP/03/01).

NOTE:

***Environmental Quality objectives** are the specific quality targets agreed among stakeholders, or set by local jurisdictions. They are based on water and sediment quality guidelines but may be modified by other inputs, such as social, cultural, economic or political constraints. The relative importance placed on the quality guidelines and these other, potentially very important but less tangible, considerations would be site-specific, and therefore would be determined on a case by case basis. Quality objectives are therefore established at a local level to protect and support the designated uses, and against them performance can be measured. The site-specific objectives may be adopted into legislation to become standards.*

It is very important to realise that the existence of national (or regional) quality guidelines does not imply that environmental quality should be degraded to those levels. A continuous effort should be made to ensure that coastal marine resources are of the highest attainable quality, taking into account principles such as:

- Precautionary approach
- Pollution prevention
- Waste minimisation
- Recycling and re-use
- Best available or best attainable technologies.

NOTE: Difference between uniform effluent standards and water quality guidelines

The Uniform Effluent Standard Approach has been followed extensively throughout the world to manage and control waste discharges, particularly from land. Uniform effluent standards are legally enforceable limits to which waste stream or effluents must comply prior to discharging into a water resource. These uniform limits were applied widely and did not necessarily take into account the assimilative capacity of the receiving water environment (particularly with reference to physico-chemical variables, nutrients and other naturally occurring chemicals such as trace metals) or cumulative and synergistic effects related to other marine pollution sources in a particular area.

Also, when such uniform effluent limits were applied to a discharge into calm, near-stagnant water bodies they could have been insufficient to adequately protect the marine environment and its uses while, when applied to a discharge into dynamic, well-flushed water bodies, such limits could have been too stringent.

The World Bank's General Environmental Emission Guidelines (World Bank Group, 1998), for example, fall within the 'uniform effluent ' category, in that they specify emission limits.

To address these shortfalls[one word], many countries adopted the Receiving Water Quality Objectives Approach, in which, in short, the physical, chemical and biological processes and uses of a particular (receiving) water resource dictate the 'limits of discharge'. In turn, this approach led to the development of national (or regional) water and sediment quality guidelines so as to assist managers and local governing authorities in setting objectives for water and sediment quality in a particular area.

The Receiving Water Quality Approach (and the use of quality guidelines) does not mean that standards can no longer be set for waste or effluent discharges, but rather that these standards are determined by the physical, chemical and biological processes and assimilative capacity of the receiving water resource, as well as its designated uses.

Uniform effluent standards also still have a role, particularly in terms of controlling the discharge of hazardous chemicals that bio-accumulate in the environment with severe adverse effects on aquatic ecosystems. These standards are usually based on best available (or best attainable) technologies in the treatment of waste and are enforced for particular industry types so as to pressurise industries to apply such technologies (e.g. the World Bank provides emission guidelines related to specific industries – World Bank Group, 2004).

In the European Union, in addition to setting water and sediment quality guidelines for hazardous substances, uniform effluent standards are also enforced for a number of hazardous chemicals, i.e. priority substances (CEC, 2000).

For the purposes of this project, the marine water and sediment quality guidelines from the following countries or organisations, considered to be the global leaders in this regard, were included in the critical review:

- Australia & New Zealand
- United States of America
- European Community
- Canada
- World Health Organisation
- South Africa.

The World Bank Environmental Guidelines are not discussed as part this study, as these are emission guidelines and do not directly apply to the receiving environment (World Bank Group, 2004).

3. CURRENT STATUS IN BCLME REGION

As far as could be established, within in the BCLME region, only South Africa currently has an official set of *Water quality guidelines for coastal marine waters* (DWAF, 1995b). None of the three countries in the region, however, has official *Sediment quality guidelines for the coastal region*.

In 1991, South Africa's Department of Water Affairs and Forestry (DWAF) published the *Water quality management policies and strategies in the RSA* (RSA DWAF, 1991). These were further elaborated in *Procedures to assess effluent discharge impacts*, published in 1995 (RSA DWAF 1995a) and are currently being updated (RSA DWAF, 2002). These policies and strategies changed the DWAF's approach to water quality management from the Uniform Effluent Standard approach (i.e. enforcing compliance to *General and Special Standard*) to the Receiving Water Quality Objectives approach. As the department is also being responsible for the management and control of land-based wastewater discharges to the marine environment, it commissioned a project to determine *South African Water Quality Guidelines for Coastal Marine Waters* (RSA DWAF, 1995b). This was done in consultation with marine scientists and other relevant government departments, e.g. Department of Environmental Affairs and Tourism (DEAT).

The documents provide guidance on setting water quality target values for the protection of the natural marine environment, as well as for designated beneficial uses of marine waters that, in the case of South Africa, are subdivided into three categories, namely:

- Marine aquaculture (including collection of seafood for human consumption)
- Recreational use
- Industrial uses (e.g. taking in cooling water and water for fish processing and/or marine aquaculture).

The recommended target values in the 1995 version are still largely based on the initial set of values that was drawn up by an ad hoc working committee back in 1984 (Lusher, 1984). In 1992, the Water Research Commission convened a two-day workshop to review these guidelines. This workshop was attended by a broad spectrum of representatives from the scientific/engineering community, national and local authorities, industries and environmental organisations. In essence, the group found that most of the guidelines recommended in 1984 still constituted the best suitable ones for South Africa, taking into account the absence of any new local information on such matters (DWAF, 1992). Therefore, although the 1995 set of documents (RSA DWAF, 1995b) provides extensive background information necessary for the application of water quality guidelines, the recommended target values for different variables are essentially still the same as those proposed in 1984 (Lusher, 1984; RSA DWAF, 1992).

Namibia is in the process of revising its legislation and policies with regard to disposal of land-derived wastewater to the marine environment. In most instances, the Uniform Effluent Standard approach, requiring compliance to *General Standards* issued under the Water Act 54 of 1956, is still being used (Mr Roland Roeis, Department of Water Affairs, Namibia, pers. comm.).

In terms of quality requirements related to marine aquaculture, Namibia is in the process of designing a shellfish sanitation programme that will satisfy both the European Union as well as the United States Food and Drug Association (US FDA) requirements (Bronwen Currie, Ministry of Fisheries and Marine Resources, Namibia, pers. comm.).

In Angola, international legislation is used for managing the quality of water intended for human consumption, in particular the European Commission's Council Directive 98/83/EC. This directive includes guidelines provided by the World Health Organisation.

The Biological and Aquatic Resources Act (adopted in October 2004) to some extent also includes aquaculture and quality of marine products - Lei 6-A/04 (Maria Paulina Paulo & Domingas Paim, Angola, pers. comm.). The law sets out the principles and objectives of the use of biological and aquatic resources, the regulations governing fishing and the granting of fishing rights, special rules for the protection of aquatic resources and ecosystems, regulations on fishing vessels and ports, scientific research, the monitoring of resources and the licensing of fish processing and marketing establishments, as well as control and management, activities harmful to resources and ecosystems, and procedures for dealing with breaches of the law (www.un.int/angola/newsletter13.htm).

SECTION 1.
INTERNATIONAL REVIEW - WATER QUALITY GUIDELINES FOR PROTECTION OF MARINE AQUATIC ECOSYSTEMS

1.1 INTRODUCTION

Water quality guidelines for the protection of marine aquatic ecosystems from the following countries and regions were included in the review.

i. Australia and New Zealand

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000) provide comprehensive information and procedures for setting water guideline values. In the case of these two countries, water quality guideline values are defined as the concentration of biogeochemical variables below which there is a low risk that adverse biological effects will occur.

NOTE:

To assist regional groups in setting environmental values and water quality targets for their catchments/region, Water Quality Targets: A Handbook was published by Environment Australia in 2002 (www.deh.gov.au/water/quality/targets/handbook/) . The handbook outlines the steps to be followed in setting default targets derived from the published guidelines in The Australian and New Zealand Guidelines for Fresh and Marine Water Quality. When used in conjunction with Water Quality Targets: On Line (www.ea.gov.au/water/quality/targets), this handbook simplifies the task of setting water quality targets. It is not prescriptive and is intended as a tool for assisting the planning process.

ii. United States of America

The United States Environmental Protection Agency (US-EPA) compiled national recommended water quality criteria for the protection of aquatic ecosystems as required under Section 304(a) of the Clean Water Act (CWA) (US-EPA, 1986a; 2001; 2002a). Their criteria provide guidance to States and Tribes in adopting their own water quality standards under Section 303(c) of the CWA.

The US-EPA water quality guidelines, or criteria as they are referred to, are extensive. Unlike, for example, Australia and New Zealand where an approach and methodology for the derivation of target values are specified for different categories of variables - e.g. physico-chemical variables, nutrients and toxic substances, the US-EPA lists a Federal Register citation, a US-EPA document number or an Integrated Risk Information System (IRIS) entry (www.epa.gov/iris/index.html) for each variable. Therefore, the information pertinent to the derivation of individual criteria is very extensive. Relevant information on a single variable may even be captured in more than one document. Within the constraints (time and resources) of this project, it was not possible to distill the approach and methodology used in deriving criteria for each and every variable listed in their guideline document. However, where a generic approach and methodology have been provided for a category of variables (e.g. trace metals), these are discussed in further detail.

The US-EPA does, however, follow a generic process when developing new criteria for a specific variable or re-assessing an existing criterion, which is as follows (US-EPA, 1999):

- Undertake a comprehensive review of available data and information
- Publish a notice in the *Federal Register* and on the Internet announcing its assessment or reassessment of the pollutant for public comment
- Utilise information obtained from the review and the public to develop draft recommended water quality criteria
- Conduct peer review of the draft criteria as well as publish a notice in the *Federal Register* and on the Internet of the availability of the draft water quality criteria and solicit public comment
- Prepare a response document for the record
- Revise the draft criteria as necessary, and announce the availability of the final water quality criteria in the *Federal Register* and on the Internet.

ii. Canada

In 1987, the Canadian Council of Resource and Environment Ministers (CCREM) published the Canadian *Water* Quality Guidelines (CCREM, 1987). In 1999, the Canadian Council of Ministers of the Environment published the Canadian *Environmental* Quality Guidelines, which integrated national environmental quality guidelines for all environmental media, including water (drinking water, recreational water, water for aquatic life, irrigation water, and livestock water), soil (agricultural, residential/ parkland, commercial, and industrial land uses), sediment, tissue residue (for wildlife consumers of aquatic biota), and air (for human health, vegetation, animals, materials, and aesthetic atmospheric properties) (CCME, 1999b). The Canadian protocol for the derivation of water quality guidelines for the protection of aquatic life is described in CCME (1999a).

A summary document of the Canadian Environmental Quality Guidelines (as revised in 2002) has been consulted to obtain specific guideline values for different substances (CCME, 2002).

iii. European Community

In October 2000, the European Parliament and the Council adopted the Water Framework Directive, which establishes a framework for Community action in the field of water policy, including coastal waters (CEC, 2000). In this regard, the Water Framework Directive provides guidance to Member States to set their own environmental quality standards. This Water Framework Directive repealed and will be repealing a number of other Directives, including *Council Directive on Water pollution by discharges of certain dangerous substances* (CEC, 1976b). The Water Framework Directive does not give specfic environmental quality standards for physico-chemical variables and nutrients, other than providing narrative targets associated with different classes (i.e. High, Good, Moderate). High status waters are considered to be near pristine. For the purposes of this review, the narrative target for 'Good Status' is therefore quoted as being equivalent to 'water quality guidelines' as used elsewhere (CEC, 2000) .

In addition to providing general guidance on setting environmental quality standards, the Water Framework Directive also identifies a list of priority (toxic) substances for which the the Council is responsible for setting specific environmental quality standards for the protection of aquatic ecosystems. Such standards have been derived for about 18 priority substances. The approach and methodology followed in deriving such standards are comprehensively discussed in the EC Directives on the particular substance or suite of substances (CEC, 1983, 1984a, 1984b, 1986, 1988, 1990).

iv. South Africa

The *South African Water Quality Guidelines for Coastal Marine Waters for the Natural Environment* (equivalent to *Protection of Aquatic Ecosystems*) are included as part of a series of documents on this matter (RSA DWAF, 1995b). The recommended target (or guideline) values for the protection of the marine aquatic ecosystems, however, are still largely based on the initial set of values that were derived by an ad hoc working committee in 1984 (Lusher, 1984).

In the belief that simplicity is more likely to succeed in practice, only those physico-chemical properties that have the most marked importance to marine communities have been considered (Lusher, 1984). In the absence of any documented evidence of harmful effects of nutrients along the South African coast (at the time), narrative target values governing nutrient concentrations, rather than numerical levels, were proposed (Lusher, 1984). In the case of toxic substances (i.e. trace metals), the *Maximum Allowable Toxicant Concentration* (MATC) was selected as the guideline value, where a reasonable set of reliable chronic toxicity data were available from studies on marine organisms (chronic toxicity is defined as an observable toxic effect after exposure for an extended period of time equal to the lifespan of the organism or the span of more than one generation). Where data appeared unreliable, a more conservative level was selected, with guidance from available international guidelines (Lusher, 1984).

1.2 INTERNATIONAL APPROACH AND METHODOLOGY

The approach and methodologies applied by the international community to derive water quality guidelines for the protection of aquatic ecosystems appear to be different for the different sub-categories of substances, namely:

- Objectionable matter
- Physico-chemical variables
- Nutrients
- Toxic substances.

For this reason, the approach and methodologies for the different sub-categories are discussed separately.

The water quality guidelines for the protection of marine aquatic ecosystems, recommended by the countries and organisations included in this review, are summarised in Appendix A.

1.2.1 Objectionable matter

Although guidelines related to the presence of objectionable matter are typically linked to recreational waters (in which case they are referred to as *Aesthetic guidelines*) (RSA DWAF, 1995b; ANZECC, 2000a; CEC, 2002; CMNHW, 1992), objectionable matter can also be a concern in terms of the protection of marine aquatic organisms, for example, litter and other plastic pollution. Water quality guidelines related to objectionable matter or aesthetic issues are usually narrative and typically require that areas be free from:

- Objectionable floating matter or oily films
- Non-natural matter that will settle to form objectionable deposits on the seabed
- Submerged objects and other subsurface hazards that arise from non-natural origins and which would be a danger to recreational users

- Objectionable smells or odours.

Currently, it is only South Africa in the BCLME region that has explicitly listed recommended quality guidelines for objectionable matter/aesthetics relating to the protection of marine aquatic ecosystems (DWAF, 1995b):

Water should not contain floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance. ***Water should not contain materials from non-natural land-based sources which will settle to form putrescence.*** ***Water should not contain submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use.***

Proposed approach and methodology for the BCLME region:

For the BCLME region, it is proposed that the **South African guideline** ***for aesthetic quality be adopted.***

1.2.2 Physico-chemical variables

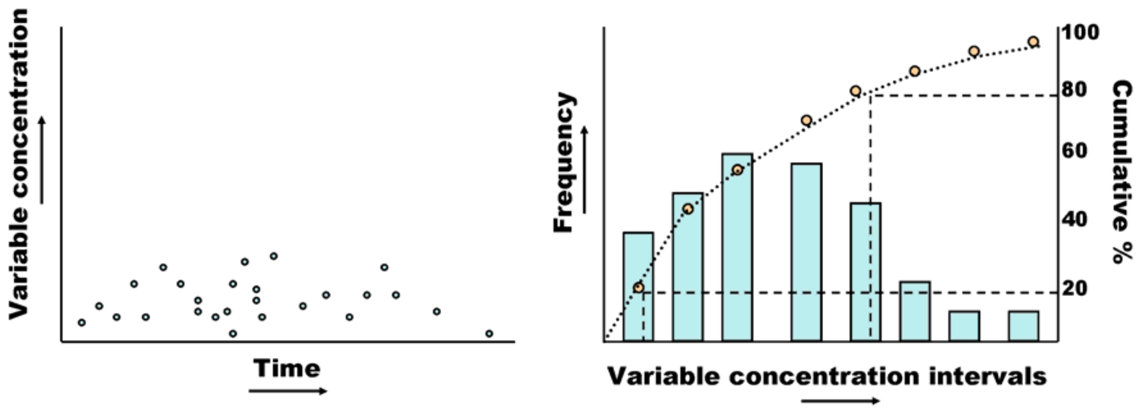
Physico-chemical variables typically include temperature, salinity, pH, dissolved oxygen, turbidity and suspended solids. Different approaches can be applied in deriving water quality guideline values for these variables, including (ANZECC, 2000):

- *Biological and ecological effects data*, obtained from biological effects tests using local biota and local waters. Ecological effects data are obtained through site- or ecosystem-specific laboratory and field experiments. Such data can also be derived from relevant scientific literature.
- *Reference system data*, obtained from either the same (undisturbed) ecosystem or from a regional reference ecosystem.
- *Predictive modelling,* which is particularly useful for certain variables whose disturbance occurs through transformation in the environment. In these cases, because of other factors involved, there may not be a direct relationship between the ambient concentration of the variable and the biological response, but there is often a relationship between flux and biological response.
- *Professional judgement* is used in cases in which there are insufficient data to derive quality guidelines. Such judgement should be supported by appropriate scientific information.

In many instances, the guideline documents from the different countries were not explicit about the approach that was followed, but based on the rationale or motivations provided for setting a particular value, it appears as if the *biological and ecological effects data* and the *reference system data* routes were mostly applied in the case of physico-chemical variables (ANCEZZ, 2000; CCREM, 1987; CEC, 2000; US-EPA, 2000a, 2002a). The Australian and New Zealand document provided the most useful (and practical) guidance in this regard (ANCEZZ, 2000).

The physico-chemical characteristics of marine waters are usually site-specific and often also subject to large natural variability. Water quality guideline values therefore need to be as specific as possible to each ecosystem. This, in turn, requires site-specific data on the statistical distribution of a physico-chemical variable, obtained from a specific site (or an appropriate reference site), as well as information on the ecological and biological effects of such physico-chemical variables. Guideline values are then defined by taking into account natural variability as well as ecological or biological effects (e.g. meaningful changes to the biology or ecology should not occur).

However, where there is insufficient information on biological and ecological effects to determine an acceptable change from the reference condition, it is recommended that an appropriate percentile of data collected on a physico-chemical variable from a specific site (or an appropriate reference site) be used to derive the guideline values (the percentile represents a measure that can be applied to data whether they be normally or non-normally distributed). ANCEZZ (2000) recommended that the guideline concentrations be determined as either the 20^{th} or the 80^{th} percentile of the reference system(s) distribution, or as the range defined by these percentiles, depending on whether trigger values need to be set for a low concentration limit, a high concentration limit or both. This choice of the percentile values was arbitrary, but considered to be reasonably conservative. This concept is graphically illustrated below:



Monthly data collected over a two-year period were considered to be sufficient to indicate ecosystem variability and can be used to derive guideline values for variables that do not show large seasonal- or event-scale effects. However, in ecosystems where concentrations of physico-chemical variables and the ecological and biological responses can be influenced by strong seasonal- or event-scale effects, it will be necessary to monitor (or model) so as to detect these seasonal influences or events. Therefore, where seasonal- or event-driven processes dominate, data need to be grouped and guideline values need to be derived for corresponding key periods. As an interim measure, where few reference data are available and seasonal and event influences poorly defined, single guideline values could be derived from available data based on *professional judgement.*

Proposed approach and methodology for the BCLME region:

Taking into account the large variability in the physico-chemical characteristics of marine aquatic ecosystems within the BCLME region, it is recommended that water quality guidelines for physico-chemical variables be based on the **Reference system data** ***and/or*** **Biological and ecological effects data** ***approaches.***

As it is envisaged that there will be limited biological and ecological effect data for most physico-chemical variables for the BCLME region, it is recommended that, in such instances, the method put forward by ANZECC (2000) be applied. This method uses an appropriate percentile (e.g. 20th and/or 80th percentile) of the physico-chemical data collected from a specific site (or an appropriate reference site) to derive water quality guideline value/s.

Where few reference data are available and seasonal and event influences poorly defined, single guideline values could be derived from available data based on professional judgement, as an interim measure.

NOTE: The South African guidelines provide mainly narrative statements for physico-chemical variables that can easily be accommodated in the above-mentioned approach. Where numerical guidelines are provided, the approach and methodology whereby these were derived are not clear (RSA DWAF, 1995). A more transparent approach is therefore proposed for the larger BCLME region.

1.2.3 Nutrients

Nutrients typically refer to dissolved inorganic nutrients (i.e. nitrate, nitrite, ammonium, reactive phosphate and reactive silicate) as well as particulate and dissolved organic nutrients (mainly carbon and nitrogen).

In the case of nutrients, impact or disturbance occurs through transformations in the environment. Because of other factors involved, there may not be a direct relationship between the ambient concentration of these variables and the biological response, but there is often a relationship between flux and biological response. For example, the concentration of dissolved inorganic nitrogen and phosphate measured in the water column reflects the net effect of the rate at which these nutrients are taken up by the primary producers and the rate at which they are regenerated. A very low nutrient concentration could therefore indicate that a particular nutrient is essentially depleted from the water column and is therefore limiting primary production in the water column, but equally could simply be the net result of a very rapid uptake and release of the nutrient. Furthermore, these processes tend to occur over different time-scales - turnover of inorganic nitrogen and phosphate pools may be measured in minutes, algal growth processes occur over periods of hours, days or weeks and loading rates of nitrogen and phosphate may be seasonal (ANZECC, 2000).

As a result, predictive modelling (dynamic simulation) has become a very useful tool for deriving water quality guideline values for nutrients, in addition to the other approaches, e.g. *Biological and ecological effects data* and *Reference system data* approaches (ANZECC, 2000; CEC, 2000; US-EPA, 2001).

Although ANZECC (2000) recognises the advantages of using predictive modelling in setting water quality guideline values for nutrients, the *Reference system data* approach is still applied. It is recommended that, where an appropriate local reference system(s) is available, the guideline value for the causative (e.g. inorganic nitrogen and phosphate) as well as response (e.g. *Chlorophyll a*) variables be determined as the 80^{th} percentile of the reference system(s) distribution. Where possible, the guideline value should be obtained for that part of the seasonal or flow period when the probability of aquatic plant growth is most likely.

In terms of using the modelling approach, the US-EPA provides extensive guidance through the *Nutrient Criteria Technical Guidance Manual for Estuarine and Coastal Marine Waters*

(US-EPA, 2001). Its definition of 'nutrient criteria' includes numerical values for both causative (e.g. inorganic nitrogen and phosphate) as well as response (e.g. algal biomass and water clarity) variables that are required to assess potential eutrophic conditions (in waters that already experience hypoxia, dissolved oxygen should be added as a response variable).

The approach put forward by the US-EPA consists of a number of key steps, which can be summarised as follows:

- Establishment of reference condition and assessment of historical information - reference conditions in terms of nutrient related characteristics are required to provide a site-specific benchmark. Such information may be available from the literature but can also be obtained from the least affected sites remaining (e.g. areas of minimally developed shoreline, areas of least intrusive use or areas fed by rivers that are from least developed catchments). It is also important to assess historical information, in particular, to reveal the nutrient quality and to deduce the ambient, natural nutrient levels associated with periods of algal blooms (or eutrophication).

- Application of environmental water quality modelling – in this regard, models are usually applied to reduce ecosystem complexity to a manageable level, to improve the scientific basis for development of theory, to provide a framework for making and testing predictions and to increase understanding of cause-and-effect relationships. Both empirical and mathematical models have been applied.

  Statistical models are empirical and are derived from observations. To be useful as predictive tools, relationships must have a basis, typically represented by conceptual models. However, extrapolation from empirical data is known to be uncertain. Thus, these models are most reliable when applied within the range of observations used to construct the model. Empirical models are typically useful if only a sub-system of the larger ecosystem is of primary interest.

  Mathematical models are capable of addressing many more details of underlying processes when properly calibrated and validated. They also tend to be more useful forecasting (extrapolation) tools than simpler models, because they tend to include a greater representation of the physics, chemistry, and biology of the system being modelled. For example, these models can be used to (1) Develop a relationship between external nutrient loads and resulting nutrient concentrations, which can then be used to define allowable loads; (2) Define the relationship between nutrient concentrations and other endpoints of concern, such as biomass or dissolved oxygen; (3) Provide an increased understanding of the factors affecting nutrient concentrations, such as the relative importance of point and non-point source loads; and (4) Simulate relationships between light attenuation and expected depth of primary production.

- Assessment and refinement of initial water quality guidelines – the US-EPA requires that proposed guidelines be assessed by regional specialists prior to application. The refinement process also needs to include verification either by field trials or by use of an existing database of assured quality.

Recommended approach and methodology for the BCLME region:

Taking into account that the impact or disturbance caused by nutrients occurs through transformation in the environment and that there may, therefore, not be a direct relationship between the ambient nutrient concentration and the biological response, it is recommended that the **Predictive modelling** ***approach be the preferred method for setting site-specific water quality guidelines in the BCLME region.***

However, where this approach may be difficult to implement, it is recommended that the **Reference system data** ***approach be applied – using appropriate local reference system(s), the 80th percentile of the reference system distribution for both causative (e.g. inorganic nitrogen and phosphate) and response (e.g. Chlorophyll a) variables is derived as a guideline value (where possible, these should be obtained for that part of the seasonal or flow period when the probability of aquatic plant growth is most likely).***

Where few reference data are available and seasonal and event influences poorly defined, single guideline values could be derived from available data (e.g. information from related areas linking ambient, natural nutrient levels with period of algal blooms) based on professional judgement, as an interim measure.

NOTE: The South African guidelines provide only a broad narrative statement with regard to nutrients and could easily be accommodated in the above-mentioned approach (RSA DWAF, 1995).

1.2.4 Toxic Substances

Toxic substances can typically be categorised into:

- General toxicants (including substances such as ammonia, chlorine, sulphide, phenol cyanide and fluoride)
- Trace metals (including arsenic, cadmium, chromium, lead, mercury, nickel, vanadium and zinc)
- Volatile organic carbons (e.g. benzene, ethyl-benzene, toluene and xylene)
- Poly-aromatic hydrocarbons
- Poly-chlorinated biphenyls (PCBs)
- Pesticides.

In setting guideline values for toxic substances, the *Ecological and biological effects data* approach is mainly used (ANZECC, 2000, CCME, 1999; CEC, 1983, 1984a, 1984b, 1986, 1988, 1990; Russo, 2002). For the purposes of this review, the focus will be on the approach and methodologies followed in Australia and New Zealand (ANZECC, 2000), US-EPA (Russo, 2002) and Canada (CCME, 1999a).

NOTE:

No-Observable-EffectsConcentration (NOEC) ***is the highest test concentration that does not cause a significant effect while the*** **Lowest-Observable-Effects Concentration (LOEC)** ***is the lowest test concentration that does cause an effect. Although NOEC and LOEC figures are dependent on the choice of the tester, overall, NOECs are broadly around 2.5 times lower than LOECs (ANZECC, 2000)***

For the development of national water quality guideline values, toxicological databases - of which the US-EPA's AQUIRE (Aquatic Toxicological Information and Retrieval Database) appears to be the most popular - are regularly used to obtain relevant data (US-EPA, 1994; ANZECC, 2000; Russo, 2002).

A minimum set of aquatic toxicological data is required to set water quality guideline values for toxic substances. The specific data requirements tend to vary from one country to another. Furthermore, because the quality and type of toxicity data varied greatly from one substance to another, the reliability of the guideline values varied. Depending on the quality and type of data available, Australia and New Zealand, for example, categorised their guideline values into (1) *high reliability,* (2) *moderate reliability,* and (3) *low reliability,* while Canada distinguished between (1) *full* and (2) *interim* guidelines (ANZECC, 2000; CCME, 1999a). Although the EC Directives and US-EPA do provide guidance on minimum data requirements, they do not make allowance for different categories of 'confidence' (CEC, 2000; Russo, 2002).

NOTE:

Data collated in preparation for deriving water quality guideline values for toxic substances for Australia and New Zealand included (ANZECC, 2000):

- ***Overseas criteria documents, particularly those produced by the United States (US-EPA 1986a), Canada (CCREM 1987), the Netherlands (MHSPE 1994), Denmark (Samsoe-Petersen & Pedersen 1995), United Kingdom (e.g. Mance et al. 1984a-c, 1988a-e, Mance & Yates, 1988a-b) and the previous ANZECC (1992) guidelines.***
- ***US-EPA AQUIRE (1994) (Aquatic Toxicology Information and Retrieval) database, which has over 100 000 entries***
- ***Papers containing field mesocosm, chronic NOEC and LOEC data and those papers containing LC_{50} data on the same species***
- ***Data on the Australasian Ecotoxicology Database (EPA of NSW and Australasian Society for Ecotoxicology; Warne et al. 1998) which contains around 3500 entries***
- ***Reviews on ecotoxicology of a particular chemical***
- ***Data on physico-properties, especially K_{OW} values, and bio-concentration factor (BCF) data.***

The minimum toxicological data requirements specified by the different countries and organisations is summarised in Table 1.1. Stringent data evaluation procedures apply which are too comprehensive to discuss in detail as part of this review, but can be obtained from the literature listed in Table 1.1.

TABLE 1.1: Summary of the minimum toxicological data requirements for the derivation of water quality guidelines for the protection of marine aquatic ecosystems: Toxic substances

COUNTRY	CONFIDENCE CATEGORY	MINIMUM TOXICOLOGICAL DATA REQUIREMENTS
Australia and New Zealand[1]	High Reliability	No-Observable-Effect Concentration (NOEC) data of suitable quality from chronic or sub-chronic tests for 5 or more species belonging to at least four different taxonomic groups. Alternatively, NOEC data from at least 3 well-conducted field or mesocosm studies that: • Include fish and shellfish or data related to these • Include components that represent basic properties of ecosystems (e.g. nutrient cycling, trophic structures) • Are of sufficient duration to account for life-history of organisms and fate of the toxic substance • Have rigorous experimental design with adequate controls and exposure/effect data (i.e. at least 3 treatments plus control) • Have sufficient replication to give adequate statistical power
	Medium Reliability	LC_{50} or EC_{50} of suitable quality for 5 or more species belonging to at least four different taxonomic groups.
	Low Reliability	At least 3 chronic NOEC values or at least 3 acute LC_{50} or EC_{50} values. Alternatively, use freshwater quality guideline, where available
Canada[2]	Full	• At least 3 studies on 3 or more temperate marine fish species, including at least 2 chronic • At least 2 chronic studies on 2 or more temperate marine invertebrate species from different classes • At least 1 study on a temperate marine vascular plant or marine algal species
	Interim	• At least 2 acute and/or chronic studies on 2 or more marine fish species, one of which is a temperate species • At least 2 acute and/or chronic studies on 2 or more marine invertebrate species from different classes, one of which is a temperate species • (Where toxicity data indicate that a plant species is most sensitive, then that data must be included) In addition, data on the fate and behaviour of the substance are required, such as: • Mobility of substance and the components of the aquatic environment where it is like to be distributed • Kinds of chemical and biological reactions that take place during transport and after deposition • Eventual chemical form • Persistence of substance in water, sediment and biota It is not required to have information on all of the above, but the intent is to determine the major environmental pathways of the variable in the aquatic environment

TABLE 1.1: ***continued…***

COUNTRY	CONFIDENCE CATEGORY	MINIMUM TOXICOLOGICAL DATA REQUIREMENTS
US-EPA[3]	No level specified	• Acute toxicity test results with at least 1 animal species in at least 8 different families so as to include 2 families in the phylum Chordata, 1 family in a phylum other than Arthropoda or Chordata, either the Mysidae or Penaeidae family, 3 other families not in Chordata, and any other family • Acute-chronic ratios with species in aquatic families in at least 3 different phyla, one fish, one invertebrate and one in an acutely sensitive saltwater species (the other 2 may be freshwater) • At least one acceptable toxicity test on a saltwater alga or vascular plant • At least one acceptable bio-concentration factor determined with an appropriate saltwater species, if a maximum permissible tissue concentration is available
European Community[4]	No level specified	Where possible, both acute and chronic data shall be obtained for the taxa set out below that are relevant for the water body type concerned, as well as any other aquatic taxa for which data are available. The 'base set' of taxa is: • algae and/or macrophytes • daphnia or representative organisms for saline waters • fish

1: For details refer to ANZECC, 2000

2: For details refer to CCME, 1999a

3: For details refer to US-EPA (1985) and Russo (2002)

4: For details refer to CEC, 2000

The approach and methodology that is followed in Australia and New Zealand to derive water quality guidelines for toxic substances are schematically illustrated in Figure 1.1.

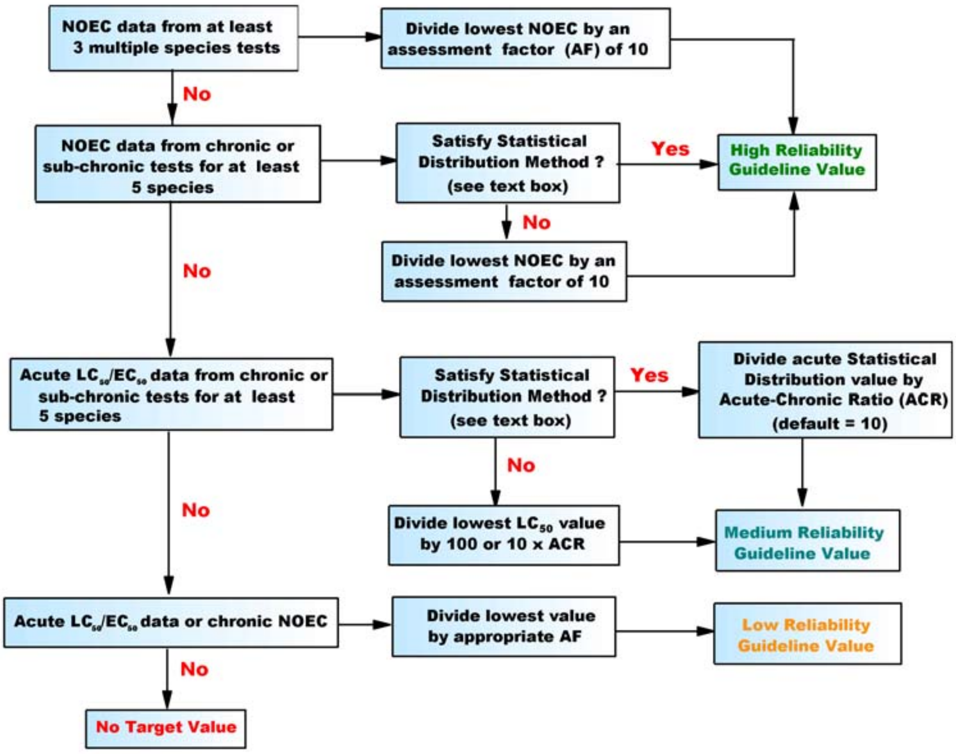


Figure 1.1: Schematic illustration of the guideline derivation procedures followed for Australia and New Zealand (adapted from ANZECC, 2000)

Recommended Application Factors (AF) for deriving low reliability guideline values, based on those proposed by the OECD (1992), are as follows (ANZECC, 2000):

- Apply an assessment factor of 1000 to the lowest acute LC_{50} or EC_{50} value within a dataset on only one or two aquatic species or a factor of 200 to limited chronic data
- Apply a factor of 100 to the lowest acute LC_{50}, EC_{50} value within a data set comprising, at a minimum, algae, crustaceans and fish
- Apply a factor of 20 (OECD (1992) recommends a factor of 10) to the lowest chronic NOEC value within a dataset comprising, at a minimum, algae, crustaceans and fish.

It has been recommended that, in cases in which toxicity data or guideline values were missing for marine waters but available for fresh water, managers may use freshwater figures as tentative working levels (OECD 1992), taking into account any known salinity effects.

NOTE: STATISTICAL DISTRIBUTION METHOD

The statistical distribution method that was used by the Australians to determine high reliability guideline trigger values is schematically illustrated below:

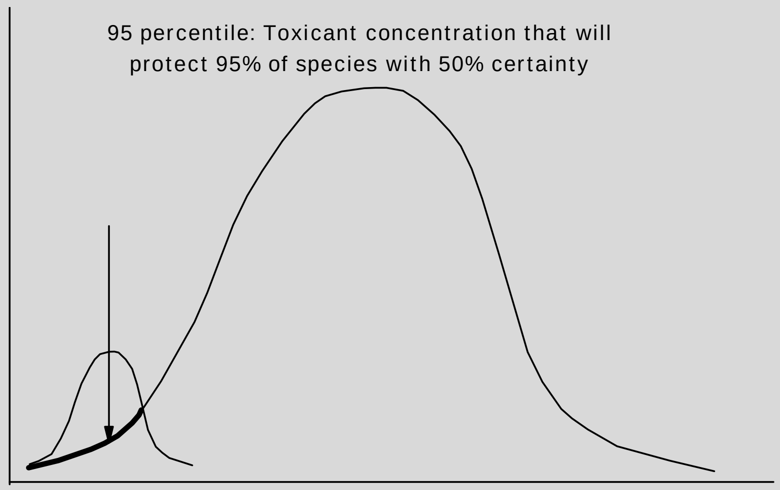


Figure 1.2 schematically illustrates the US-EPA approach and methodology to derive water quality guidelines for toxic substances.

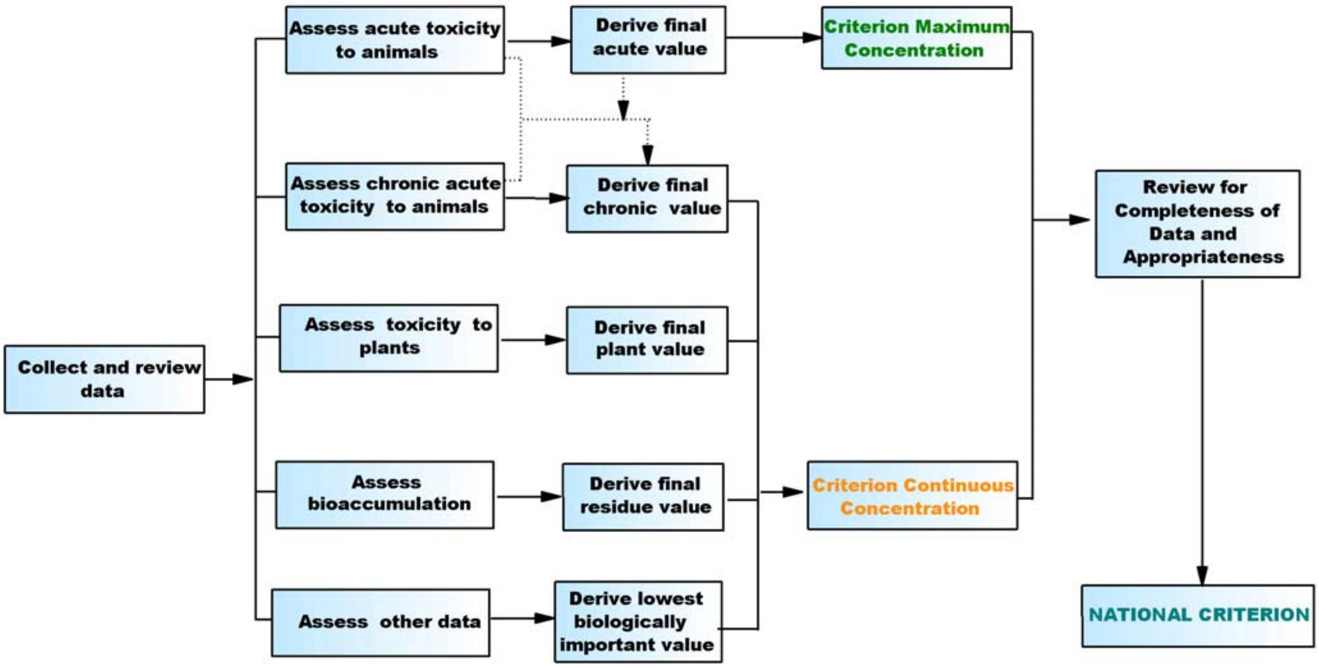


Figure 1.2: Schematic illustration of the guideline (criterion) derivation procedures followed by the US-EPA (adapted from Russo, 2002)

Final values referred to in Figure 1.2 are calculated as follows:

- *Final acute values* are calculated as an estimate of the concentration of the substance corresponding to a cumulative probability of 0.05 in the acute toxicity data from the genera with which acceptable tests have been conducted (if the acute value for a commercially or recreationally important species is lower than the calculated value, then the value of that species is accepted as the final value)
- *Final chronic values* are calculated as the geometric mean of the Lowest-Observable-Effects Concentration (LOEC) and the No-Observable-EffectsConcentration (NOEC) from the chronic data sets
- *Final plant values* are calculated as the lowest result from a 96-h test conducted with an alga or a chronic test conducted on an aquatic vascular plant
- *Final residue values* are calculated by dividing the maximum permissible tissue concentration (e.g. a US Food and Drug Administration action level for fish oil or the edible portion of fish or shellfish) divided by an appropriate bio-concentration factor (BCF).

The US-EPA water criteria provide two guideline values for toxic substances, based on the level of exposure, namely (US-EPA, 2002a; Russo, 2002):

- *Criterion Maximum Concentration* (CMC), which is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect = one half of the final acute value
- *Criterion Continuous Concentration* (CCC) is an estimate of the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect = lowest of the final chronic value, final plant value and final residue value.

Note that the US-EPA water quality guidelines for trace metals, as revised in 2002 – listed in Appendix A – are expressed as dissolved metal concentrations in the water column. These concentrations were calculated from the aquatic life criteria (US-EPA, 1986a), which were initially expressed in terms of total recoverable metal. The term "Conversion Factor" (CF) represents the recommended conversion factor used to convert a metal criterion expressed as the total recoverable fraction in the water column to a criterion expressed as the dissolved fraction in the water column (US-EPA, 2002a).

The guideline derivation procedures followed in Canada are illustrated in Figure 1.3

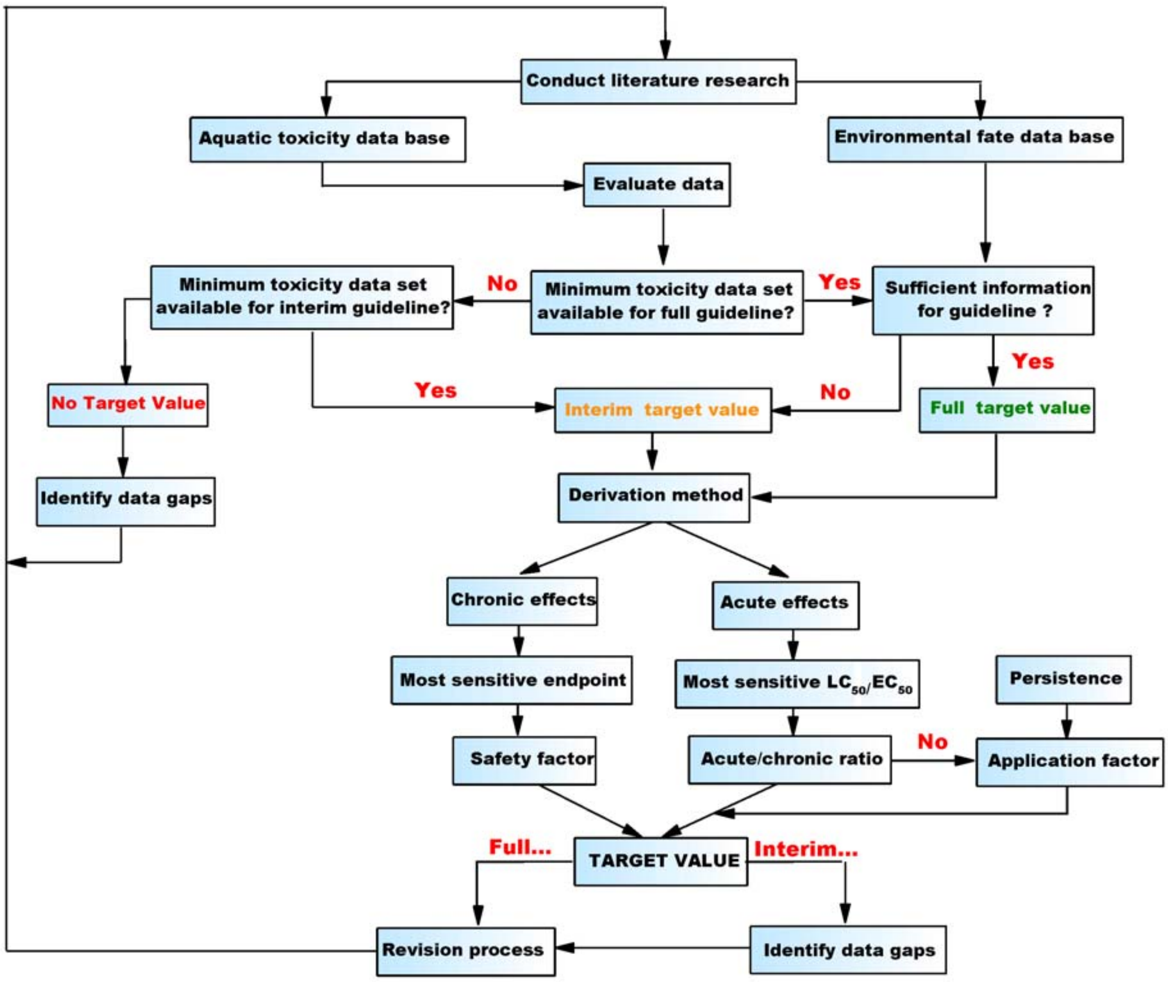


Figure 1.3: Schematic illustration of the guideline derivation procedures followed for Canada (adapted from CCME, 1999a)

Guideline values are derived from the lowest-observable-effect concentration (LOEC) from a chronic study, using a non-lethal endpoint for the most sensitive life stage of the most sensitive aquatic species investigated. The most sensitive LOEC is multiplied by a safety factor of 0.1 to arrive at a guideline value. This safety factor has been chosen to account for differences in sensitivity to a variable due to differences in species, laboratory versus field conditions, and test endpoints.

Where the above-mentioned data are not available, guideline values can be derived from acute studies by converting short-term median lethal or median effective concentrations (LC_{50}, EC_{50}) to long-term no-effect concentrations. Acute/chronic ratios (ACRs) are used to convert the median lethal results of a short-term study to an estimated long-term no-effect concentration. An ACR is calculated by dividing an LC_{50} or EC_{50} by the no-observed-effect concentration (NOEC) from a chronic exposure test for the same species. In the event that ACRs are not available, the alternate method of choice for deriving a guideline value from an acute study is to multiply the LC_{50} or EC_{50} value by a universal application factor. The application factor (AF) for non-persistent variables (t½ in water < 8 weeks) is 0.05; for persistent variables, the AF is 0.01.

Unless otherwise specified, a guideline value for toxic substances refers to the total concentration in an unfiltered sample. Total concentrations will apply unless it can be demonstrated that (a) the relationship between variable fractions and their toxicity is firmly established, and (b) analytical techniques have been developed that unequivocally identify the toxic fraction of a variable in a consistent manner using routine field-verified measurements (CCME, 1999a).

In the case of the European Union, the ultimate aim of the Water Framework Directive is to achieve the elimination of priority hazardous substances and contribute to achieving concentrations in the marine environment of near background values for naturally occurring substances. Thirty-three substances or groups of substances are currently on the list of priority substances, including biocides, metals and other groups like polyaromatic hydrocarbons (PAH). The complete list is given below. (europa.eu.int/comm/environment/water/water-framework/priority_substances.htm).

PRIORITY SUBSTANCES		
Alachor	Fluoranthene	Pentachlorobenzene
Anthrene	Hexachlorobenzene	Pentachlorophenol
Atraziner	Hexachlorobutadiene	Polyaromatic hydrocarbons
Benzene	Hexachlorocyclohexane	(Benzo(a)pyrene
Brominated diphenylethers	(gamma-isomer, Lindane)	Benzo(b)fluoroanthene
Cadmium and its compounds	Isoproturon	Benzo(g,h,i)perylene
C10-13 chloroalkanes	Lead and its compounds	Benzo(k)fluoroanthene
Chlorfenvinphos	Mercury and its compounds	Indeno(1,2,3-cd)pyrene
Chlorpyrifos	Naphthalene	Simazine
1,2-Dichloroethane	Nickel and its compounds	Tributyltin compounds
Dichloromethane	Nonylphenols	Tributyl-cation
Di(2-ethylhexyl)phthalate	4-(para)-nonylphenol	Trichlorobenzene
Diuron	Octylphenols	Trichloromethane (chloroform)
Endosulfan	(para-tert-octylphenol)	Trifluralin
(apha-endosulfan)		

It is the responsibility of the Council to specify emission limit values and environmental quality objectives for these priority substances. Such limits have already been set for 18 substances in five specific directives, also called 'daughter' directives:

- Council Directive on limit values and quality objectives for mercury discharges by the chlor-alkali electrolysis industry (CEC, 1982)
- Council Directive on limit values and quality objectives for cadmium discharges (CEC, 1983)
- Council Directive on limit values and quality objectives for mercury discharges by sectors other than the chlor-alkali electrolysis industry (CEC, 1984a)
- Council Directive on limit values and quality objectives for the discharges of hexachlorocyclohexane (CEC, 1984b)
- Council Directive on limit values and quality objectives for discharges of certain dangerous substances in List I of the Annex to Directive 76/464/EEC (CEC 1976b, 1986, 1988 & 1990).

The Water Framework Directive also provides a list of pollutants for which member states must set environmental quality standards (CEC, 2000), namely:

INDICATIVE LIST OF THE MAIN POLLUTANTS
Organohalogen compounds and substances which may form such compounds in the aquatic environment
Organophosphorous compounds
Organotin compounds
Substances and preparations, or breakdown products of such, which have been proved to possess carcinogenic or mutagenic properties or properties which may affect steroidogenic, thyroid, reproduction or other endocrine-related functions in or via the aquatic environment
Persistent hydrocarbons and persistent and bioaccumulable organic toxic substances
Cyanides
Metals and their compounds
Arsenic and its compounds
Biocides and plant protection products
Materials in suspension
Substances which contribute to eutrophication (in particular, nitrates and phosphates)
Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.)

The following procedure applies to the setting of a maximum annual average concentration (further details are provided in the Water Framework Directive document [CEC, 2000]):

- Safety factors to be used are as follows:

	SAFETY FACTOR
At least one acute $L(E)C_{50}$ from each of three trophic levels of the base set	1000
One chronic NOEC (either fish or daphnia or a representative organism for saline waters)	100
Two chronic NOECs from species representing two trophic levels (fish and/or daphnia or a representative organism for saline waters and/or algae)	50
Chronic NOECs from at least three species (normally fish, daphnia or a representative organism for saline waters and algae) representing three trophic levels	10
Other cases, including field data or model ecosystems, which allow more precise safety factors to be calculated and applied	Case-by-case assessment

- Where data on persistence and bioaccumulation are available, these shall be taken into account in deriving the final value of the environmental quality standard
- The standard thus derived should be compared with any evidence from field studies. Where anomalies appear, the derivation shall be reviewed to allow a more precise safety factor to be calculated
- The standard derived shall be subject to peer review and public consultation, including allowing for a more precise safety factor to be calculated, if required.

Proposed approach and methodology for the BCLME region:

For the BCLME region the approach and methodology followed in **Australia and New Zealand** ***are proposed (ANZECC, 2000). In the process of determining a suitable approach and methodology, ANZECC (2000) conducted a critical review of procedures followed elsewhere, (including those discussed in this document). Their approach and method are also considered to be the most conservative in that guideline values are derived from NOEC data, rather than LOEC data (as is the case in Canada).***

As it is unlikely that there will be sufficient (and appropriate) toxicological data available from the BCLME region to refine the guideline values, it is further recommended that the Australian and New Zealand guideline values for toxic substances be adopted until such time as these could be refined for the BCLME region. The Australia and New Zealand guidelines constitute the only set of guidelines that was refined with data from the southern hemisphere, making it more appropriate to the BCLME region that those sets developed with data from the northern hemisphere only (e.g. for USA, Canada and Europe).

NOTE: Although the target values recommended for South Africa (RSA DWF, 1995b) are within the same order as most of the ANZECC guidelines, the selection criteria are not that transparent, other than that the Maximum Acceptable Toxicant Concentration (MATC) approach was followed. Also, these guidelines date back to 1984. For the larger BCLME region, it is therefore recommended that a more recent and more transparent approach be selected.

1.3 INTERNATIONAL IMPLEMENTATION PRACTICES

Water quality guideline values are not designed to be used as 'magic numbers' or threshold values at which an environmental problem is inferred if they are exceeded, i.e. they are usually NOT standards (legally enforceable values). Water quality guideline values are primarily used to set targets for water quality (or water quality objectives), within broader management strategies, so as to sustain marine aquatic health in the long term. They can also be used as benchmarks for water quality data obtained either through monitoring programmes or simulated through modelling studies (e.g. to asses potential impacts from future developments).

Water quality guideline values are set at a national or federal level to provide guidance to local managers and responsible authorities to derive site-specific quality. The aim is to set these guideline values at reasonably conservative levels, so that adverse biological affects are not expected when the concentrations in the water column are below or at the guideline value. The potential for adverse biological effects is recognised when guideline values are exceeded (CCME, 1995). Water quality guideline values are typically based on bio-available concentrations, and hence are relatively conservative when compared with total concentrations in the marine environment (comparing total concentrations with guideline values is therefore seen as a simple and low-cost point of departure).

Refinement of water quality guideline values can occur on different levels (ANZECC, 2000):

- Values can be adjusted and refined upfront, based on site-specific information on key physical and chemical variables in the marine environment. For example, the toxicity and bioavailability of some metals (e.g. copper, zinc and cadmium) are strongly influenced by water quality characteristics such as dissolved organic matter and pH and the toxicity of different metal species.
- After continuous and extensive monitoring show that exceedances of a guideline value are consistently assessed as posing no risk to the ecosystem.
- Where it is shown that natural background concentrations of a particular variable exceed the guideline values.

Internationally, a risk assessment or phased approach is typically followed: Where guideline values are exceeded, this *triggers* the incorporation of additional information or further investigation to determine whether or not a real risk to the ecosystem exists and, where possible, to adjust the guideline values for site-specific conditions (ANZECC, 2000).

This is illustrated by the Australian and New Zealand approach (Figure 1.4). ANZECC (2000) recommends that, for these assessments, water quality guideline values be compared with the <u>median or average</u> (whichever is considered most appropriate) of the measured or simulated data set. Statistically, the median usually represents the most robust descriptor of the test site data.

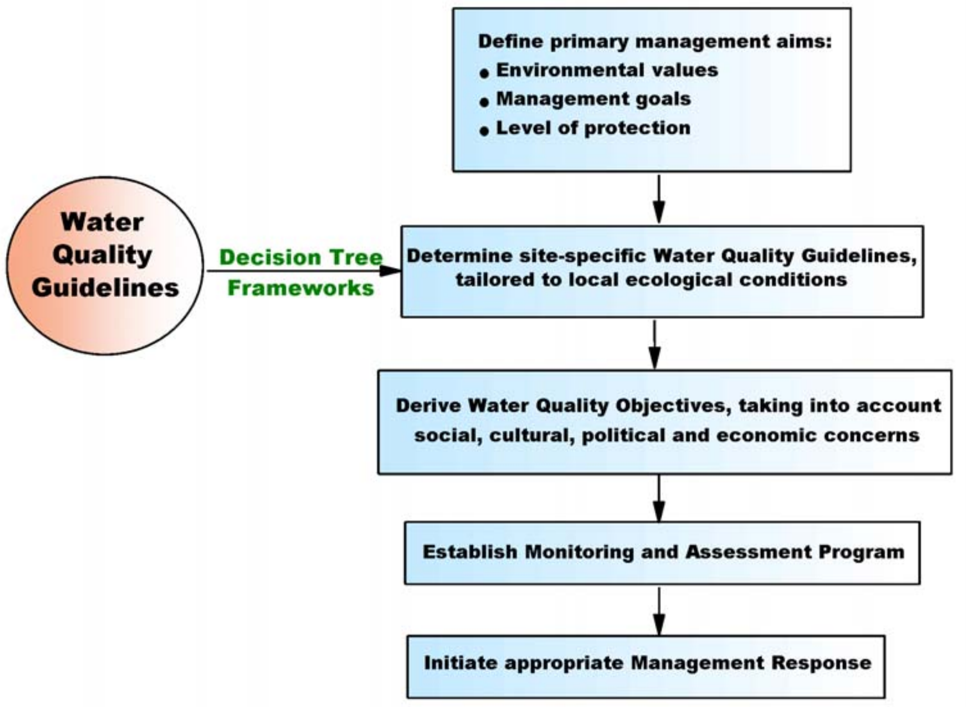


Figure 1.4: Implementation of water quality guidelines in the broader water quality management framework (adapted from ANZECC, 2000)

To adapt water quality guideline values for a particular site, a risk assessment approach, using decision tree frameworks is used (example illustrated in Figure 1.5). In these frameworks, exceedance of recommended water quality guideline values 'triggers' further investigation. The subsequent investigation then aims to assess whether exceedances will result in adverse biological effects by accounting for site-specific environmental factors that can modify the effect of the variable. Although in some cases this will require more work, it will result in much more realistic goals for management and therefore has the potential to reduce both costs and confrontation. These frameworks provide a structured approach within which to reduce the amount of conservatism necessarily incorporated in the guideline values, and so produce values more appropriate to a particular environment (ANZECC, 2000).

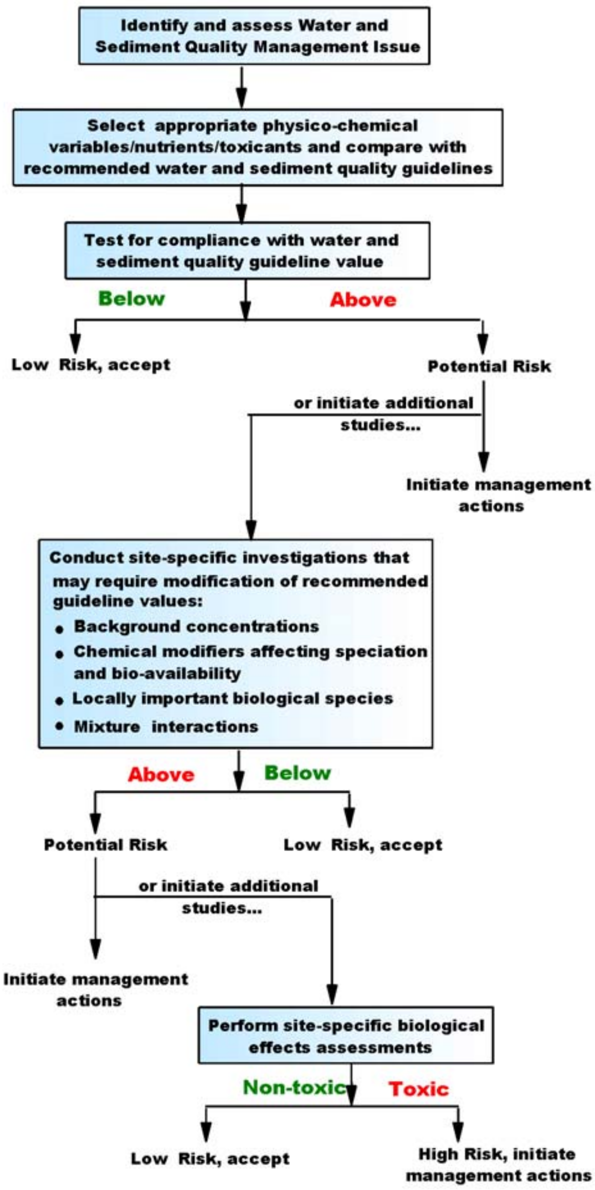


Figure 1.5: Decision tree framework for assessing toxic substances in ambient waters using water quality guidelines (ANZECC, 2000)

Similar to the Australian approach, the Canadian water quality guideline values are also not used as blanket values for national water quality, as variations in environmental conditions will affect water quality in different ways and many of the guideline values may need to be modified according to local conditions, such as assimilative capacity, sensitivity of endangered species, and habitat (Figure 1.6). Using the generic water quality guideline values to set site-specific water quality objectives requires an understanding of the physical and biological characteristics of the water body and an understanding of the behaviour of a substance once it is introduced into the aquatic environment (CCME, 1999a).

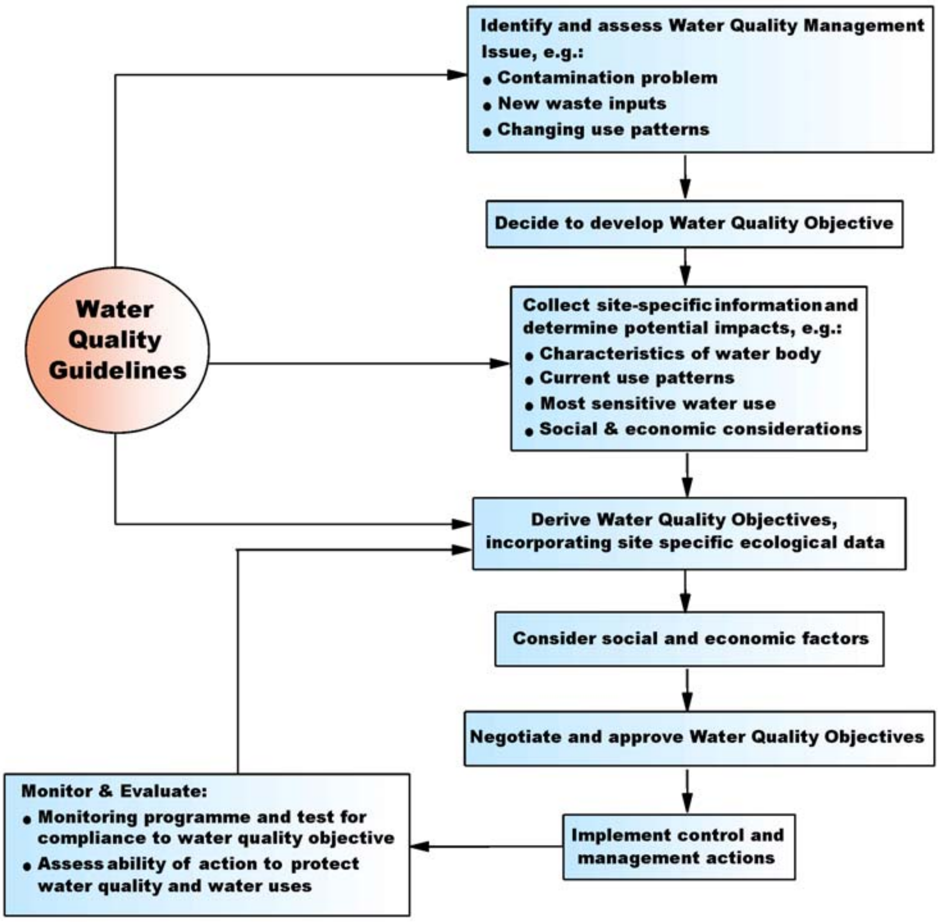


Figure 1.6: Implementation of water quality guidelines in Canada (adapted from CCME, 1999a)

Section 304(a)(1) of the Clean Water Act (USA) requires that the EPA develop criteria for water quality that accurately reflect the latest scientific knowledge (US-EPA, 2004). These criteria are based solely on data and scientific judgements on pollutant concentrations and environmental or human health effects. Section 304(a) also provides guidance to states and tribes in adopting water quality standards. Criteria are developed for the protection of aquatic life as well as for human health. States and authorised tribes adopt water quality criteria with sufficient coverage of parameters and of adequate stringency to protect designated uses.

In adopting such criteria, States and Tribes may (US-EPA, 2004):

- adopt the criteria that EPA publishes under section 304(a) of the Clean Water Act
- modify the section 304(a) criteria to reflect site-specific conditions, or
- adopt criteria based on other scientifically-defensible methods.

The US-EPA therefore also recognises that water quality guideline values are recommended numerical and descriptive values for assisting states and tribes in developing site-specific water quality standards by taking local conditions into account.

In the European Union waters (including marine waters), the use of water determines the level to which quality of water needs to be protected (CEC, 2003). In contrast to some uses for which water is protected only in specified areas (e.g. recreation or culture of shellfish), ecological protection should apply to all waters: The central requirement of the European Treaty is that the natural environment (aquatic ecosystems) be protected to a high level in its entirety.

To protect aquatic ecosystems, it was realised that no quality standards can be set which apply across the Community. Therefore, to cover all surface waters, the Water Framework Directive introduced a concept of setting a general requirement for ecological protection, and a general minimum chemical standard (CEC, 2000).

Good ecological status is defined, in Annex V of the Water Framework Directive, in terms of the quality of the biological community, the hydrological characteristics and the physico-chemical characteristics. In this regard, members need to set site-specific standards that will ensure that conditions defined as indicative of a 'good eclogical status' are attained.

Good chemical status, in turn, is defined in terms of compliance with all the quality standards established for substances (toxic) at European level. In this regard, some numerical chemical standards are provided at European level (in so-called 'daughter' directives (CEC, 1982, 1983, CEC, 1984a, CEC, 1984b, CEC 1976b, 1986, 1988 & 1990)), while for others Annex X of the Water Framework Directive provides guidance on how such standards should be determined (also refer to Chapter 2 of this Section).

Proposal for the BCLME region:

It is proposed that the recommended water quality guidelines for the BCLME region be applied as benchmarks following a **risk assessment or phased approach** ***where, if the values are exceeded, the incorporation of additional information or further investigation is triggered to determine whether or not a real risk to the ecosystem exists and, where possible, to adjust the guideline values for site specific conditions.***

Water quality guideline values should be compared with the median of the measured or simulated data set.

Water quality guidelines are valuable tools for assisting in managing complex systems (such as an aquatic marine ecosystem) in a phased approach. As part of the initial phases, guidelines provide a means of 'screening' for potential adverse biological effects related to the chemical quality of the water column.

SECTION 2.
INTERNATIONAL REVIEW - SEDIMENT QUALITY GUIDELINES FOR THE PROTECTION OF MARINE AQUATIC ECOSYSTEMS

2.1 INTRODUCTION

Sediments are an important component of aquatic ecosystems and provide a habitat for many benthic (and epibenthic) organisms. In addition, sediment found in depositional areas tends to integrate (or accumulate) contaminant inputs over time - many toxic and accumulative substances form associations with particulate matter (either biogenic or lithogenic), which eventually becomes incorporated into bed sediments. Consequently, sediments can also act as a long-term source of toxic substances to the aquatic environment, not only to benthic organisms, but also to overlying waters.

Sediment quality guideline values for the protection of marine aquatic ecosystems from the following countries and regions were included in the review:

i. United States of America

The National Oceanic and Atmospheric Administration (NOAA) in the United States developed a set of sediment quality guideline values that was originally intended to provide a means of interpreting sediment monitoring data, collected as part of the National Status and Trends Program (Long and Morgan, 1990; revised by Long *et al.* 1995, NOAA, 1999). In the late 1990s, MacDonald and co-workers expanded on the NOAA approach when they developed a set of saltwater sediment quality guideline values for the State of Florida (USA), Department of Environmental Protection (MacDonald *et al.*, 1996). They expanded the saltwater database that was originally used by Long and co-workers with additional data on saltwater. The procedures that were developed as part of these two studies currently form the basis for the derivation of sediment quality guideline values worldwide, e.g. Australia and New Zealand (ANZECC, 2000), and Canada (1995).

To assist regulatory authorities in making decisions concerning contaminated sediments, the US-EPA also embarked on studies to develop sediment quality guidelines, primarily for non-ionic organic compounds. From the available literature, guidance in this regard has been documented for dieldrin, endrin and a mixture of PAHs (US-EPA 2003c, d & e).

ii. Australia and New Zealand

Few reliable data on sediment toxicity are available for either Australia or New Zealand from which to derive sediment quality guidelines. With little likelihood of further data forthcoming in the immediate future, these countries opted to use best available overseas guidelines and to refine them with local knowledge of local baseline concentrations, as well as by using local effects data, as and when such data become available (ANZECC, 2000). The interim sediment quality guideline values adopted by Australia and New Zealand are based primarily on the approach followed by NOAA (USA) (NOAA, 1999; Long *et al*., 1995).

iii. Canada

In 1988, Environment Canada commissioned a study to review and evaluate available approaches used to develop sediment quality guidelines in the world (CCME, 1995). This resulted in the development of a formal protocol for the development of sediment quality guidelines, which is based primarily on the approach and methodology used by MacDonald *et al.* (1996) in the derivation of sediment quality guidelines for the State of Florida (USA).

A summary document of the Canadian Environmental Quality Guidelines (as revised in 2002) has been consulted to obtain specific guidelines values for different substances (CCME, 2002). Unless otherwise specified, sediment quality guidelines refer to <u>the total concentration of the substance</u> in surficial sediments (e.g. upper few centimetres).

2.2 INTERNATIONAL APPROACH AND METHODOLOGIES

Ideally, sediment quality guidelines should be developed from detailed dose-response data that describe the acute and chronic toxicity of individual substances in sediments to sensitive life stages of sensitive aquatic organisms. Such data should be generated in controlled laboratory studies in which the influence of important environmental variables affecting bioavailability (and toxicity) are identified and quantified. Subsequently, the results from the laboratory studies should be validated in field trials to ensure that any guideline value derived from such data will be applicable to a broad range of locations. A detailed understanding of site-specific factors that influence bioavailability and toxicity (e.g. total organic carbon, sediment grain size and acid volatile sulphide) is also required so as to define and predict the extent to which such modifiers will affect toxicity under field situations.

However, in most countries, such detailed data are usually not available and are also very costly to collate. In response to the identified need for sediment quality guidelines, numerous approaches were investigated worldwide, taking into account practicality, scientific defensibility and wide applicability.

Sediment quality guideline values for the protection of marine aquatic ecosystems, recommended by the countries and organisations included in this review, are summarised in Appendix B.

Sediment quality guideline values are generally only specified for the protection of aquatic ecosystems, in particular in terms of toxic substances. Approaches that have been documented as being used in the derivation of sediment quality guidelines for toxic substances include:

i. Effects range approach

The effect range approach involves the use of large effects databases, for which concentrations have been measured in sediment and the biological effects simultaneously recorded. Such data can be obtained through field, laboratory and/or modelling studies. Sediment quality guideline values are then derived using statistical analyses of matching sediment chemistry and biological effects data.

This approach requires sufficient amounts of matching sediment chemistry and biological effects data, collected from sediments with different physical and geo-chemical characteristics and from numerous locations so as to provide a basis for establishing guideline values that should be widely applicable. The use of data collated through field studies, in which mixtures of substances occur within samples, is also considered to maximise applicability to most real-world situations. Furthermore, data from a variety of toxicological end-points are also likely to broaden the applicability of guideline values derived through this approach (Long and McDonald, 1998).

The effects-based approach is also thought to be the most ecological relevant and scientifically defensible approach as it relies directly on observed biological effects of sediment associated substances (whereas , for example, equilibrium partitioning models are based only on indirect biological effects – see later) (CMME, 1995).

ii. Screening level concentrations

This approach uses field data and patterns of co-occurrence in sediments of specific contaminant concentrations and specific benthic biota. For a particular species, the screening level concentration is estimated as the concentration which co-occurs with 95% of a particular organism. Sediment quality guideline values are then derived by determining screening level concentrations for a number of species (ANZECC, 2000).

iii. Apparent effects threshold

The apparent effects threshold is defined as the sediment concentration above which statistically significant ($p< 0.5$) biological effects are always observed for a given data set. The approach involves collection of matched biological effects data from tests carried out on sub-samples from the same field sample. Impacted and non-impacted sites are measured and the statistical significance of adverse biological effects is tested (ANZECC, 2000).

iv. Sediment quality triad

This approach involves data from three separate measurements: sediment chemistry, sediment bioassays, and *in situ* biological effects and is conducted at the community or ecosystem level. Chemical (and physical) measurements are also taken to assess the level of contamination, as well as other parameters which may influence the abundance of biota. The bioassay data provide information on the toxicity of the contaminants, while the *in situ* biological measurements assess histopathological abnormalities, community structure and other parameters that can be related to sediment chemistry (ANZECC, 2000).

v. Spiked sediment toxicity tests

The spiked sediment toxicity approach involves the mixing and equilibration of sediments with a contaminant spike, added either to sediment slurry or to overlying water. The information generated provides precise dose-response data on specific toxic substances, as well as quantitative data on interactive effects of substances. This approach can also account specifically for factors influencing toxicity of substances in sediments.

Although results obtained from such controlled laboratory tests have a high degree of precision, they require field validation. This approach is therefore usually best applied in combination with, for example, the effects range approach and is typically included in databases used in the effects range approach (CCME, 1995; ANZECC, 2000).

vi. Equilibrium partitioning models

The equilibrium partitioning (EqP) approach primarily derives sediment quality guideline values by defining the contaminant concentration in the sediment that is in equilibrium with the quality guideline value of the particular contaminant in the pore water. In most cases, the (surface) water quality guideline value (as discussed earlier) is applied. This approach is most widely applied to non-ionic organic compounds primarily because it is well-established that the partitioning is dominated by sediment organic carbon (this approach is less advanced in terms of trace metals, as metal bioavailability is often dependent on more than one phase in the sediments) (ANZECC, 2000).

Where this approach is applied to non-ionic organic compounds (e.g. PAHs), the sediment/pore water partitioning coefficient, K_D, needs to be related to the organic carbon partitioning coefficient, K_{OC} and f_{OC}, the fraction by weight of organic carbon:

$$K_D = K_{OC} f_{OC}$$

The sediment quality guideline (SQG) value can therefore be calculated from a water quality guideline (WQG) value as follows:

$$SQG = K_{OC} f_{OC} \ WQG$$

Although the approach is attractive to many regulators, it is important to realise that partitioning coefficients are dependent on sediment type (% fine fraction) and this needs to be taken into consideration when applying guidelines derived though EqP models. Also, this approach assumes that benthic organisms are as sensitive to toxic effects from a particular substance as water column organisms (water quality guideline values are based on their sensitivity) (ANZECC, 2000).

Outputs from EqP models are therefore also best applied in conjunction with, for example, the effect range approach. Data generated from EqP models for non-ionic organic compounds are also incorporated in databases used in the effect range approach (ANZECC, 2000).

The effects range approach is currently the most widely accepted approach for sediment guideline development, often utilising data generated through some of the other approaches (CCME, 1995; MacDonald *et al.*, 1996; NOAA, 1999; ANZECC, 2000). In this regard, the National Status and Trends Program approach of NOAA is most widely applied throughout the world. This approach is discussed in greater detail in the following sections. The equilibrium partitioning (EqP) approach, which is primarily applied by the US-EPA, is also discussed.

2.2.1 National Status and Trends Program Approach (effects range approach)

Long and his co-workers were the first to investigate and implement the effects range approach on a comprehensive level (Long and Morgan, 1990, revised by Long *et al*., 1995 using only salt-water data). The approach was originally developed to provide a means of interpreting sediment monitoring data collected throughout the United States as part of the National Status and Trends Program of the National Oceanic and Atmospheric Administration in the United States – known as the National Status and Trends Program Approach (NOAA, 1999). For this project, an extensive data set on matching sediment chemistry and biological effects was collated into a database, derived from field, laboratory and modelling studies performed on sediments with different physical and geo-chemical characteristics and from numerous locations so as to provide a basis for establishing guidelines that should be widely applicable throughout North America.

The majority of data used to derive the guideline values were from field studies in which a mixture of substances occurred in the samples, thus maximising the applicability for the guidelines to most real-world situations (Long & MacDonald, 1998). Data on each substance were organised into an ascending data table, for both effect data (i.e. data for which end-points showed adverse biological effects) and no-effect data (i.e. data for which end-points showed no adverse biological effects).

From the ascending data tables, threshold values were calculated from the effect data (i.e. excluding no-effect data) as follows:

- Effect Range-Low (ERL) value: 10^{th} percentile of the effect data, representing a threshold value below which adverse effects are unlikely to occur
- Effect Range-Median (ERM) value: 50^{th} percentile of the effect data, representing a threshold value above which adverse effects frequently occur.

In the late 1990s, MacDonald and co-workers put forward an alternative method to the original *National Status and Trends Program Approach* when they developed a set of saltwater sediment quality guidelines for the Florida (USA) Department of Environmental Protection (MacDonald *et al.*, 1996). They expanded the original database with additional data on saltwater and also revised the database by carefully screening data (the updated database is referred to as BEDS (Biological Effects Database for Sediments) (CCME, 1995).

NOTE:

Each BEDS record included information on (CCME, 1995):

- ***Location***
- ***Concentration of (expressed as total of on a dry weight basis)***
- ***Biological response observed***
- ***Test duration***
- ***Species tested or benthic community assessed***
- ***Information on factors that could influence bioavailability, e.g. total organic carbon, grain size and acid volatile sulphide)***

Strict criteria are also applied in the quality control of data for inclusion in BEDS (CCME, 1995)

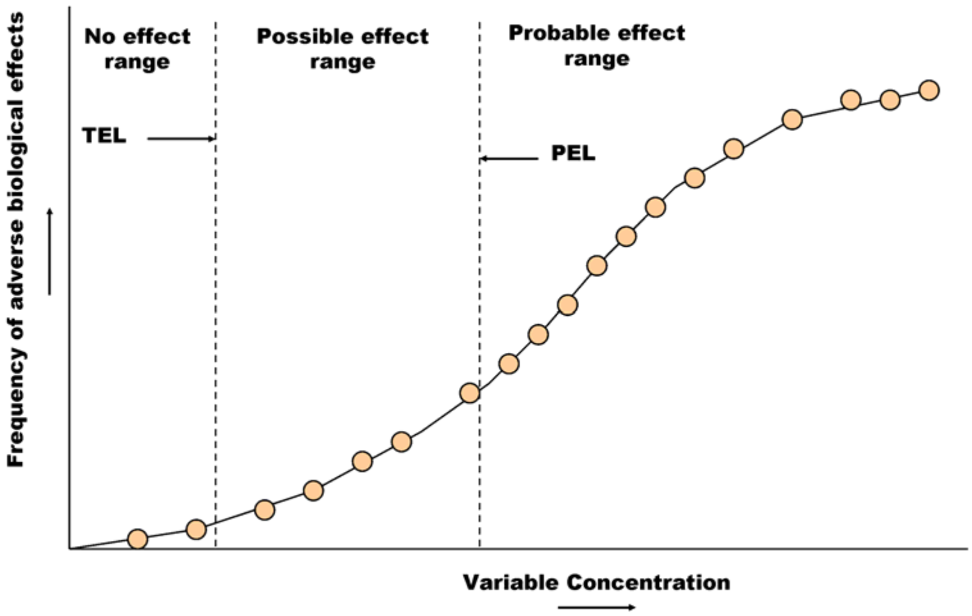
The threshold values calculated by MacDonald *et al.* (1996) differed from those calculated earlier in that no-effect data were used rather than effect data:

- Threshold effect level (TEL): Calculated as the square root of the product of the lower 15^{th} percentile of the effect data and the 50^{th} percentile of the no-effect data, representing a threshold value below which adverse biological affects are unlikely to occur (i.e. represents no significant hazard to aquatic organisms)
- Probable effect level (PEL): Calculated as the square root of the product of the lower 50^{th} percentile of the effect data and the 85^{th} percentile of the no-effect data, representing a threshold value above which adverse biological affects usually or always occur

However, a comparison of the threshold values from the two studies of ‘unlikely occurrence of adverse biological effects’ (ERL and TEL) and ‘adverse biological effects usually or always occurring’ (ERM and PEL) showed remarkable similarity (on average they vary within a factor of 2) even though they were derived differently (ANZECC, 2000; CCME, 1995; Long and MacDonald, 1998).

Furthermore, studies on the reliability and predictability of these thresholds found that ERL and TEL values provided reliable and predictive tools for identifying concentrations of chemicals in sediments that are unlikely to be associated with adverse biological effects (to test predictability large independent data sets compiled from studies of the Atlantic, Gulf and Pacific coasts were used). It was concluded that these guideline values provided a scientifically defensible basis for assessing the quality of soft sediments in marine and estuarine environments (Long and MacDonald, 1998).

Key to the *National Status and Trends Program Approach* is that it defines concentration ranges (rather than absolute values) to provide more flexible interpretative tools with broader application: By deriving two threshold values, i.e. a ‘low’ (ERL/TEL) and a ‘median’ (ERM/PEL), three ranges of concentration are defined, namely, those that are rarely, occasionally and frequently associated with adverse biological effects, as illustrated below (CCME 1995, Long and MacDonald, 1998).



Canada, Australia and New Zealand opted for the National Status and Trends approach, after a critical review of international approaches (CCME, 1995; ANZECC, 2000).

As few reliable data on sediment toxicity were available for either Australia or New Zealand, it was decided to adopt the ERL/ERM values as applied in the National Status and Trends Program (NOAA, 1999; Long *et al*., 1995). The 'low' value corresponds to the ERL of the NOAA listing, while the 'high' value corresponds to the ERM value. The 'low' or ERL value is used at the 'trigger value'. For substances that were considered important, but for which the National Status and Trends Program did not propose target values, other international sources were used. For example, guidelines for tributyltin were estimated on the basis of equilibrium partitioning, based on data summarised from the US-EPA (ANCEZZ, 2000), while values for lindane were taken from MacDonald *et al.* (1996).

To provide a standardised approach to the derivation of sediment quality guidelines, the Canadians developed a formal protocol, with the *National Status and Trends Program Approach* forming an integral part (CCME, 1995) (Figure 2.1). This protocol has also been adopted by Australia and New Zealand for any future revision of their sediment guideline values (ANZECC, 2000).

In applying this protocol, the following are important considerations to take into account:

- In deriving sediment quality guidelines for the protection of an aquatic ecosystem, all components (e.g. bacteria, algae, macrophytes, invertebrates and fish) need to be considered, if data are available, focusing on ecologically relevant species
- Sediment quality guidelines are to be refined as new and relevant scientific data become available (following the *Adaptive Management Approach*)
- Interim sediment quality guidelines are developed where insufficient data are available.

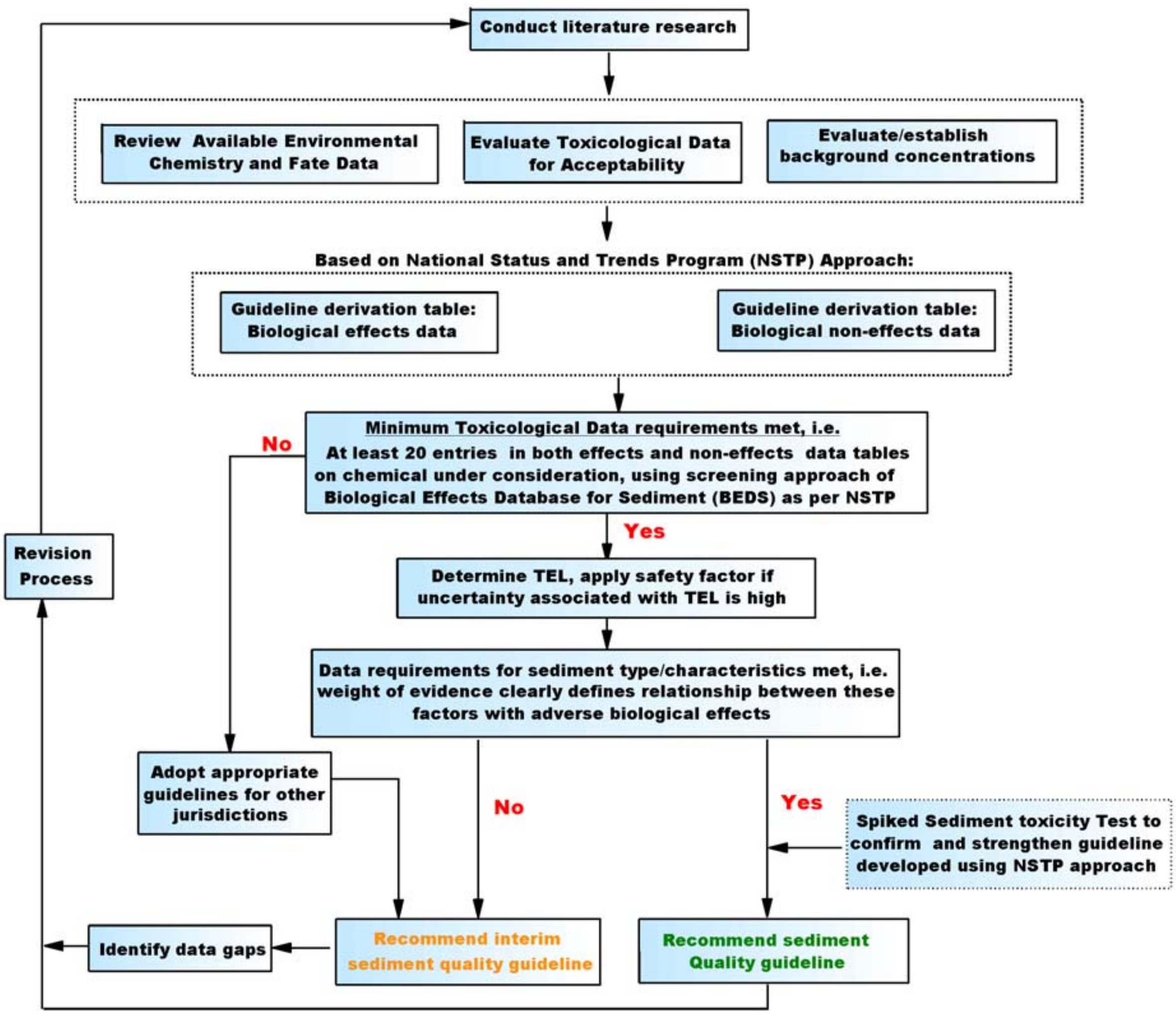


Figure 2.1: Canadian protocol for the derivation of sediment quality guidelines (adapted from CCME, 1995)

Where insufficient data are available to derive sediment quality guidelines, suitable interim sediment quality guidelines should be derived from other jurisdictions, using the following default process that gives preference to biological effect-based values (CCME, 1995):

- Select the lowest sediment quality guidelines that incorporate data on effects of sediment-associated substances on sediment dwelling organisms (e.g. effects range approach, screening level concentrations, apparent effects threshold or sediment quality triad)
- For non-ionic organic compounds select the lower value obtained using the EqP and water quality guidelines approach (if a water quality guideline exists and if no biological effect based values are available)

Select the upper background limit (at a particular site) if an interim sediment guideline cannot be derived using the above procedures or if the value obtained through the above procedures is below the upper background concentration of the substance at the particular site

NOTE:

An important aspect that is clearly highlighted in the Canadian protocol is the consideration of background concentrations of naturally occurring chemicals, e.g. in the case of trace metals. This information should be considered in the site-specific application of sediment quality guidelines, since generically determined sediment quality guidelines may be lower than the respective naturally occurring substances at a particular site. This is therefore an important component that needs to be considered when deriving (site-specific) a quality objective for a particular site from (generic) nationally derived quality guidelines. A method that is commonly used to distinguish between the probable origin of trace metals (i.e. natural versus anthropogenic) involves the determination of the ratio of trace metal concentrations to that of a reference element at a number of uncontaminated sites (such ratios are relatively constant in the earth's crust). Elements that are typically used in this regard are aluminium, iron and lithium. The relationship between the trace element and reference element is typically linear. Usually anthropogenic enrichment of the trace element is suspected when the trace element to reference element (e.g. aluminium) at a site exceeds the upper 95% confidence limit, calculated from a simple linear regression (CCME, 1995).

Currently, most of the sediment quality guidelines for Canada are interim guideline values, derived from other jurisdictions. The guidelines values adopted are those put forward by MacDonald *et al.* (1996) using the PEL/TEL approach rather than the ERL/ERM approach (CCME, 2002).

Guidelines developed in terms of the *National Status and Trends Program Approach* do have a number of limitations that should be taken into account (Long and MacDonald, 1998), namely:

- There are many substances that could be highly toxic for which SQG are currently not available
- These guidelines do not address bioaccumulation pathways
- These guidelines are not toxicity thresholds, i.e. there is no certainty that they will always correctly predict toxicity or non-toxicity
- These guidelines are best applied in conjunction with measures such as toxicity tests and/or benthic community surveys and/or bioaccumulation tests, particularly in sediments showing intermediate concentrations
- Care should be taken when using the sediment quality guidelines to identify the contaminants that are actually causing toxicity in sediments with complex mixtures of

chemicals. Other, more precise methods, such as spiked sediment toxicity tests, should rather be applied to confirm which chemicals actually warrant the greatest concern.

2.2.2 Equilibrium Partitioning Approach (US-EPA)

To assist regulatory authorities in making decisions concerning contaminated sediments, the US-EPA embarked on studies to develop defensible equilibrium partitioning sediment benchmarks (i.e. sediment quality guidelines based on the EqP approach), primarily for non-ionic organic compounds. From the available literature, guidance in this regard has been documented for dieldrin, endrin and a mixture of PAHs (US-EPA 2003c, d & e).

The US-EPA also highlights the limitations of using this approach, namely:

- EqP models derive sediment guideline values from water quality guideline values and the partition coefficient between sediment/pore water, assuming that the level of protection provided by the water quality guideline for a particular substance is similar to that required by benthic organisms. These guidelines are therefore not considered suitable where locally important benthic species are very sensitive or where sediment organic carbon is less than 0.2%, the reason being that, at such low organic carbon concentrations, second-order effects such as particle size and adsorption to non-organic mineral fractions become more important (US-UPA, 2003e, ANZECC, 2000)
- Antagonistic, additive or synergistic effects of other sediment contaminants in combination with the specific substance are not addressed
- Potential for bioaccumulation and trophic transfer is not addressed.

As a result, guidelines derived from EqP models should not be used as stand-alone or pass-fail criteria for all applications but, rather, exceedances of these values could trigger collection of additional assessment data.

Proposed approach and methodology for the BCLME region:

It is recommended that, for the BCLME region, the Canadian protocol (which incorporates the National Trends and Status Program Approach) be adopted for the derivation of sediment quality guidelines (CCME, 1995).

Although this approach does have limitations (as discussed earlier), it appears to be accepted worldwide as the preferred option (CCME, 1995; NOAA, 1999; ANZECC, 2000).

Whilst it is unlikely that there will be sufficient (and appropriate) toxicological data available from the BCLME region to refine sediment guideline values, it is further recommended that the NOAA guidelines (TEL/PEL), as per MacDonald et al. (1996), be adopted as interim sediment quality guidelines for toxic substances until such time as these can be refined for the region. MacDonald et al. (1996) *expanded the original database used by Long et al. (1995) with additional data on salt water and also revised the database by carefully screening data.*

Also, studies on the reliability and predictability of these thresholds found that TEL values provide reliable and predictive tools for identifying concentrations of chemicals in sediments that are unlikely to be associated with adverse biological effects (to test predictability, a large independent data set compiled from studies of the Atlantic, Gulf and Pacific coasts was used). It was concluded that these guidelines provide a scientifically defensible basis for assessing the quality of soft sediments in marine and estuarine environments (Long and MacDonald, 1998).

2.3 INTERNATIONAL IMPLEMENTATION PRACTICES

Sediment quality guidelines are primarily used to set targets for sediment quality (or sediment quality objectives), within broader management strategies, so as to sustain marine aquatic health in the long term. They can also be used as benchmarks for sediment chemistry data, either obtained through monitoring programmes or simulated through modelling studies (e.g. to asses potential impacts from future developments).

Guidelines are usually set at a national or federal level to provide guidance to local managers and responsible authorities to derive site-specific quality objectives or benchmarks. The aim is to set guideline values at reasonably conservative levels, so that adverse biological affects are not predicted when the concentration of a sediment-associated toxic substance is below or at the guideline value. The potential for adverse biological effects is recognised when guideline values are exceeded (CCME, 1995).

Still, sediment quality guidelines are NOT standards (i.e. legally enforceable numbers) and it is essential to further investigate site-specific factors, for example, site background concentrations, bio-availability of toxic substances, and susceptibility of local biological communities to the toxic effects of a toxic substance.

In essence, sediment quality guidelines (like water quality guidelines) are a means of dealing with a complex issue (i.e. the aquatic marine ecosystem) in a phased approach, their application being the first phase.

In a recent review of international sediment quality criteria, Burton (2002) also emphasised the limitation of sediment quality guidelines and concluded that such guidelines should be used only in a "screening" manner or in a "weight-of-evidence" approach. Aquatic ecosystems (including sediments) must be assessed in a 'holistic' manner, in which multiple other components are assessed (e.g., habitat, hydrodynamics, resident biota, toxicity and physico-chemistry) by using integrated approaches.

The above-mentioned caution is echoed in the implementation of sediment quality guidelines worldwide (CCME, 1995; ANZECC, 2000), as illustrated by the Canadian approach (Figure 2.2) (CCME, 1995).

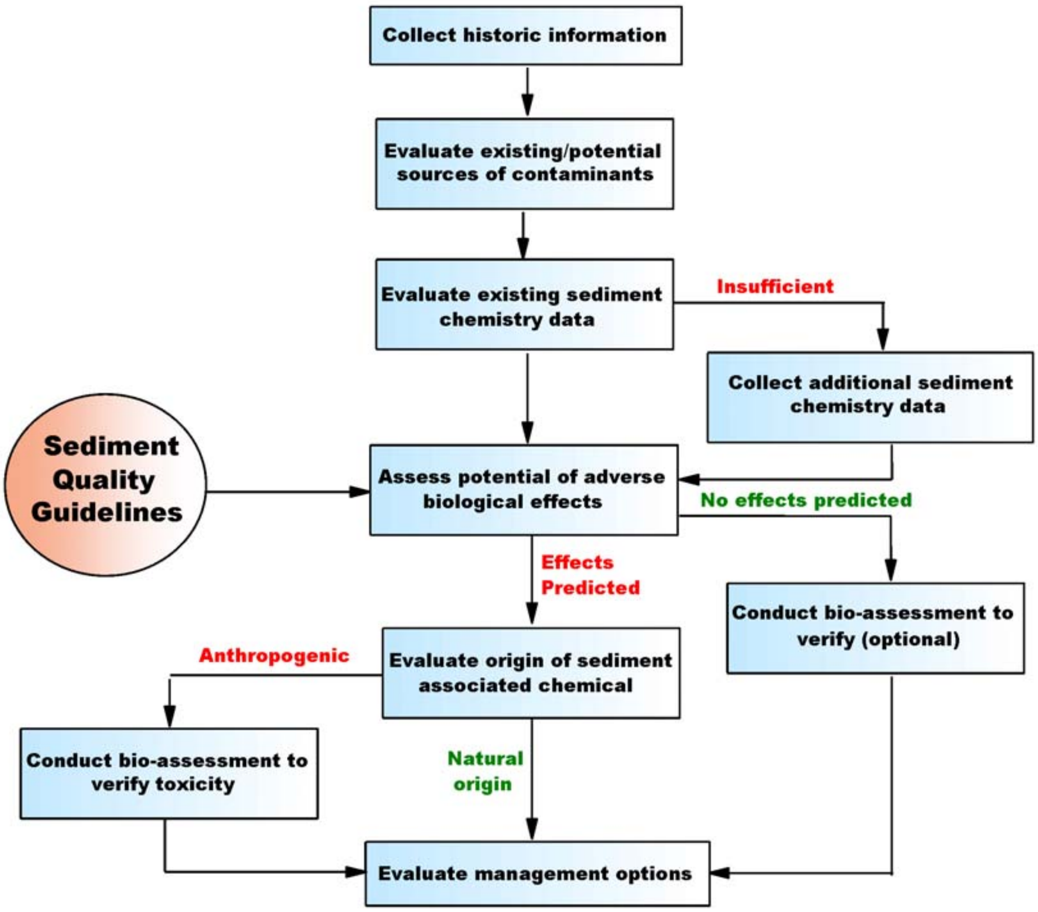


Figure 2.2: Implementation of sediment quality guidelines in Canada (adapted from CCME, 1995)

Whilst the Australian and New Zealand approach is focused mainly on the use of sediment quality guidelines as a benchmark for assessing monitoring data, it also highlights the importance of taking local biogeochemical and ecological factors into account (Figure 2.3)

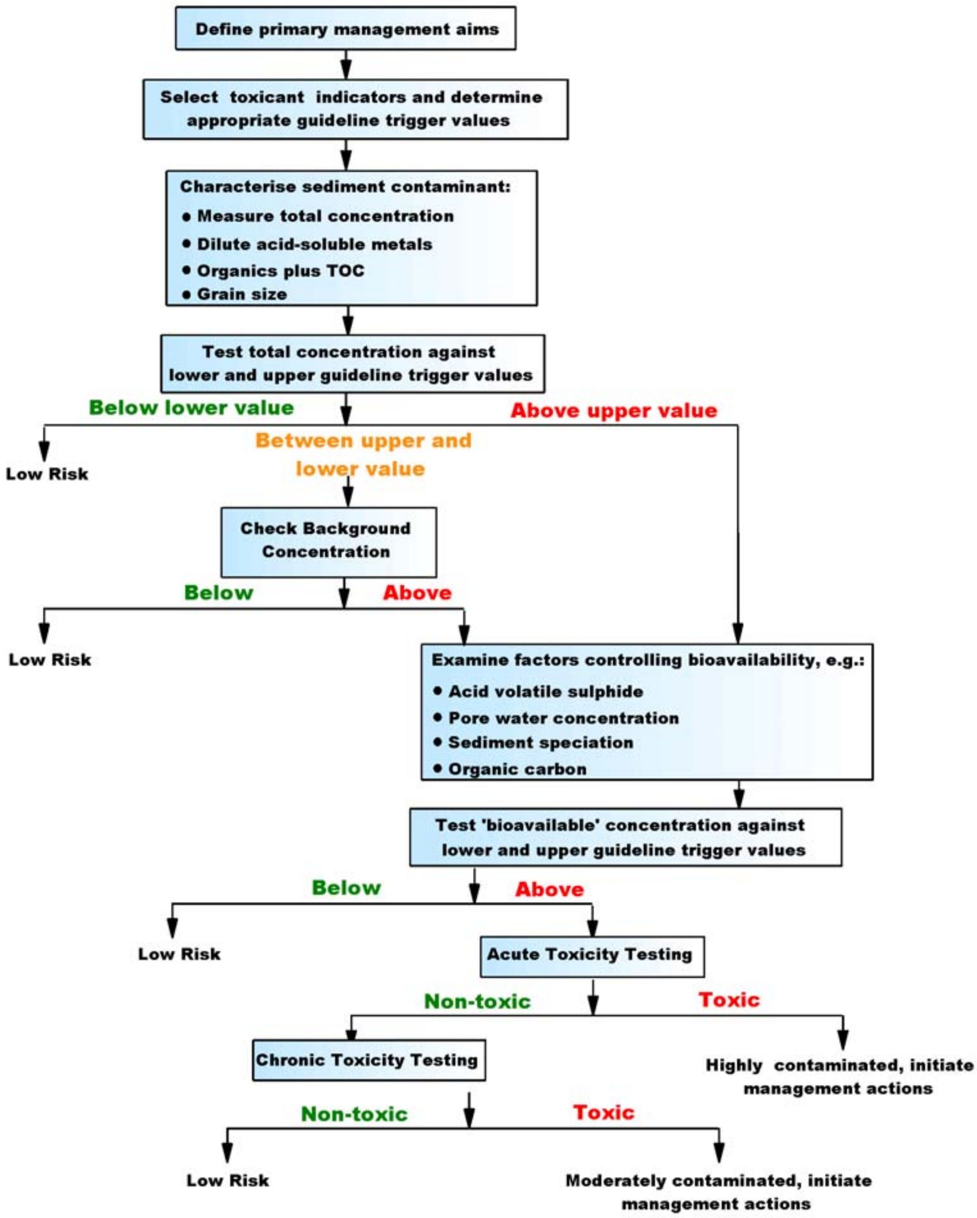


Figure 2.3: Application of sediment quality guidelines in Australia and New Zealand as part of monitoring programmes (ANZECC, 2000)

Proposed approach and methodology for the BCLME region:

It is proposed that the recommended sediment quality guidelines for the BCLME region be applied as benchmarks, following a* risk assessment or phased approach*, for which exceeded values will trigger the incorporation of additional information or further investigation to determine whether or not a real risk to the ecosystem exists and, where possible, to adjust the guideline values for site specific conditions.

Sediment quality guideline values should be compared with the median of the measured or simulated data set.

Similar to water quality guidelines, sediment quality guidelines are valuable tools for assisting in managing complex systems (such as aquatic marine ecosystems) in a phased approach. As part of the initial phases, guidelines provide a means of 'screening' for potential adverse biological effects related to the chemical quality of sediments.

SECTION 3.
INTERNATIONAL REVIEW - WATER QUALITY GUIDELINES FOR MARINE AQUACULTURE

3.1 INTRODUCTION

Marine aquaculture refers to the farming of marine (or estuarine) organisms, either in off-stream (land-based) facilities or in-stream in marine and estuarine environments. Marine aquaculture typically focuses on seaweeds, shellfish, crustaceans and fish culture.

Water quality related requirements that apply to marine aquacultureare also relevant to activities in which marine organisms are collected (e.g. subsistence use) or harvested from natural stocks for human usages (e.g. fisheries). These include activities such as:

- Seaweed collection (e.g. *Gracilaria*)
- Shellfish collection (for human consumption)
- Recreational fishing
- Subsistence fishing
- Commercial fisheries.

In terms of setting water quality guideline values for marine aquaculture, current practice in the following countries was reviewed:

i. European Union

In terms of water quality management, the focus within the European Union is primarily on shellfish. Water quality requirements are documented in two main directives, namely:

- *EC Shellfish Waters Directive* (CEC, 1979) – providing limits for waters in which shellfish are cultured for human consumption
- *EC Shellfish Hygiene Directive* (CEC, 1991) – providing limits for substances in shellfish flesh and a means of classifying shellfish growing areas.

ii. Australia and New Zealand

The Australian and New Zealand water quality guidelines provide general guideline values for the protection of local aquaculture species in Australia and New Zealand (ANZECC, 2000).

The Shellfish Industry in Australia and New Zealand is controlled and managed in terms of the *Australian Shellfish Quality Assurance Program* and the *New Zealand Shellfish Quality Assurance Circular*. These include the classification of safe shellfish-growing areas to permit commercial harvesting for domestic and/or export markets. The classification is based on a sanitary survey and a microbiological survey (Australian Shellfish Quality Assurance Advisory Committee, 2002; MAF, 1995).

iii. United States

The US-EPA's ambient water quality criteria provide guidelines aimed at minimising the risk of adverse effects occurring to humans from chronic (lifetime) exposure to substances through consumption of organisms obtained from surface waters (US-EPA, 2000b; US-EPA, 2002a).

The *National Shellfish Sanitation Program* (NSSP) of the United States Food and Drug Administration also requires that shellfish growing areas be classified on the basis of a sanitary survey (documenting all factors that have a bearing on water quality in a shellfish growing area). This includes microbiological surveys (US-FDA, 2003).

iii. Canada

In Canada, the Department of Fisheries and Ocean is the leading federal agency for aquaculture and acts as both a regulator and enabler of the aquaculture sector (www.dfo-mpo.gc.ca/aquaculture/main_e.htm). The *Canadian Shellfish Sanitation Program* (CSSP) is jointly administered by the Department of Fisheries and Oceans, Canadian Food Inspection Agency, and Environment Canada. Its primary objective is to protect the public from the consumption of contaminated shellfish by controlling the recreational and commercial harvesting of all shellfish within Canada (CFIA, DFO & EC, 2004). The *Canadian Shellfish Sanitation Program* follows closely the United States *National Shellfish Sanitation Program* (US-FDA, 2003).

iv. South Africa

The South African Water Quality Guidelines for Coastal Marine Waters also contain a set of recommended target values related to marine aquaculture (RSA DWAF, 1995b). Target values pertaining to the protection of human consumers are limited to microbiological indicator organisms. Although, at the time, faecal coliforms were considered to be the most appropriate indicator for the South African situation, the shortcoming of these indicators was realised. It was therefore suggested that additional tests may be desirable when inspection of the environment suggests a potential health risk (RSA DWAF, 1992).

3.2 INTERNATIONAL APPROACH AND METHODOLOGY

In terms of water quality requirements for marine aquaculture, the key issues to consider are:

- Protection of the health of the aquatic ecosystem so as to ensure sustainable production and quality of products
- Protection of the health of human consumers
- Tainting of seafood products.

3.2.1 Protection of Aquatic Organism Health

It can generally be accepted that the health of organisms used for aquaculture purposes will be protected if the water quality meets requirements as laid down for the protection of aquatic ecosystems (particularly where the activity relies on natural stocks) (RSA DWAF, 1995; ANCEZZ, 2000).

Although countries like Australia and New Zealand do specify separate water quality guidelines for marine aquaculture, these are provided as a general guide for the protection of local aquaculture species (ANZECC, 2000, also summarised in Appendix C). The guidelines are based primarily on available international information relating to aquaculture, as well as on personal experience of local industry specialists. Their guidelines, however, do recommended that, for aquaculture species for which guidelines are not available or where such activities rely on wild populations of fish, crustaceans or shellfish species, the water quality guidelines for the protection of aquatic ecosystems be consulted (refer to Section 1).

At present, the European Union also specifies separate water quality limits for physico-chemical variables and toxic substances related to the protection of organisms in shellfish waters (no details were provided on the approach and methodology that were followed in setting these target values) (CEC, 1979, also summarised in Appendix C). The EC, however, envisages that water quality target values related to the health of aquatic organisms will eventually be consolidated in the *Water Framework Directive,* which requires the establishment of a comprehensive chemical and biological monitoring system for coastal waters to be implemented by 2006 (CEC, 2000; CEC, 2002).

3.2.2 Protection of Human Health

To protect human consumers, the allowable limits of toxic substances and human pathogens in seafood are usually legislated (i.e. limits are specified as legally enforceable standards). Therefore, even though water quality guideline values may be recommended for marine aquaculture (e.g. as in the US-EPA, 2002a), the legally binding limits set for toxic substances and human pathogens ultimately need to be complied with – water quality guideline values should therefore be applied together with such legislation.

NOTE:

An approach to link the concentration in organisms (as specified in legislation) to a recommended guideline value for surface waters (or sediments), the bioaccumulation approach, is sometimes also applied: Where the uptake of a chemical is not controlled by the organism's metabolism, a concentration of the chemical in the organism will be proportional to the concentration of the chemical in the water or food (or sediment). This can be calculated by applying known bio-concentration factors (BCF) (ANZECC, 2000)

In South Africa, for example, the legal limits for chemical and human pathogens in seafood are specified under the Foodstuffs, Cosmetics and Disinfectants Act (No. 54 of 1972) and are provided in (Table 3.1):

- Regulation - Marine food (Department of Health, 1973)
- Regulations related to metals and foodstuffs (Department of Health, 1994)

TABLE 3.1: South African legal standards for chemical and microbiological constituents in the flesh of shellfish and fish used for human consumption

PARAMETER	STANDARD	
	Shellfish	Fish
Aesthetic characteristics	No decomposition shall have occurred	
Arsenic Antimony Cadmium Copper Lead Mercury (as methyl mercury) Tin Zinc	3 µg/g (wet mass) 1. µg/g (wet mass) 3 µg/g (wet mass) 50 µg/g (wet mass) 4 µg/g (wet mass) 1 µg/g (wet mass) 40 µg/g (wet mass) 300 µg/g (wet mass)	1 µg/g (wet mass) 1 µg/g (wet mass) 1 µg/g (wet mass) 30 µg/g (wet mass) 1 µg/g (wet mass) 0.5 µg/g (wet mass) 40 µg/g (wet mass) 40 µg/g (wet mass)
E. coli Type I	500 per 100 g (uncooked) 1 000 per 100 g (cooked)	
Salmonella	0 (uncooked and cooked)	
Shigella	0 (uncooked and cooked)	
Vibrio sp.	0 (uncooked and cooked)	
Staphylococcus aureus (coagulate +)	10 per g (uncooked and cooked)	
Antibiotics	None shall be present	

Another example is formed by the requirements of the European Union, as set out in the *Shellfish Hygiene Directive* (Table 3.2) (CEC, 1991).

TABLE 3.2: EC Requirements concerning live bivalve molluscs (CEC, 1991)

Live bivalve molluscs intended for immediate human consumption must comply with the following requirements:
1. The possession of visual characteristics associated with freshness and viability, including shells free of dirt, an adequate response to percussion, and normal amounts of intravalvular liquid.
2. They must contain less than 300 faecal coliforms or less than 230 E. Coli per 100 g of mollusc flesh and intravalvular liquid based on a five-tube, three-dilution MPN-test or any other bacteriological procedure shown to be of equivalent accuracy.
3. They must not contain salmonella in 25 g of mollusc flesh.
4. They must not contain toxic or objectionable compounds occurring naturally or added to the environment such as those listed in the Annex to Directive 79/923/EEC in such quantities that the calculated dietary intake exceeds the permissible daily intake, or that the taste of the molluscs may be impaired. (The Commission shall determine the testing methods for checking the chemical criteria and the limit values applicable.)
5. The upper limits as regards the radionuclide contents must not exceed the limits for foodstuffs as laid down by the Community.
6. The total Paralytic Shellfish Poison (PSP) content in the edible parts of molluscs (the whole body or any part edible separately) must not exceed 80 microgrammes per 100 g of mollusc flesh in accordance with the biological testing method - in association if necessary with a chemical method for detection of Saxitoxin - or any other method recognized in accordance with the procedure laid down in the Directive. If the results are challenged, the reference method shall be the biological method.
7. The customary biological testing methods must not give a positive result to the presence of Diarrhetic Shellfish Poison (DSP) in the edible parts of molluscs (the whole body or any part edible separately).
8. In the absence of routine virus testing procedures and the establishment of virological standards, health checks must be based on faecal bacteria counts.
When there is scientific evidence indicating the need to introduce other health checks or to amend the parameters in this Chapter for the purpose of protecting public health, such measures must be adopted in accordance with the procedure laid down in the Directive.

Similar standards, applying elsewhere in the world, include:

- Australia and New Zealand *Food Standards Code* (ANZFA 1996, and updates) – these standards are continually under review and can be examined on their website (www.foodstandards.gov.au/foodstandardscode/)
- United States Food and Drug Administration's website on *Seafood Information and Resources* (US FDA, 2004), as well as the *National Shellfish Sanitation Program* (US FDA, 2003)

The US-EPA (2002a) also provides guidelines for toxic substances in waters in which organisms are collected for human consumption (summarised in Appendix C). These target values were primarily derived using the *Methodology for deriving ambient water quality criteria for the protection of human health* (US-EPA, 2000b)

- Canadian Food Inspection Agency, which specifies action levels for different seafood products (Canadian Food Inspection Agency, 2004).

NOTE:

Shellfish imported to the European Union must comply with the standards laid down in the Shellfish Directive (CEC, 1991).

In the USA, shellfish imports must meet both Federal and State requirements to gain free access to US markets. In addition, fresh and fresh frozen molluscan shellfish products must meet the specific temperature, microbiological, and identification standards contained in the NSSP. The NSSP standards have been adopted into state law and are enforced by both federal and state officials. The NSSP standards apply equally to both domestic and imported fresh and frozen shellfish (FDA, 2003).

The protection of the *health of consumers* is mainly a concern with shellfish farming or where these organisms are harvested from natural stocks. Shellfish, such as mussels and oysters, are filter feeders. These organisms filter food from the water in which they live and tend to retain contaminants, which often accumulate to high concentrations in their tissue, not only toxic substances, but also pathogenic organisms.

As human pathogenic organisms (such as bacteria, protozoa and viruses) are usually very expensive to measure on a routine basis, most countries opted for the use of microbiological indicator organisms (i.e. micro-organisms that may not pose a major human health risk, but that are indicative of the presence of human pathogens).

Faecal coliform is universally used at the indicator organism for detecting risk to human consumers in shellfish waters. The US-EPA, Canada, Australia and New Zealand all use the same guideline value, namely:

Median faecal coliform concentration should not exceed 14 Most Probable Number (MPN) per 100 ml with not more than 10% of the samples exceeding 43 MPN per 100 ml for a 5-tube, 3-dilution method.

This guideline value appears to originate from the 1986 Water Quality Criteria published by the US-EPA (Gold Book) (US-EPA, 1986a). At the time, it was accepted through international agreement that the microbiological criterion for shellfish water should be 70 total coliforms per 100 ml, using a median MPN with no more than 10% of the values exceeding 230 total coliforms (no evidence of disease outbreaks from consumption of raw shellfish grown in water meeting this criterion could be demonstrated). This criterion was considered to be a practical limit when supported by a sanitary survey, acceptable quality of shellfish meat and good epidemiological evidence (US-EPA, 1986a). Furthermore, the National Shellfish Sanitation Program initiated studies through which total coliform data could be related to numbers of faecal coliforms. These studies showed that the total coliform count should be set equivalent to a faecal coliform count.

The target values recommended for South Africa (RSA DWAF, 1995b) differ slightly:

Maximum acceptable faecal coliform count should be (using the membrane filtering technique):

- ***20 for 80% of the samples (i.e. median values)***
- ***60 in 90% of the samples (i.e. less than 10 % should exceed this value)***

The 1984 guideline values that were recommended for shellfish water for South Africa closely resembled those of the US-EPA and others (Lusher, 1984):

Maximum acceptable faecal coliform count should be:

- ***15 for 50% of the samples (i.e. median values)***
- ***45 in 90% of the samples (i.e. less than 10 % should exceed this value)***

In 1992, the Water Research Commission convened a two-day workshop to review these guidelines. This workshop was attended by a broad spectrum of representatives from the scientific/engineering community, national and local authorities, industries and environmental organisations (DWAF, 1992). At this workshop, specialists modified the South African guidelines to the current values. Unfortunately, no clear reasoning for this change was documented at the time.

Interestingly, the interim guideline values currently recommended by the European Union are the least stringent (CEC, 1979):

Pending adoption of a directive on the protection of consumers, faecal coliform counts in water in which live shellfish directly edible to man should not exceed 300 counts/100 ml in 75% of the samples based on quarterly sampling over 12 months.

3.2.3 Tainting of Seafood Products

Tainting substances refer to a large variety of chemicals, usually organics, which can taint marine products, thus affecting their quality and market price. These substances can seriously affect the palatability of seafood, resulting in major adverse impacts to the aquaculture and wild-capture fishing industries.

Estimated threshold concentrations above which tainting of aquatic food can be expected have been provided for South Africa, Australia and New Zealand and by the US-EPA (RSA DWAF, 1995b; ANZECC, 2000; US-EPA, 2002a) and are similar throughout. These are summarised in Appendix C.

Proposed approach and methodology for the BCLME region:

With reference to the protection of aquatic organisms used in the culture and harvesting of seafood, it is proposed that the water quality guidelines proposed for the **protection of aquatic ecosystems** ***be applied, rather than developing a separate series of quality guidelines. This simplified approach seems to be the international trend, particularly where these activities rely on natural stocks. This approach is also current practice in South Africa (RSA DWAF, 1995b).***

With reference to the protection of human consumers, it is proposed that the allowable limits of toxic substances and human pathogens be controlled through **legislation*****, as is the norm internationally. Where such standards are currently not in place, it is recommended that the relevant Government Departments be approached to initiate such legislation.***

In terms of shellfish growing areas, it is proposed that the water quality guideline values for bacteria (faecal coliform) put forward by the **US-EPA** ***(and which have been adopted by most other countries) also be adopted for the BCLME region (US-EPA, 1986a). However, this guideline must be supported by a sanitary survey, as well as acceptable quality of shellfish meat (i.e. as required by legislation).***

Estimated threshold concentrations for **tainting substances*****, as listed for South Africa, Australia and New Zealand and by the US-EPA (RSA DWAF 1995b; ANCEZZ, 2000; US-EPA, 2002a), can also be used to provide guidance in the BCLME region.***

3.3 INTERNATIONAL IMPLEMENTATION PRACTICES

The protection of the health *of consumers* is mainly a concern with shellfish farming or where these organisms are harvested from natural stocks. An approach that is increasingly being implemented as part of the management and control of shellfish industries, in particular, shellfish growing areas, is the *classification approach* (CEC, 1991; Australian Shellfish Quality Assurance Advisory Committee, 2002; MAF, 1995; US-FDA, 2003).

3.3.1 National Shellfish Sanitation Program Approach

This classification approach finds its origin in the United States where it was first implemented by the United States Food and Drug Administration as part of the *National Shellfish Sanitation Program* (NSSP) (US-FDA, 2003).

This approach tends to move away from the traditional approach of classifying waters as either safe or unsafe for shellfish culture or harvesting (based on a percentage compliance with a faecal index organism) to a ranking approach. The classification of coastal and estuarine areas for the harvesting of shellfish (e.g. clams, oysters, scallops, mussels and other bivalve molluscs) is based on the results of Sanitary Surveys that consist of:

- Identification and evaluation of all potential and actual pollution sources (Shoreline Survey) — requiring studies to identify and quantify pollution sources and estimate the movement, dilution and dispersion of pollutants in the receiving environment
- Monitoring of growing waters and shellfish to determine the most suitable classification for the shellfish harvesting area (Bacteriological Survey) — this refers to the measurement of faecal indicator levels in the growing areas.

Re-surveys are conducted regularly to determine if sanitary conditions have undergone significant change.

The NSSP approach largely forms the basis of the classification approaches applied in Australia, New Zealand and Canada (Australian Shellfish Quality Assurance Advisory Committee, 2002; MAF, 1995; CFIA, DFO & EC, 2004).

Although there are some minor differences in the classification sub-categories proposed by different countries, these generally include:

CLASS	DESCRIPTION
Approved	Approved areas need to be free from pollution, and shellfish from such areas are suitable for direct human consumption of raw shellfish.
Conditionally approved/restricted	Where areas are subjected to limited, intermittent pollution caused by discharges from wastewater treatment facilities, seasonal populations, non-point source pollution, or boating activity [the area can be classified as conditionally approved or conditionally restricted. However, it must be shown that the shellfish harvesting area will be open for the purposes of harvesting shellfish for a reasonable period of time and the factors determining this period are known, predictable and are not so complex as to preclude a reasonable management approach. When 'open' for shellfish harvesting for direct human consumption, the water quality in the area must comply with the limits as specified for 'Approved' area. When 'closed' for direct consumption but 'open' to harvesting for relaying or depuration, the requirements of 'Restricted' area must be met. At times when the area is 'closed' for all harvesting, then the requirements of 'Prohibited Areas' apply.
Restricted	Restricted areas are subject to a limited degree of pollution. However, the level of faecal pollution, human pathogens and toxic or deleterious substances are at such a level that shellfish can be made fit for human consumption by either relaying or depuration.
Prohibited	An area is classified as 'Prohibited' for shellfish harvesting if no comprehensive survey has been conducted or where a survey finds that the area is: • adjacent to a sewage treatment plant outfall or other point source outfall with public health significance • contaminated by (an) unpredictable pollution source(s) • contaminated with faecal waste so that the shellfish may be vectors for disease micro-organisms • affected by algae which contain biotoxin(s) sufficient to cause a public health risk • contaminated by poisonous or deleterious substances which may detrimentally affect the quality of shellfish. NOTE: Where an event such as a flood, storm or marine biotoxin outbreak occurs in either 'Approved' or 'Restricted' areas, these can also be classified as temporarily 'Prohibited' areas.

The general, water quality-related requirements pertaining to each of these classes are summarised in Table 3.3 (distilled from Australian Shellfish Quality Assurance Advisory Committee, 2002; MAF, 1995; CFIA, DFO & EC, 2004).

TABLE 3.3: Summary of National Shellfish Sanitation Program classification approach for shellfish growing areas

CLASS	REQUIREMENTS[3]
Approved	A sanitation survey must be completed according to specification to be reviewed annually. The area shall not be contaminated with faecal coliform (as listed) and shall not contain pathogens or hazardous concentrations of toxic substances or marine biotoxins (an approved shellfish growing area may be temporarily made a prohibited area, e.g. when a flood, storm or marine biotoxin event occurs). Evidence of potential pollution sources, such as sewage lift station overflows, direct sewage discharges, septic tank seepage, etc., is sufficient to exclude the growing waters from the approved category. Systematic Random Sampling Strategy[1]: Faecal coliform median/geometric mean of water sample results must not exceed 14/100 ml and the estimated 90th percentile must not exceed 21/100 ml (using Membrane Filtration) or 14/100 ml and the estimated 90th percentile must not exceed 43/100 ml for a 5 tube decimal dilution test, or 49/100 ml for a 3 tube decimal dilution test (using Most Probable Number [MPN]). Total coliform median/geometric mean of water sample results must not exceed 70/100 ml and the estimated 90th percentile must not exceed 230/100 ml for a 5 tube decimal dilution test, or 330/100 ml for a 3 tube decimal dilution test (using MPN). Adverse Pollution Sampling Strategy[2]: Faecal coliform median/geometric mean of water sample results must not exceed 14/100 ml and not more than 10% of samples must exceed 21/100 ml (using Membrane Filtration) or 14/100 ml and no more than 10% of samples must exceed 43/100 ml for a 5 tube decimal dilution test, or 49/100 ml for a 3 tube decimal dilution test (using MPN) Total coliform median/geometric mean of water sample results must not exceed 70/100 ml and no more than 10% of samples must exceed 230/100 ml for a 5 tube decimal dilution test, or 330/100 ml for a 3 tube decimal dilution test (using MPN).
Conditionally approved/restricted	Factors determining this period are known, predictable and are not so complex as to preclude a reasonable management approach. A management plan must be/shall be developed for every conditionally approved/restricted area. When 'open' for shellfish harvesting for direct human consumption, the water quality in the area must comply with the limits as specified for 'Approved' area. When 'closed' for direct consumption but 'open' to harvesting for relaying or depuration, the requirements of 'Restricted' area must be met. At times when the area is 'closed' for all harvesting, then the requirements of 'Prohibited Areas' apply.
Restricted	Systematic Random Sampling Strategy: Faecal coliform median/geometric mean of water sample results must not exceed 70/100 ml and the estimated 90th percentile must not exceed 85/100 ml (using Membrane Filtration) or 88/100 ml and the estimated 90th percentile must not exceed 260/100 ml for a 5 tube decimal dilution test, or 300/100 ml for a 3 tube decimal dilution test (using MPN). Total coliform median/geometric mean of water sample results must not exceed 700/100 ml and the estimated 90th percentile must not exceed 2300/100 ml for a 5 tube decimal dilution test, or 3300/100 ml for a 3 tube decimal dilution test (using MPN).

CLASS	REQUIREMENTS[3]
	Adverse Pollution Sampling Strategy: Faecal coliform median/geometric mean of water sample results must not exceed 70/100 ml and not more than 10% of the samples must exceed 85/100 ml (using Membrane Filtration) or 88/100 ml and not more than 10% of the samples must exceed 260/100 ml for a 5 tube decimal dilution test, or 300/100 ml for a 3 tube decimal dilution test (using MPN) Total coliform median/geometric mean of water sample results must not exceed 700/100 ml and not more than 10% of the samples must exceed 2300/100 ml for a 5 tube decimal dilution test, or 3300/100 ml for a 3 tube decimal dilution test (using MPN)
Prohibited area	Does not meet requirements as above

1: Systematic random sampling means a method of water sampling and data analysis (which may be applied to a growing area which is not impacted by point source pollution)

2: Adverse pollution sampling strategy means a water quality sampling programme designed to target the adverse pollution conditions described in the growing area management plan

3: The implementation and interpretation of the microbiological limits is subject to some understanding of statistical shortcomings (which are discussed in further detail in US FDA, 2003)

3.3.2 European Union's Approach

The classification approach applied by the European Union, as set out in the Shellfish Hygiene Directive (CEC, 1991), differs from that of the NSSP (US-FDA, 2003) in that it classifies shellfish growing areas on the basis of the limits of constituents in shellfish flesh. The classification systems consist of 3 classes (Table 3.4)

TABLE 3.4: EC: Classification of shellfish growing areas

Class A	Life bivalve molluscs from these areas must meet the requirements as set out in Table 3.2 and can be sold direct for consumption
Class B	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three-dilution MPN-test of 6 000 faecal coliforms per 100 g of flesh or 4 600 *E. Coli* per 100 g of flesh in 90 % of samples. Organisms can be collected but only placed on the market for human consumption after treatment in a purification centre, after relaying. After purification or relaying, all the requirements set out Table 3.2 must be met.
Class C	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three-dilution MPN-test of 60 000 faecal coliforms per 100 g of flesh. Organisms can be collected but placed on the market only after relaying over a long period (at least two months), whether or not combined with purification, or after intensive purification for a period to be fixed in accordance with the Directive. After purification or relaying, all the requirements set out Table 3.2 must be met.
Waters below Class C are prohibited for Shellfish harvesting.	

Proposed approach and methodology for the BCLME region:

It is proposed that a system be put in place on the basis of a* classification of shellfish growing areas *in the BCLME region. It is envisaged that the location of major export markets may eventually dictate the approach that will have to be followed. It is recommended that a dedicated task team, consisting of marine aquaculture specialists and representatives from the responsible authorities from the different countries in the BCLME region, be convened to decide on the final approach for the classification of shellfish growing areas in the BCLME.

In the interim, unless dictated otherwise, it is proposed that the National Shellfish Sanitation Program approach be followed for the classification of shellfish growing areas in the BCLME region. This approach is considered to be more practical in terms of implementation, as it classifies areas based on the condition of the growing area, rather than, for example the European Union's approach, which is based on levels in shellfish flesh (a more indirect manner of classification). The NSSP's approach is also the most widely used internationally.

SECTION 4.
INTERNATIONAL REVIEW - WATER QUALITY GUIDELINES FOR RECREATION

4.1 INTRODUCTION

Water quality guidelines for recreational use of coastal waters have received much attention worldwide. For the purpose of this review, the criteria and guidelines from the following countries and organisations were reviewed:

i. World Health Organisation

The World Health Organisation (WHO) published a document entitled *Guidelines for Safe Recreational Water Environments* (WHO, 2003). These guidelines are intended to be used as the basis for the development of international and national approaches (including standards and regulations) to manage recreational water environments.

ii. New Zealand

New Zealand has recently updated its microbiological water quality guidelines for recreational areas (New Zealand Land Ministry of Environment, 2003). The new approach largely adopted the revised WHO approach as documented in 'Annapolis Protocol' (WHO, 1999) and the *Guidelines for Safe Recreational Water Environments* (WHO, 2003).

iii. Australia

Australia is in the process of revising its water quality guidelines for recreation in alignment with recent developments put forward by the WHO (1998, 2003). Until these revised guidelines are endorsed, water quality guidelines in recreational waters will be applied as per ANZECC (2000).

iv. European Union

In the European Union, bathing water target values are set as binding standards and incorporated in European environmental legislation, namely the *Council Directive on Bathing Water Quality* (CEC, 1976a). However, since 1976, epidemiological knowledge has progressed and managerial methods have improved with the result that, in 2002, the Commission adopted a proposal for a revised Directive of the European Parliament and of the Council concerning the Quality of Bathing Water (CEC, 2002).

NOTE:

The 1976 Directive established 19 parameters, against the then prevailing background of knowledge and experience, existing problems in water quality and the fact that the Directive was amongst the very first pieces of European Union water legislation. The 2002 proposal drastically reduced the number of parameters to 2 key microbiological parameters in the new Directive, complemented by visual inspection (algae bloom, oil). The reasons for this reduction were:

- ***Microbiological pollution is, in the vast majority of cases, the limiting factor for achieving good bathing water quality.***
- ***Water Framework Directive (refer to section 4.4) has established a comprehensive and biological monitoring system for coastal waters to be implemented by 2006.***

v. Canada

In preparing the Canadian water quality guidelines for recreational water quality, a working group thoroughly reviewed the existing (international) criteria, current indicators of hygienic quality, water quality data from recreational areas in various parts of Canada and pertinent epidemiological studies (CMNHW, 1992).

vi. United States

In terms of recreational use, the US-EPA water quality guidelines focus on microbiological parameters, in particular for primary contact recreation (US-EPA, 1986b, 2002b). The US-EPA also provides limited guidance on setting target values for toxic substances for recreational waters (US-EPA, 2000b).

vii. South Africa

A sub-series of guidelines, including water quality for recreational use, is included in the series *South African Water Quality Guidelines for coastal marine waters* (DWAF, 1995b).

4.2 INTERNATIONAL APPROACH AND METHODOLOGY

Recreational use of coastal waters fits into different categories, based on the degree of water contact, (ANZECC, 2000; RSA DWAF, 1995b; WHO, 2003) namely:

- *Whole-body (or primary) contact*—recreational activity in which the whole body or the face and trunk are frequently immersed or the face is frequently wetted by spray, and where it is likely that some water will be swallowed, e.g., swimming, diving.
- *Incidental (or secondary) contact*—recreational activity in which only the limbs are regularly wetted and in which greater contact (including swallowing water) is unusual, e.g. boating, fishing, wading.

- *No contact*—recreational activity in which there is normally no contact with water (e.g. angling from shore), or where water is incidental to enjoyment of the activity (such as sunbathing on a beach).

In terms of water quality, the following key aspects are important in relation to recreational use of coastal waters:

- Aesthetics
- Protection of human health relating to toxic substances
- Protection of human health relating to microbiological contaminants.

4.2.1 Aesthetics

Water quality guidelines related to aesthetic issues are usually narrative and typically require that areas be free from (RSA DWAF, 1995b; ANZECC, 2000a; CEC, 2002; CMNHW, 1992):

- Objectionable floating matter or oily films
- Non-natural matter that will settle to form objectionable deposits on the seabed
- Submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger to recreational users
- Objectionable smells or odours.

Such guidelines usually apply to all the categories of recreational used, as described above.

Examples of available water quality guidelines that are recommended for the aesthetic quality of recreational waters are summarised in Table 4.1.

TABLE 4.1 Summary of available water quality guidelines related to aesthetics

COUNTRY	GUIDELINE
Australia	Natural visual clarity should not be reduced by more than 20%. Natural hue of the water should not be changed by more than 10 points on the Munsell Scale Natural reflectance of the water should not be changed by more than 50%. Horizontal sighting of a 200 mm diameter black disc should exceed 1.6 m. Macrophytes, phytoplankton scums, filamentous algal mats, sewage fungus, leeches, etc. should not be present in excessive amounts. Direct contact activities should be discouraged if algal levels of 15 000–20 000 cells/mℓ are present, depending on the algal species. Oil and petrols should not be noticeable as a visible film on the water nor should they be detectable by odour
Canada	Turbidity and colour should not be so intense as to impede visibility in areas used for swimming e.g. 100 platinum-cobalt (Pt-Co) units or 50 Nephelometric Turbidity Units (NTU). Water should be sufficiently clear that a Secchi disc is visible at a minimum depth of 1.2 m. Water should be as free as possible from nuisance organisms that could affect swimmers. Nuisance is defined as something that can cause harm or is annoying, unpleasant, or obnoxious Water should be free from substances attributable to wastewater or other discharges in amounts that would interfere with the existence of life forms of aesthetic value a) materials that will settle to form objectionable deposits b) floating debris, oil, scum, and other matter c) substances producing objectionable colour, odour, taste, or turbidity d) substances and conditions or combinations thereof in concentrations that produce undesirable aquatic life. Oil or petrols should not be present in concentrations that: a) can be detected as a visible film, sheen, or discolouration on the surface b) can be detected by odour c) can form deposits on shorelines and bottom sediments that are detectable by sight or odour.
EC (proposed)	Negative results to be obtained for phytoplankton blooms & macro-algae proliferation (where physically sensitive to such occurrences), either based on cell counts, toxicity test or visual inspections (based on the 95 percentile) Mineral oils (visual & olfactory inspection): No film visible on surface of water and no odour Tarry residues and floating materials such as wood, plastic, glass, rubber or any other waste substance should be absent (Visual inspection)
South Africa	Water should not contain floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance. Water should not contain materials from non-natural land-based sources which will settle to form putrescence. Water should not contain submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use.

4.2.2 Toxic Substances

Although international guidance on setting quality targets for toxic substances in recreational waters is available, e.g. US-EPA (2002b), the WHO, in its studies, concluded that the concentrations in which these substances occur, generally do not seem to represent a serious health risk for recreational users (WHO, 2003). In most cases, the concentrations of contaminants are found to be below drinking-water target values. The WHO therefore recommends that, as long as care is taken in their application, the *WHO Guidelines for Drinking-water Quality* (WHO, 2004) can be used as a starting point for preliminary risk assessments. These guideline values relate, in most cases, to lifetime exposure following consumption of 2 litres of drinking-water per day. For recreational water contact, an intake of 200 ml per day—100 ml per recreational session with two sessions per day—is considered a reasonable assumption. This approach may, however, not apply to substances of which the effects are related to direct contact with water, e.g. skin irritations. A similar approach is recommended in the Australian guidelines, in which the *1987 drinking water guidelines* for toxic substances were applied (NHMRC & AWRC, 1987). However, those guidelines have since been revised and updated (NHMRC & ARMCANZ, 1996 updated 2001).

Water quality guidelines for toxic substances typically apply to the category: *Primary Contract Recreation* and to a lesser extent to the Category: *Secondary Contact Recreation.*

4.2.3 Microbiological contaminants

The most important (and most researched) aspect of water quality guidelines for recreation waters relates to the selection of microbiological indicators that have the most appropriate '*quantifiable relationship between the density of an indicator in the water and the potential human health risks involved in the water's recreational use*' (US-EPA, 1986a).

In this regard, most countries found <u>enterococci</u> to be the most suitable indicator for marine waters (ANZECC, 2000; CMNHW, 1992; US-EPA, 1986a; US-EPA, 2002b; WHO, 2003, New Zealand Minister of Environment, 2003) (Table 4.2). A number of deficiencies with using faecal coliform as indicator organism of health risks in marine waters have been documented (McBride *et al.,* 1991) and recent epidemiological studies also showed poorer relationships between faecal coliform densities and illness rates in bathers than are obtained using enterococci (Cabelli 1983a & 1983b, Cabelli *et al*. 1982 & 1983). Furthermore, there is now considerable evidence that faecal coliforms die off faster than pathogens under certain circumstances and may, therefore, go undetected during beach monitoring programmes, resulting in the disease risks being underestimated (CMNHW, 1992).

TABLE 4.2 Summary of microbiological water quality guidelines recommended for recreational waters (marine)

COUNTRY	GUIDELINE
US-EPA	35 counts/100 ml (enterococci), based on the geometric mean of at least 5 samples, taken during a period not to exceed 30 days. Single sample max should not exceed: • 104 for designated beach area (75%ile) • 158 for moderate full body recreation (82%ile) • 276 for lightly used full body contact (90%ile) • 501 for infrequent full body contact (95%ile)
Australia	Primary contact: 35 counts/100 ml (enterococci) based on the median concentration over bathing season (maximum number in any sample: 60–100 counts/100 ml), alternatively… 150 counts/100ml (faecal coliform) based on the median concentration over the bathing season (minimum of 5 samples taken at regular intervals not exceeding 1 month, 4 out of 5 samples containing less than 600 counts/100 ml) Secondary contact: 230 counts/100 ml (enterococci) based on the median concentration over bathing season (maximum number in any 1 sample: 450–700 counts/100 ml), alternatively… 1000 counts/100ml (faecal coliform) based on the median concentration over bathing season should not exceed 1000 counts/100 ml (minimum of 5 samples taken at regular intervals not exceeding 1 month, 4 out of 5 samples containing less than 4000 counts/100 ml NOTE: Although the Australian guideline also recommends limits for faecal coliform, enterococci is the preferred indicator for marine waters (ANZECC, 2000a)
Canada	35 counts/100 ml (enterococci) based on the geometric mean of at least 5 samples, taken during a period not to exceed 30 days. Resample if any sample exceeds 70 counts/100ml. If it can be demonstrated that either faecal coliform or *E. coli* are suitable indicators: 200 counts/100ml (faecal coliform) based on the geometric mean of at least 5 samples, taken during a period not to exceed 30 days. Resample if any sample exceeds 400 counts/100 ml
WHO	Refer to Table 4.3
New Zealand	
EC	Refer to Table 4.4
South Africa	Maximum acceptable count per 100 ml of faecal coliforms: 100 in 80 % of samples 2000 in 95 % of samples (if exceeded apply the same target values to *E. coli*)

The enterococci guideline recommended by the US-EPA was originally based on a series of epidemiological studies conducted by the UP-EPA, based on an ('acceptable') illness rate of

19 illnesses per 1000 for marine waters (this criterion is primarily aimed at protecting recreational users from acute gastrointestinal illness and may not provide protection against other waterborne diseases, such as eye, ear, skin, and upper respiratory infections, nor illnesses that may be transmitted from swimmer to swimmer) (US-EPA, 1986a; US-EPA, 2002b). This guideline value has also been adopted by other countries, e.g. Australia and Canada (ANZECC, 2000; CMNHW, 1992), with some modifications (Table 4.2).

The WHO also found that, in marine waters, only intestinal enterococci (faecal streptococci) showed a dose–response relationship for both gastrointestinal illness (GI) and acute febrile respiratory illness (AFRI) (WHO, 2003). Instead of using 'single' target values that classify a beach either as 'safe' or 'unsafe', the WHO opted for a range of target values corresponding to different levels of risk. The target values for different risk levels were derived from a number of key studies and are based on exposure of healthy adult bathers to marine waters in temperate north European waters (WHO, 2003) (Table 4.3).

TABLE 4.3: The World Health Organisation microbiological target values recommended for recreational waters (representing different risk levels) (WHO, 2003)

CATEGORY	95th PERCENTILE OF ENTEROCOCCI per 100 ml	ESTIMATED RISK PER EXPOSURE
A	<40	<1% gastrointestinal (GI) illness risk <0.3% acute febrile respiratory (AFRI) risk
B	40 – 200	1–5% GI illness risk 0.3–1.9% AFRI risk
C	201 – 500	5–10% GI illness risk 1.9–3.9% AFRI risk
D	> 500	>10% GI illness risk >3.9% AFRI risk

The above approach has also been adopted by New Zealand (New Zealand Minister of Environment, 2003).

The European Union is currently also proposing a revision of its water quality guidelines for recreation (CEC, 2002). Where the 1976 Directive used three microbiological parameters, i.e. total coliforms, faecal coliform and faecal streptococci (CEC, 1976), investigations for the revised directive found that intestinal enterococci and *Escherichia coli* provide the best match between faecal pollution and health impacts in recreational waters. The target values are based on the 95 percentile evaluation of the $\log_{10}$ normal probability density function of microbiological data acquired from bathing beaches. These values are equivalent to a risk of 5% (Good Quality) and 3% (Excellent quality) for contracting gastro-enteritis and to a risk of 2.5% (Good Quality) and 1% (Excellent quality) for contracting acute febrile respiratory illness. Furthermore, research undertaken by the WHO also indicated that *E. coli* to Enterococci ratios ranging from 2 to 3 would be appropriate to reflect equal risk (CEC, 2002). Based on these latest studies, the Commission is proposing guideline values for intestinal Enterococci and *E. coli* concentrations in bathing water as set out in Table 4.4.

TABLE 4.4: The European Union proposed microbiological target values recommended for recreational waters (representing different risk levels) (CEC, 2002)

	EXCELLENT	GOOD	POOR
Enterococci (95 percentile) or	≤100 cfu/100 ml	≤ 200 cfu/100 ml	> 200 cfu/100 ml
E. coli (95 percentile)	≤ 250 cfu/100 ml	≤ 500 cfu/100 ml	> 500 cfu/100 ml

cfu = colony forming unit

South Africa still uses <u>faecal coliform</u> as a broad-spectrum indicator of faecal pollution and the sanitary quality of water – at the time considered the most appropriate for their situation (RSA DWAF, 1992; RSA DWAF, 1995b) (Table 4.2). Potential shortcomings of using faecal coliform as indicator, however, were realised and as a result additional tests (including enterococci, human viruses and/or coliphages) were also recommended where inspection of beaches suggested potential health risks.

NOTE:

It has been noted that faecal coliform and* E. coli*, although not well correlated with health risks, may be used as indicators in addition to enterococci in environmental conditions in which enterococci levels alone may be misleading.

For example,* E. coli *rather than Enterococci should be used as an indicator wherever the primary source of faecal contamination is a waste stabilisation pond (WSP). Enterococci are damaged in WSP, whereas faecal coliforms that emerge from a pond appear to be more sunlight resistant than those that enter it. Thus WSP enterococci are inactivated in receiving water faster than WSP faecal coliforms (New Zealand Ministry of Environment, 2003).

Also, while it is correct to infer that water exceeding the guideline values poses an unacceptable health risk, the converse is not necessarily true. This is because wastewater may be treated to a level where the indicator bacteria concentrations are very low, but pathogens such as viruses and protozoa may still be present at substantial concentrations. This would require the generation of statistically robust data to establish that the treatment process produces an effluent that meets the guideline indicator bacteria values, but at the same time is capable of destroying pathogenic micro-organisms. Also, wastewater plants may not always operate 100% of the time (e.g. during high water flows) (New Zealand Ministry of Environment, 2003).

Proposed approach and methodology for the BCLME region:

For the BCLME region, it is proposed that water quality guidelines for recreational areas be provided for **aesthetic** *quality (narrative) as well as for* **microbiological indicators.** *As illustrated in Table 4.1, water guidelines related to aesthetic quality are quite similar and it is proposed that the* **South African guideline** *for aesthetic quality be adopted.* *With reference to* **toxic substances**, *it is proposed that suitable Drinking water quality guidelines be consulted to make preliminary risk assessments in recreational areas where toxic substances could be present at levels posing a risk to human health (following the example of the* **WHO,** *2003). Drinking water quality guidelines relate, in most cases, to lifetime exposure following consumption of 2 litres of drinking water per day. For recreational water contact, an intake of 200 ml per day—100 ml per recreational session with two sessions per day—may often be reasonably assumed. This approach may, however, not apply to substances of which the effects are related to direct contact with water, e.g. skin irritations.* *As for microbiological indicators, it is recommended that both* **E. coli** *and* **Enterococci** *be used as indicator organisms. The reasoning is that, although* **Enterococci** *is considered to be most suitable for marine waters, instances have been documented where* **E. coli** *(faecal coliforms) may be more suitable, e.g. where faecal pollution originates for a waste stabilisation pond (WSP). Also, in South Africa,* **E. coli** *(faecal coliforms) have been used as indicator organisms for several years and it will therefore be crucial to run a dual system, for continuation.* *It is also proposed that, instead of using 'single' target values that classify a beach as either 'safe' or 'unsafe', a range of target values be derived corresponding to different levels of risk. As it is envisaged that there will not be sufficient epidemiological data from the BCLME region to customise such values, it is recommended that the risk-based target values of the* **WHO** *(2003) be adopted. In this regard, research undertaken by the WHO indicated that E. coli to Enterococci ratios ranging from 2 to 3 reflect equal risk (CEC, 2002).*

4.3 INTERNATIONAL IMPLEMENTATION PRACTICES

Throughout the world, the implementation of beach water quality guidelines is tending to move away from the traditional approach of classifying recreational waters as either safe or unsafe (based on a percentage compliance with a faecal indicator organism) to an approach of ranking recreational waters, i.e. recognising a gradient of health risks with increasing faecal pollution of human and animal origin. This approach requires that a range of water quality categories be defined and that individual locations be classified according to the level of potential health risks.

Both the World Health Organisation and the European Union are in support of using such a holistic approach, with countries like New Zealand and, soon, Australia following suit (WHO, 2003, CEC, 2002; ANZECC, 2000; New Zealand Land Ministry of Environment, 2003). The Blue Flag Initiative (FEE, 2004) and Canada (CMNHW, 1992) also propose a more holistic approach to the management of recreational area, but do not necessarily allow for different classes associated with different risk rates.

4.3.1 World Health Organisation Approach

Where the traditional approach for managing beach water quality is primarily based on microbiological quality, the WHO's new approach is more holistic (WHO, 2003). It recognises that potential risks or hazards associated with recreational water environments comprise different categories, namely:

- physical hazards (leading, for example, to drowning or injury)
- cold, heat and sunlight
- *(microbiological) water quality*
- contamination of beach sand
- algae and their toxic products
- *chemical and physical agents (e.g. toxic substances)*
- presence of dangerous aquatic organisms.

With reference to microbiological quality, classification or ranking is primarily based upon a combination of:

- degree of influence of (human) faecal material (sanitary inspection)
- counts of faecal bacteria (microbiological quality assessment).

The aim of the sanitation inspection is to identify all sources of faecal pollution (particularly human faecal pollution). In this regard, the three most important sources of human faecal contamination are:

- sewage (e.g. wastewater discharges, sewage pump station overflow, seepage from septic/conservancy tanks, contaminated storm-water run-off)
- riverine discharges (e.g. where river is receiving sewage discharges)
- contamination from bathers (e.g. excreta)
- shipping and boating activities (e.g. inappropriate sewage disposal practices).

The Recreational Classification of a beach is based on the Sanitary Inspection Category and Microbiological Quality Assessment Category (using the microbiological guideline values as provided in Table 4.3) and is derived as illustrated in Table 4.5. The recreational beach grading process of the WHO is summarised in Figure 4.1.

TABLE 4.5: The World Health Organisation Recreational Classification system

		Microbiological Quality Assessment Category (95th percentile enterococci/100 ml)				
		A (<40)	**B (41-200)**	**C (201-500)**	**D (>500)**	**Exceptional circumstances**
Sanitary Inspection Category	**Very Low**	Very good	Very good	Fair	Follow-up	Action
	Low	Very Good	Good	Fair	Follow-up	
	Moderate	Good	Good	Fair	Poor	
	High	Good	Fair	Poor	Very poor	
	Very high	Follow-up	Fair	Poor	Very poor	
	Exceptional circumstances	Action				

NOTE

In the microbial water quality assessment, the sampling programme should be representative of the range of conditions in the recreational water environment while it is being used, and a sufficient number of samples should be collected. The precision of the estimate of the 95th percentile is higher when sample numbers are increased. For example, the number of results available can be increased significantly by pooling data from multiple years, unless there is reason to believe that local (pollution) conditions have changed. For practical purposes, data on at least 100 samples from a 5-year period and a rolling 5-year data set can be used for water quality assessment purposes.

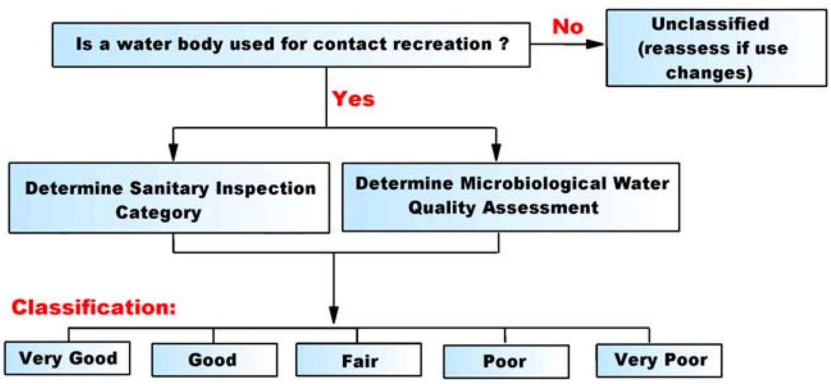


Figure 4.1: The recreational beach grading process of the WHO (adapted from WHO, 2003)

In terms of day-to-day management, this approach also provides a means of assessing whether immediate actions need to be implemented to reduce exposure. For example, managers can identify periods when water quality is poor and then ensure that advisory notices are put out warning the public of increased risk. The management component of this approach has been further developed as part of the New Zealand guidelines (see below).

In essence, this approach is seen to have the benefit of protecting public health, but also of providing the potential both to improve the classification of a location through low-cost measures as well as to enable the safe use of areas for certain periods that might otherwise be considered inappropriate for recreational use.

New Zealand also applies the WHO approach with some modifications. In the case of New Zealand, recreational areas are also classified in terms of a qualitative *risk grading* of the catchment (sanitary survey), supported by the *direct measurement of appropriate faecal indicators* (microbiological quality assessment) (New Zealand Land Ministry of Environment, 2003).

In addition, alert and action guideline levels are used for surveillance throughout the bathing season (i.e. for the day-to-day management). The 'Suitability for Recreation Grade' is allocated to a site through a risk assessment approach, by combining historical microbiological results and sanitary inspection information, which provide an assessment of the condition at any given time. Single samples are used to identify any immediate health risk as part of the day-to-day management of recreational beaches. For New Zealand, the grading, surveillance, alert and action process is illustrated in Figure 4.2.

A detailed Catchment Assessment (or Sanitary Survey) checklist is provided in the New Zealand Guideline Document (New Zealand Minister of Environment, 2003).

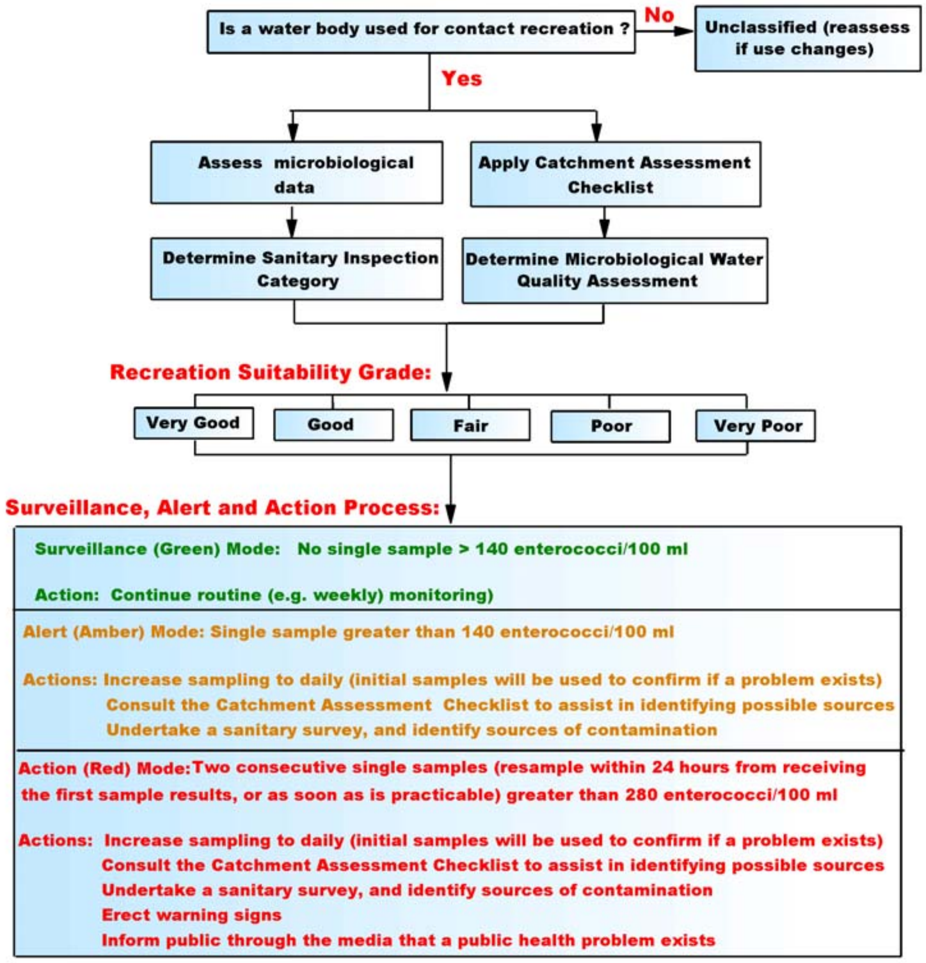


Figure 4.2: New Zealand grading and surveillance, alert and action process for the management of recreational use of marine waters (adapted from New Zealand Land Ministry of Environment, 2003)

4.3.2 European Union Approach

In the European Union, bathing water target values are set as binding standards and incorporated in European environmental legislation, namely Council Directive on Bathing Water Quality (CEC, 1976a). In 2002, the Commission adopted a proposal for a revised Directive of the European Parliament and of the Council concerning the Quality of Bathing Water (CEC, 2002).

Similar to the WHO approach, the revised Directive proposes that beaches be classified, in this instance, as “Poor”, “Good” or “Excellent” (mainly based on microbiological and aesthetic qualities). At the end of each bathing season, monitored data collected during the last three years are assessed. The requirements for different classes are illustrated in Table 4.6.

TABLE 4.6: The European Union Recreational Classification system (CEC, 2002)

	EXCELLENT	GOOD	POOR
Enterococci (95 percentile)	≤100 cfu/100 ml	≤ 200 cfu/100 ml	> 200 cfu/100 ml or
E. coli (95 percentile)	≤ 250 cfu/100 ml	≤ 500 cfu/100 ml	> 500 cfu/100 ml
Phytoplankton blooms & macro-algae proliferation (where physically sensitive to such occurrences), either based on cell counts, toxicity test or visual inspections (95 percentile)	-	Negative result	-
Mineral oils (visual & olfactory inspection)	-	No film visible on surface of water and no odour	-
Tarry residues and floating materials such as wood, plastic, glass, rubber or any other waste substance (Visual inspection)	-	Absence	-
Length of bathing season and management measures reflect other recreational activities practised	Yes	-	-

cfu = colony forming unit

The Commission further proposes a legally binding *Good Quality* value and an *Excellent Quality* guide value for intestinal *Enterococci* and *E. coli* concentration in bathing waters. Therefore, a minimum classification of *Good* and full monitoring of all parameters are needed to ensure that bathing water conforms to the Directive. However, if a *Good* classification cannot be reached, a bathing beach will still be regarded as conforming to the Directive on condition that appropriate measures are taken to bring the water quality into compliance within a three-year period. Measures must also be taken to inform the public and to prevent human exposure to pollution. The revised Directive also proposes that member states consult and allow all interested parties to participate in the classification process (CEC, 2002).

NOTE:

To prevent misinterpretation, the revised EC Directive proposes that statistical data analysis of the 95 percentile be conducted as follows (CEC, 2002):

- ***take the log_{10} value of all bacterial enumerations in the data sequence to be evaluated***
- ***calculate the arithmetical mean of the log_{10} values (μ)***
- ***calculate the standard deviation of the log_{10} values (σ).***

The upper 95 percentile point of the data probability density function is derived from the following equation: 95 percentile = antilog ((μ)+(1.65 x σ)).

4.3.3 Blue Flag Campaign

The Blue Flag campaign is an international initiative that was started in the mid-1980s to encourage local authorities to provide clean and safe beaches for local populations and tourists (UNEP, 1996). It is a voluntary and non-punitive scheme and is targeted at local authorities, the general public and the tourism industry. The main objectives of the Blue Flag campaign are to:

- improve understanding of the coastal environment
- promote the incorporation of environmental issues in the decision-making processes of local authorities and their partners.

In essence, beaches that meet specific criteria are annually awarded a Blue Flag, which can be used as part of the local tourism marketing strategy. Areas for which specific criteria are assigned are:

- *water quality*
- beach management and safety
- environmental information and education.

Although not legally required, South Africa (through its Department of Environmental Affairs and Tourism) initiated the Blue Flag Campaign to encourage socio-economic development and to improve coastal livelihoods through better management of marine and coastal-related resources. Detailed criteria differ slightly from one region to another. For example, the South African criteria for water quality are listed in Table 4.7 (FEE, 2004).

TABLE 4.7 Blue Flag Campaign: South African Criteria related to Water Quality

CRITERIA	CRITERIA AIM	GUIDANCE NOTES
Compliance with recreational bathing water quality	The Blue Flag beach must comply with recreational bathing water quality standards for faecal coliform	• In order to be eligible for the Blue Flag award, a beach must comply with the bathing water quality requirements in the previous Blue Flag season • Samples must be taken every 2 weeks during the Blue Flag season • Sampling must begin 2 weeks before the start of the Blue Flag season • Samples should be taken where the daily average density of bathers is highest. If the beach is long and/or there are possible sources of pollution (e.g. outlets), additional samples must be taken. Samples should preferably be taken 30 cm below the surface of the water • An independent accredited laboratory is responsible for the samplings and must undertake all sample analyses. • Faecal coliform: Guideline value: 100/100 ml (max 20% of the test results higher than the guideline value). Imperative values: 2000/100 ml (max 5% of the test results higher than the imperative value) • If compliance with the guideline and imperative values cannot be met during a Blue Flag season, the Flag must immediately be withdrawn • The results of the analyses must be displayed in the water quality display on the Notice Board (icons with smiling and frowning faces plus date)
Management of stormwater pollution	Ensure that a beach area has no pollution from stormwater or any other effluents	Outlets must be clean at all times. Check daily
		During stormwater flows, clean outlets and surrounding areas daily
		When regular water sampling coincides with storm-water flows, then water samples must also be taken in storm-water outlets
Compliance with National Oil Pollution Contingency Plans	Ensure that oil pollution contingency plans are in place, up to date and ready for implementation	Provide a statement that all requirements of the National Oil Spill Contingency Plan are met
		In case of oil pollution, implement the Oil Spill Contingency Plan
Compliance with Planning Legislation	All Blue Flag beaches must comply with the applicable building regulations and environmental management procedures	The applicable Planning or Building Department of the local authority must provide a written statement that all buildings on the Blue Flag beach meet local building regulations
		All new developments must follow the Integrated Environmental Management (IEM) procedure as stipulated by the Integrated Environmental Management procedures – available from the DEAT

4.3.4 Canada

The holistic approach followed by Canada in assessing and managing the quality of recreational waters includes the following (CMNHW, 1992):

- *Environmental health assessments*. An annual assessment is carried out prior to the bathing season in order to identify all potential sources of contamination and physical hazards that could affect the recreational area.
- *Epidemiological evidence*. Wherever possible, surveillance for bather illness or injuries is established, which can either be comprehensive epidemiological studies or formal and informal reporting from physicians and hospital emergency departments.
- *Indicator organism monitoring*. Routine microbiological monitoring of a recreational area is carried out, the frequency of which is determined by the usage of the area, the environmental health assessment, and epidemiological evidence.
- *Presence of pathogens*. Tests for pathogenic organisms are carried out when there have been reports of illnesses, when there is suspected illness of undetermined cause, or when levels of an indicator organism demonstrate a continuous suspected hazard.

Proposal for the BCLME region:

It is proposed that the BCLME region adopt a beach classification system, rather than the traditional approach of classifying recreational waters as either safe or unsafe (based on a percentage compliance with a faecal indicator organism). With reference to water quality, the classification should be based on both a sanitary survey as well as routine microbiological surveys. The classification rating should be re-evaluated on an annual basis.

As it is envisaged that there will not be sufficient epidemiological data from the BCLME region to customise such systems, it is recommended that the classification system of the **WHO** ***(2003) and*** **New Zealand** ***(New Zealand Minister of Environment, 2003) be adopted, as it is currently the most widely used in the world.***

In addition to a classification system, it is also recommended that a **day-to-day management system** ***be adopted. In this regard, the*** **New Zealand** ***approach is considered to be most useful (New Zealand Minister of Environment, 2003).***

Where beaches are earmarked as (international) tourist destinations, authorities are encouraged to subscribe to the Blue Flag, not only to provide safe beaches, but also as a marketing tool..

SECTION 5.
INTERNATIONAL REVIEW - WATER QUALITY GUIDELINES FOR INDUSTRIAL USE

Water quality guidelines for industrial uses of coastal marine water, other than marine aquaculture, do not seem to be addressed explicitly in other international guideline documents. The South African guidelines do provide limited guidelines for different industrial uses, realising that these are very much dependent on the type of industry (DWAF, 1995b). These guidelines recognise the following activities as industrial (beneficial) uses of marine water that require an acceptable water quality:

- Seafood processing
- Salt production
- Desalination
- Aquariums and oceanariums
- Harbours and ports
- Cooling water intake
- Ballast water intake
- Coastal mining
- Make-up water for offshore marine outfalls
- Exploration drilling
- Scaling and scrubbing.

The water quality guidelines for these uses are mainly focused on water quality matters related to *industrial processes,* i.e. where water quality may interfere with the mechanical operations or with the industrial processes. In the industrial uses of seawater, additional factors may also be of importance, e.g. *human health* aspects where the products will be used for human consumption, or *biological health*, where marine organisms are included in the process.

ANZECC (2000) concluded, after extensive consultation with representative industrial groups, that no specific guidance for industrial water use will be provided, because industrial water requirements are so varied (both within and between industries) and sources of water for industry have other coincidental environmental values that tend to drive management of the resource. However, industrial water use continues to be a recognised environmental value that has high economic benefit and must therefore be given adequate consideration during the planning and management of water resources.

Proposal for the BCLME region:

It is proposed that industrial water use be recognised as a (beneficial) use of marine waters in the BCLME region. However, as a result of the large variation in water quality requirements that are mainly driven by specific processes and technologies applied by industries, water quality guideline values should be derived site-specifically, based on the specific requirements of industries in the area.

SECTION 6.
RECOMMENDED WATER AND SEDIMENT QUALITY GUIDELINES FOR COASTAL AREAS IN THE BCLME REGION

6.1 RECOMMENDED BENEFICIAL USES

The ultimate goal in marine water quality management is to keep the marine environment suitable (or fit) for all designated uses. To achieve this goal, the quality objectives set for a particular marine environment should be aimed at protecting the biodiversity and functioning of marine aquatic ecosystems, as well as designated uses of the marine environment (also referred to as beneficial uses). It is proposed that three designated uses of marine waters be recognised for the BCLME region, namely:

- Marine aquaculture (including collection of seafood for human consumption)
- Recreational use
- Industrial use.

The recommended water and sediment quality guidelines that are part of this section provide guidance to managers, local governing authorities and scientists to set site-specific environmental quality objectives within a study area for the protection of marine aquatic ecosystems and other designated uses.

A summary of the constituent categories, for which recommended water and sediment quality are provided for different designated uses, as part of this study, is given in Table 6.1.

TABLE 6.1: Summary of constituent categories for the recommended water and sediment quality for different designated uses

TYPE OF QUALITY GUIDELINE		MARINE AQUATIC ECOSYSTEMS	MARINE AQUACULTURE	RECREATION	INDUSTRIAL USES*
Water	Objectionable Matter/ Aesthetics	Yes	Refer to Marine Aquatic Ecosystem Guidelines	Yes	Based on site-specific requirements of industrial use in the area
	Physico-chemical variables	Yes		Refer to Drinking Water Guidelines	
	Nutrients	Yes			
	Toxic substances	Yes			
	Microbiological indicators	-	Yes	Yes	
	Tainting substances	-	Yes	-	
Sediment	Toxic Substances	Yes	Refer to Marine Aquatic Ecosystem Guidelines	-	

* *Refer to Section 5*

As a rule of thumb, it is recommended that the following simple application rules apply:

1. Compliance with quality guideline values for the *Protection of marine aquatic ecosystems* should be aimed at in all coastal waters, except in approved sacrificial zones, e.g. near wastewater discharges and certain areas within harbours.
2. In addition to (1), the classification system recommended for *Marine aquaculture* should be applied in areas where shellfish are collected or cultured for human consumption so as to manage human health risks. The assumption is that the health of the organisms is catered for under the *Protection of marine aquatic ecosystems* (referring to 1).
3. In addition to (1), the aesthetic quality guidelines, as well as the classification system ranking waters in terms of human health risks for *Recreational use,* should be applied in relevant areas. With reference to toxic substances, it is recommended that suitable *Drinking water quality guidelines* be consulted to make preliminary risk assessments, where these substances are expected to present at levels that could pose a risk to human health (following the example of the WHO, 2003).
4. In addition to (1), site-specific water quality guidelines, based on the requirements of local *industries,* should be applied, where and if applicable.

6.2 RECOMMENDED WATER QUALITY GUIDELINES: PROTECTION OF MARINE AQUATIC ECOSYSTEMS

6.2.1 Approach and Methodology

Water quality guidelines for the protection of aquatic ecosystems are recommended for the following constituent categories:

- Objectionable matter
- Physico-chemical variables
- Nutrients
- Toxic substances.

i. Objectionable matter

For objectionable matter, it is recommended that the narrative quality guideline from South Africa be adopted (DWAF, 1995b) (Table 6.2).

TABLE 6.2 Recommended water quality guidelines for objectionable matter (aesthetic) for coastal areas in the BCLME region

PROPERTY	PROPOSED GUIDELINE
Aesthetics	Water should not contain litter, floating particulate matter, debris, oil, grease, wax, scum, foam or any similar floating materials and residues from land-based sources in concentrations that may cause nuisance. Water should not contain materials from non-natural land-based sources which will settle to form objectionable deposits. Water should not contain submerged objects and other subsurface hazards which arise from non-natural origins and which would be a danger, cause nuisance or interfere with any designated/recognized use. Water should not contain substances producing objectionable colour, odour, taste, or turbidity.

ii. Physico-chemical variables

Following the international trend and taking into account the large variability in the physico-chemical characteristics of marine aquatic ecosystems within the BCLME region, it is recommended that water quality guideline values for physico-chemical variables be based on the *Reference system data* and/or *Biological and ecological effects data* approaches (refer to Section 1, Chapter 2).

As it is envisaged that biological and ecological effect data for most physico-chemical variables will be limited for the BCLME region, it is recommended that the emphasis be placed on the *Reference system data* approach and methodology, as applied in ANZECC (2000). This method uses an appropriate percentile (i.e. 20th and/or 80th percentile) of the physico-chemical data collected from a specific site (or an appropriate reference site) to derive water quality guideline value/s. The best approach is to capture such data from a specific area prior to anticipated changes, through well-designed baseline measurement programmes.

Where few reference data are available and seasonal and event influences poorly defined, single guideline values could be derived from available data based on *professional judgement*, as an interim measure.

NOTE:

The South African guidelines provide mainly narrative statements for physico-chemical variables which can easily be accommodated in the above-mentioned approach. Where numerical guidelines are provided, the approach and methodology whereby these were derived are not clear (RSA DWAF, 1995). A more transparent approach is therefore proposed for the larger BCLME region.

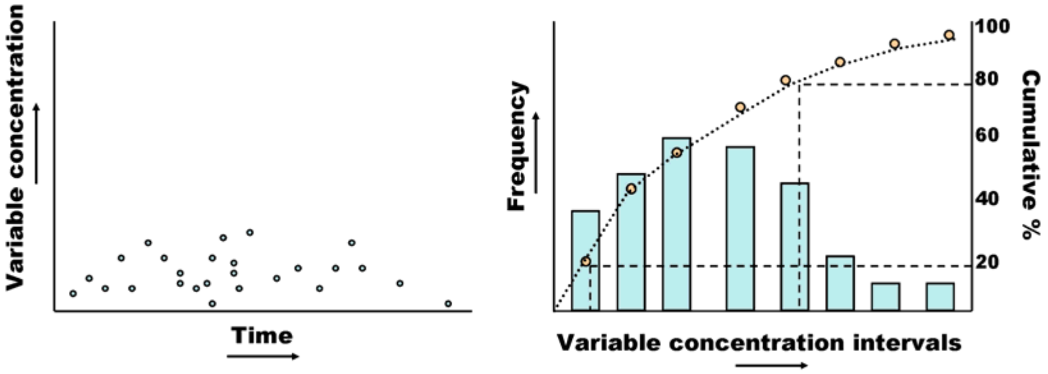
The recommended water quality guidelines for physico-chemical variables for the BCLME region are provided in Table 6.3.

TABLE 6.3 Recommended water quality guidelines for physico-chemical variables in coastal areas of the BCLME region

VARIABLE	PROPOSED WATER QUALITY GUIDELINE
Temperature	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value should be determined as the range defined by the 20%ile and 80%ile of the seasonal distribution for the reference system. Test data: Median concentration for the period
Salinity	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value should be determined as the 20%ile or 80%ile of the reference system(s) distribution, depending upon whether low salinity or high salinity effects are being considered. Test data: Median concentration for the period
pH	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value range should be determined as the range defined by the 20%ile and 80%ile of the seasonal distribution for the reference system. pH changes of more than 0.5 pH units from the seasonal maximum or minimum defined by the reference systems should be fully investigated. Test data: Median concentration for the period
Turbidity Suspended solids	Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline values should be determined as the 80%ile of the reference system(s) distribution. Additionally, the natural euphotic depth (Z_{eu}) should not be permitted to change by more than 10%. Test data: Median concentration for period
Dissolved oxygen	Where an appropriate reference system(s) is available, and there are sufficient data for the reference system, the guideline value should be determined as the 20%ile of the reference system(s) distribution. Where possible, the guideline value should be obtained during low flow and high temperature periods when DO concentrations are likely to be at their lowest. Test data: Median DO concentration for the period, calculated by using the lowest diurnal DO concentrations

Monthly data collected over a two-year period are considered to be sufficient to indicate ecosystem variability and can be used to derive guideline values for variables that do not show large seasonal or event-scale effects. However, in ecosystems in which concentrations of physico-chemical variables and the ecological and biological responses can be influenced by strong seasonal andscale effects, it will be necessary to monitor (and/or model) so as to detect these seasonal influences or events. Therefore, where seasonal or event-driven processes dominate, data need to be grouped and guideline values need to be derived for corresponding key periods.

The concept of using 20th or the 80th percentiles of the reference system(s) distribution is schematically illustrated below:



iii. Nutrients

Taking into account that the impact of nutrients on aquatic ecosystems occurs through transformations and there may, therefore, not be a direct relationship between the ambient nutrient concentration and the biological response, it is recommended that the *Predictive modelling approach* be the preferred method for setting site-specific water quality guidelines in the BCLME region (refer to Section 1, Chapter 2). To be able to derive guideline values for nutrients, it is necessary to also set target values for parameters that could be impacted on, for example, chlorophyll a (indicator of algal blooms), turbidity (as a result of algal blooms) and dissolved oxygen (affected by organic nutrient inputs and subsequent degradation of algal biomass). The recommended water quality guidelines for nutrients, (and related parameters) for the BCLME region are provided in Table 6.4.

TABLE 6.4 Recommended water quality guidelines for nutrients in coastal areas of the BCLME region

VARIABLE	PROPOSED WATER QUALITY GUIDELINE
Chlorophyll a	Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80%ile of the reference system(s) distribution.
Dissolved oxygen	Refer to Table 6.3
Turbidity	Refer to Table 6.3
Nutrients	Nutrient concentrations in the water column should not result in chlorophyll a, turbidity and/or dissolved oxygen levels that are outside the recommended water quality guideline range (see above). This range should be established by using either suitable statistical or mathematical modelling techniques. Alternatively, where a modelling approach may be difficult to implement, nutrient concentrations can be derived using the Reference system data approach: Where an appropriate reference system(s) is available and there are sufficient data for the reference system, the guideline value should be determined as the 80%ile of the reference system(s) distribution.

Where few reference data are available and seasonal and event influences poorly defined, single guideline values could be derived from available data (e.g. information from related areas linking ambient, natural nutrient levels with period of algal blooms) based on *professional judgement*, as an interim measure (i.e. until such time as measurement programmes can be implemented to obtain the desired data).

NOTE:

The South African guidelines provide only a broad narrative statement with regard to nutrients and could easily be accommodated in the above-mentioned approach (RSA DWAF, 1995b).

iv. Toxic substances

For the BCLME region, the Australian and New Zealand approach and methodology are recommended (ANZECC, 2000): In the process of determining a suitable approach and methodology, ANZECC (2000) conducted a critical review of procedures followed elsewhere, many of which are also discussed in this document. Their approach and method are also considered to be most conservative (or rigorous), in that guideline values are derived from No-observable-effects concentration (NOEC) data, rather than Lowest-observable-effects concentration (LOEC) data (as is the case in Canada) (refer to Section 1, Chapter 2).

As it is unlikely that there will be sufficient (and appropriate) toxicological data available from the BCLME region to derive specific guideline values, it is further recommended that the Australian and New Zealand guideline values for toxic substances be adopted until such time as these could be refined for the region (ANZECC, 2000). These are the only guidelines that were refined with data from the southern hemisphere, making them more appropriate to the BCLME region compared with values that were developed for northern hemisphere data only (e.g. for USA, Canada and Europe).

The recommended water quality guidelines for toxic substances for the BCLME region are listed in Table 6.5.

TABLE 6.5 Recommended water quality guidelines for toxic substances for coastal areas in the BCLME region (current South African guideline values listed in brackets where available)

TOXIC SUBSTANCES	RECOMMENDED GUIDELINE VALUE in µg/ℓ
Total Ammonia-N	910 (600)
Total Residual Chlorine-Cl	3
Cyanide (CN^-)	4 (12)
Fluoride(F^-)	(5 000)
Sulfides (S^-)	1
Phenol	400
Polychlorinated Biphenyls (PCBs)	0.03*
Trace metals (as Total metal):	
Arsenic	As(III) - 2.3; As(V) - 4.5 (12)
Cadmium	5.5 (4)
Chromium	Cr (III) - 10; Cr (VI) - 4.4 (8)
Cobalt	1
Copper	1.3 (5)
Lead	4.4 (12)
Mercury	0.4 (0.3)
Nickel	70 (25)
Silver	1.4 (5)
Sn (as Tributyltin)	0.006
Vanadium	100
Zinc	15 (25)
Aromatic Hydrocarbons (C6-C9 simple hydrocarbons - volatile):	
Benzene (C6)	500
Toluene (C7)	180
Ethylbenzene (C8)	5
Xylene (C8)	Ortho - 350; Para - 75; Meta - 200
Naphthalene (C9)	70
Poly-Aromatic Hydrocarbons (< C15 - acute toxicity with short half-life in water)	
Anthracene (C14)	0.4
Phenanthrene (C14)	4
Poly-Aromatic Hydrocarbons (> C15, chronic toxicity, with longer half-life in water)	
Fluoranthene (C15)	1.7
Benzo(a)pyrene (C20)	0.4
Pesticides:	
DDT	0.001
Dieldrin	0.002
Endrin	0.002

* *No values are recommended in ANZECC (2000) – interim values derived from the US-EPA criteria (2002a)*

NOTE:

Although the target values recommended for South Africa (RSA DWF, 1995b) (listed in brackets in Table 6.5) are within the same order as most of the ANZECC guidelines, the selection criteria of the South African guidelines are not transparent, other than that Maximum Acceptable Toxicant Concentrations (MATC) were used – the South African values were also last updated in 1984. For the larger BCLME region, it is therefore recommended that a more recent and more transparent approach be selected.

6.2.2 Protocol for Implementation

Following international best practice, it is recommended that water quality guidelines for the protection of marine aquatic ecosystems in the BCLME region be applied as benchmarks, following a risk assessment or phased approach as illustrated in Figure 6.1.

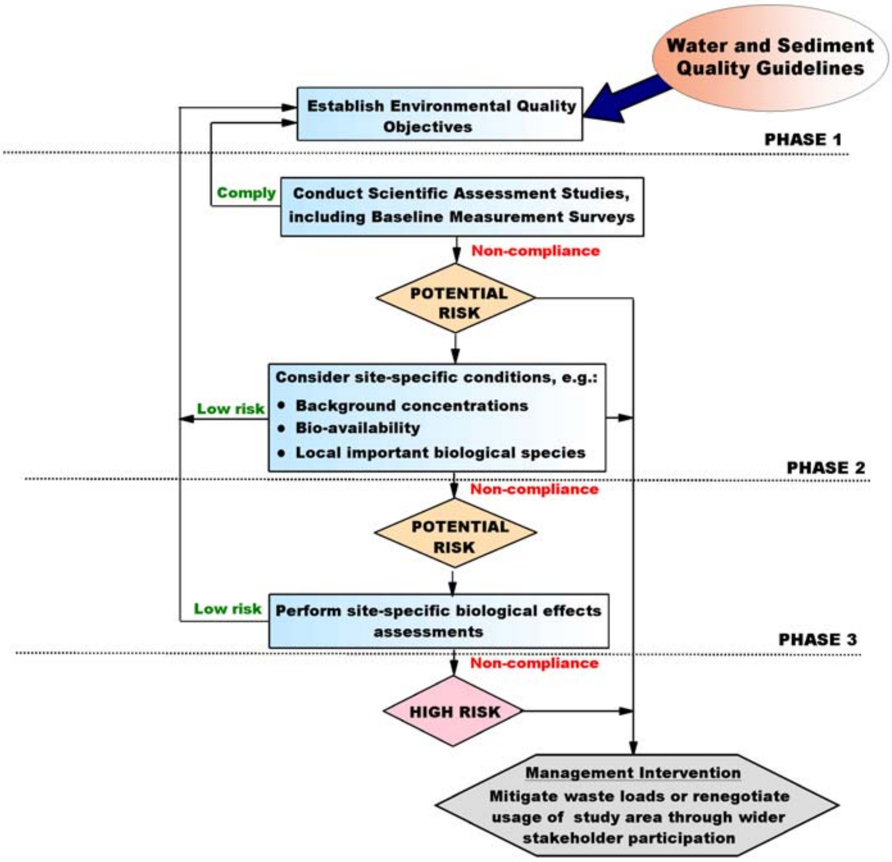


Figure 6.1: Schematic illustration of the recommended implementation process of recommended water quality guidelines in the coastal zone of the BCLME region

Where scientific assessments studies or monitoring results reveal that recommended quality guideline values are exceeded, this should trigger the incorporation of additional information or further investigation to determine whether or not a real risk to the ecosystem exists, and, where necessary, to adjust the guideline values for site-specific conditions (refer to Section 1, Chapter 3).

Quality guideline values should be compared with the <u>median</u> of the measured or simulated data set. Where a guideline value was based on professional judgement, the rationale for the selection of such a value should be provided and a process should be put in place whereby the adopted value is reviewed and supported or modified in light of emerging information, following the principle of adaptive management.

6.3 RECOMMENDED SEDIMENT QUALITY GUIDELINES: PROTECTION OF MARINE AQUATIC ECOSYSTEMS

6.3.1 Approach and Methodology

Sediment quality guideline values are generally only specified for the protection of aquatic ecosystems, in particular for toxic substances.

For the BCLME region, it is recommended that the Canadian protocol (which incorporates the National Trends and Status Program Approach) be adopted for the derivation of sediment quality guidelines (CCME, 1995). Although this approach does have limitations (as discussed earlier), it appears to be accepted worldwide as the preferred option (CCME, 1995; NOAA, 1999; ANZECC, 2000) (refer to Section 2, Chapter 2).

Whilst it is unlikely that there will be sufficient (and appropriate) toxicological data available from the BCLME region to refine sediment guideline values, it is further recommended that the NOAA guidelines (TEL/PEL), as per MacDonald *et al.* (1996), be adopted as interim sediment quality guidelines for toxic substances until such time as these could be refined for the region. MacDonald *et al.* (1996) expanded the original database used by Long *et al.* (1995) with additional data on saltwater and also revised the database by carefully screening data.

Also, studies on the reliability and predictability of these thresholds found that they provided reliable and predictive tools for identifying concentrations of chemicals in sediments that are unlikely to be associated with adverse biological effects (to test predictability a large independent data set compiled from studies of the Atlantic, Gulf and Pacific coasts was used). It was concluded that these guidelines provide a scientifically defensible basis for assessing the quality of soft sediments in marine and estuarine environments (Long and MacDonald, 1998).

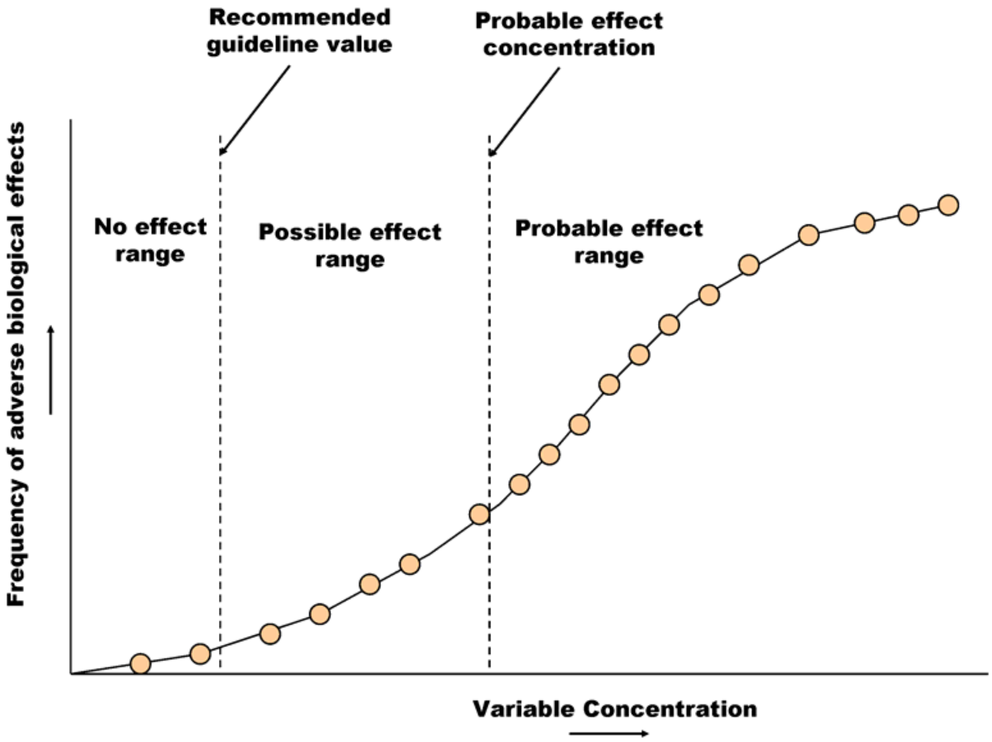
The recommended (interim) sediment quality guidelines for toxic substances for the BCLME region are listed in Table 6.6.

TABLE 6.6 Recommended interim sediment quality guidelines for the Protection of marine aquatic ecosystems in coastal areas of the BCLME region

TOXIC SUBSTANCES	RECOMMENDED GUIDELINE VALUE	PROBABLE EFFECT CONCENTRATION
TRACE METALS (mg/kg dry weight)		
Antimony	-	-
Arsenic	7.24	41.6
Cadmium	0.68	4.21
Chromium	52.3	160
Copper	18.7	108
Lead	30.2	112
Mercury	0.13	0.7
Nickel	15.9	42.8
Silver	0.73	1.77
Tin as Tributyltin-Sn*	0.005	0.07
Zinc	124	271
TOXIC ORGANIC COMPOUNDS (µg/kg dry weight normalized to 1% organic carbon)		
Total PAHs	1684	16770
Low Molecular PAHs	312	1442
Acenaphthene	6.71	88.9
Acenaphthalene	44	640
Anthracene	46.9	245
Fluorene	21.2	144
2-methyl naphthalene	-	-
Naphthalene	34.6	391
Phenanthrene	86.7	544
High Molecular Weight PAHs	655	6676
Benzo(a)anthracene	74.8	693
Benzo(a) pyrene	88.8	763
Dibenzo(a,h)anthracene	6.22	135
Chrysene	108	846
Fluoranthene	113	1494
Pyrene	153	1398
Toxaphene	-	-
Total DDT	3.89	51.7
p p DDE	2.2	27
Chlordane	2.26	4.79
Dieldrin	0.72	4.3
Total PCBs	21.6	189

* *Guidelines for tributyltin were estimated on the basis of equilibrium partitioning, based on data summarised from the US-EPA (ANCEZZ, 2000)*

By deriving two threshold values (i.e. a recommended guideline value and a probable effect concentration), three ranges of concentration are defined, namely, those that are rarely, occasionally and frequently associated with adverse biological effects as illustrated below:



6.3.2 Protocol for Implementation

Similar to the implementation practice recommended for water quality guidelines, it is recommended that sediment quality guidelines for the BCLME region be applied as benchmarks, following a risk assessment or phased approach: When scientific assessment studies or monitoring indicate that the recommended quality guideline values are exceeded, this should trigger the incorporation of additional information or further investigation to determine whether or not a real risk to the ecosystem exists, and, where necessary, to adjust the guideline values for site-specific conditions (refer to Section 2, Chapter 3). The recommended approach is schematically illustrated in Figure 6.1.

As with water quality guidelines, sediment quality guidelines are valuable tools for assisting in managing complex systems (such as an aquatic marine ecosystem) in a phased approach. As part of the initial phase, guidelines provide a means of 'screening' for potential adverse biological effects related to sediment quality.

6.4 RECOMMENDED WATER QUALITY GUIDELINES: MARINE AQUACULTURE

6.4.1 Approach and Methodology

In terms of water quality guidelines for marine aquaculture, the following key issues are considered:

- Protection of the health of the aquatic ecosystem so as to ensure sustainable production and quality of products
- Protection of the health of human consumers
- Tainting of seafood products.

With reference to the protection of aquatic organisms used in the culture and harvesting of seafood, it is recommended that the water quality guidelines proposed for the ***Protection of aquatic ecosystems*** be applied (refer to Section 6, Chapter 1), rather than developing a separate series of quality guidelines. This simplified approach seems to be the international trend, particularly where these activities rely on natural stocks. It is also current practice in South Africa (RSA DWAF, 1995b).

With reference to the protection of human consumers, it is proposed that the allowable limits of toxic substances and human pathogens in food products be controlled through legislation, as is the norm internationally (refer to Section 3, Chapter 2). Where such standards are currently not in place in countries in the BCLME region, it is recommended that the relevant government departments be approached to initiate such legislation.

In terms of shellfish growing areas, it is proposed that the water quality guidelines put forward by the US-EPA (and which have been adopted by most other countries) also be adopted for the BCLME region (US-EPA, 1986a) (Table 6.7). However, these guidelines must be supported by a sanitary survey (as is illustrated in Chapter 4.2 of this Section), as well as legislation specifying acceptable quality of shellfish meat (see above).

NOTE:

> ***Shellfish exported to the European Union must comply with the standards laid down in the Shellfish Directive (CEC, 1991).***
>
> ***In the USA, shellfish imports must meet both Federal and State requirements to gain free access to US markets. In addition, fresh and fresh frozen molluscan shellfish products must meet the specific temperature, microbiological, and identification standards contained in the NSSP. The NSSP standards have been adopted into state law and are enforced by both federal and state officials. The NSSP standards apply equally to both domestic and imported fresh and frozen shellfish (FDA, 2003).***

TABLE 6.7 Recommended microbiological indicator guidelines for areas where shellfish are collected or cultured for direct human consumption in the BCLME region

INDICATOR	PROPOSED WATER QUALITY GUIDELINE
Faecal coliform	Median concentrations should not exceed 14 Most Probable Number (MPN) per 100 ml with not more than 10% of the samples exceeding 43 MPN per 100 ml for a 5-tube, 3-dilution method.

NOTE:

> ***The target values recommended for South Africa (DWAF, 1995b) differ slightly:***
>
> ***Maximum acceptable faecal coliform count should be (using the membrane filtering technique):***
>
> - ***20 for 80% of the samples (i.e. median values)***
> - ***60 in 90% of the samples (i.e. less than 10 % should exceed this value)***
>
> ***The 1984 guideline values that were recommended for shellfish water for South Africa closely resembled those of the US-EPA and others (Lusher, 1984):***
>
> ***Maximum acceptable faecal coliform count should be:***
>
> - ***15 for 50% of the samples (i.e. median values)***
> - ***45 in 90% of the samples (i.e. less than 10 % should exceed this value)***
>
> ***In 1992, the Water Research Commission convened a two-day workshop to review these guidelines. This workshop was attended by a broad spectrum of representatives from the scientific/engineering community, national and local authorities, industries and environmental organisations (DWAF, 1992). At this workshop, specialists modified the South African guidelines to the current values. Unfortunately, no clear reasoning for this change was documented at the time.***

Estimated threshold concentrations for tainting substances, as listed for South Africa, Australia and New Zealand and by the US-EPA (RSA, DWAF, ANCEZZ, 2000; US-EPA, 2002a), can also be used to provide guidance in the BCLME region (Table 6.8).

TABLE 6.8 Recommended guidelines for tainting substances in areas used for marine aquaculture in the BCLME region

TAINTING SUBSTANCE	THRESHOLD CONCENTRATIONS ABOVE WHICH TAINTING IS LIKELY TO OCCUR (mg/ℓ)
Acenaphthene	0.02
Acetophenone	0.5
Acrylonitrile	18
Copper	1
m-cresol	0.2
o-cresol	0.4
p-cresol	0.12
Cresylic acids (meta, para)	0.2
Chlorobenzene	-
n-butylmercaptan	0.06
o-sec. butylphenol	0.3
p-tert. butylphenol	0.03
2-chlorophenol	0.001
3-chlorophenol	0.001
3-chlorophenol	0.001
o-chlorophenol	0.001
p-chlorophenol	0.01
2,3-dinitrophenol	0.08
2,4,6-trinitrophenol	0.002
2,3 dichlorophenol	0.00004
2,4-dichlorophenol	0.001
2,5-dichlorophenol	0.023
2,6-dichlorophenol	0.035
3,4-dichlorophenol	0.0003
2-methyl-4-chlorophenol	0.75
2-methyl-6-cholorophenol	0.003
3-methyl-4-chlorophenol	0.02 – 3
o-phenylphenol	1
Pentachlorophenol	0.03
Phenol	1
2,3,4,6-tetrachlorophenol	0.001
2,4,5-trichlorophenol	0.001
2,3,5-trichlorophenol	0.001
2,4,6-trichlorophenol	0.003
2,4-dimethylphenol	0.4
Dimethylamine	7
Diphenyloxide	0.05
B,B-dichlorodiethyl ether	0.09
o-dichlorobenzene	< 0.25
p-dichlorobenzene	0.25
Ethylbenzene	0.25
Momochlorobenzene	0.02
Ethanethiol	0.24
Ethylacrylate	0.6
Formaldehyde	95
Gasoline/Petrol	0.005
Guaicol	0.082
Kerosene	0.1
Kerosene plus kaolin	1
Hexachlorocyclopentadiene	0.001
Isopropylbenzene	0.25

TAINTING SUBSTANCE	THRESHOLD CONCENTRATIONS ABOVE WHICH TAINTING IS LIKELY TO OCCUR (mg/ℓ)
Naphtha	0.1
Naphthalene	1
Naphthol	0.5
2-Naphthol	0.3
Nitrobenzene	0.03
a-methylstyrene	0.25
Oil, emulsifiable	15
Pyridine	5
Pyrocatechol	0.8
Pyrogallol	0.5
Quinoline	0.5
p-quinone	0.5
Styrene	0.25
Toluene	0.25
Outboard motor fuel as exhaust	0.5
Zinc	5

6.4.2 Protocol for Implementation

It is recommended that a classification system for shellfish growing areas be adopted for the BCLME region (refer to Section 3, Chapter 3).

It is envisaged that the location of major export markets may eventually dictate the approach that will have to be followed. It is, therefore, recommended that a dedicated task team, consisting of marine aquaculture specialists and responsible authorities from the different countries in the BCLME region, be convened to decide on the final approach for the classification of shellfish growing areas in the BCLME (e.g. a task group). This process has already been initiated as part of another project in the BCLME Programme (Project EV/HAB/04/Shellsan – *Development of a shellfish sanitation programme model for application in consort with the microalgal toxins component*). This project is being undertaken under the leadership of the Ministry of Fisheries and Marine Resources, Namibia.

In the interim, unless dictated otherwise, it is recommended that the National Shellfish Sanitation Program (NSSP) approach, applied by the United States Food and Drug Administration, be followed for the classification of shellfish growing areas in the BCLME region (US-FDA, 2003). This approach is considered to be the most practical in terms of implementation, as it classifies areas on the basis of the condition of the waters in the growing area, rather than, for example, the European Union's approach, which classifies areas on the basis of levels of contaminants in shellfish flesh. The NSSP's approach is also the most widely used internationally (refer to Section 3, Chapter 3). The NSSP approach also tends to move away from the traditional approach of classifying waters as either safe or unsafe for shellfish culture or harvesting (based on a percentage compliance with faecal index organism) to a ranking approach.

The classification of coastal and estuarine areas for the harvesting of shellfish (e.g. clams, oysters, scallops, mussels and other bivalve molluscs) is based on the results for Sanitary Surveys that consist of:

- Identification and evaluation of all potential and actual pollution sources (Shoreline Survey) — this survey describes the studies required to identify and quantify pollution sources and estimate the movement, dilution and dispersion of pollutants in the receiving environment
- Monitoring of growing waters and shellfish to determine the most suitable classification for the shellfish harvesting area (Bacteriological Survey) — this survey refers to the measurement of faecal indicator levels in the growing areas.

Resurveys are conducted regularly to determine if sanitary conditions have undergone significant change.

The recommended classification system for the BCLME region is provided in Tables 6.9 and 6.10.

TABLE 6.9 Recommended (interim) classification system of shellfish growing areas in the BCLME region

CLASS	DESCRIPTION
Approved	Approved areas need to be free from pollution and shellfish from such areas are suitable for direct human consumption of raw shellfish.
Conditionally approved/restricted	Where areas are subjected to limited, intermittent pollution caused by discharges from wastewater treatment facilities, seasonal populations, non-point source pollution, or boating activity they can be classified as conditionally approved or conditionally restricted. However, it must be shown that the shellfish harvesting area will be open for the purposes of harvesting shellfish for a reasonable period of time and the factors determining this period are known, predictable and are not so complex as to preclude a reasonable management approach. When 'open' for shellfish harvesting for direct human consumption, the water quality in the area must comply with the limits as specified for 'Approved' area. When 'closed' for direct consumption but 'open' for harvesting for relaying or depuration, the requirements of 'Restricted' area must be met. At times when the area is 'closed' for all harvesting, then the requirements of 'Prohibited Areas' apply.
Restricted	Restricted areas are subject to a limited degree of pollution. However, the level of faecal pollution, human pathogens and toxic or deleterious substances

	is such that shellfish can be made fit for human consumption by either relaying or depuration.
Prohibited	An area is classified as 'Prohibited' for shellfish harvesting if no comprehensive survey has been conducted or where a survey finds that the area is: • adjacent to a sewage treatment plant outfall or other point source outfall with public health significance • contaminated by (an) unpredictable pollution source(s) • contaminated with faecal waste so that the shellfish may be vectors for disease micro-organisms • affected by algae which contain biotoxin(s) sufficient to cause a public health risk • contaminated with poisonous or deleterious substances whereby the quality of shellfish may be affected. NOTE: Where an event such as a flood, storm or marine biotoxin outbreak occurs in either 'Approved' or 'Restricted' areas, these can also be classified as temporarily 'Prohibited' areas.

TABLE 6.10: Summary of requirements associated with each class in the recommended (interim) classification system of shellfish growing areas in the BCLME region

CLASS	REQUIREMENTS*
Approved	A sanitation survey must be completed according to specification to be reviewed annually. The area shall not be contaminated with faecal coliform (as listed) and shall not contain pathogens or hazardous concentrations of toxic substances or marine biotoxins (an approved shellfish growing area may be temporarily made a prohibited area, e.g. when a flood, storm or marine biotoxin event occurs). Evidence of potential pollution sources, such as sewage lift station overflows, direct sewage discharges, septic tank seepage, etc., is sufficient to exclude the growing waters from the approved category. Faecal coliform median/geometric mean of water sample results must not exceed 14/100 ml and the estimated 90th percentile must not exceed 21/100 ml (using Membrane Filtration) or 14/100 ml and the estimated 90th percentile must not exceed 43/100 ml for a 5 tube decimal dilution test, or 49/100 ml for a 3 tube decimal dilution test (using Most Probable Number [MPN]) Total coliform median/geometric mean of water sample results must not exceed 70/100 ml and the estimated 90th percentile must not exceed 230/100 ml for a 5 tube decimal dilution test, or 330/100 ml for a 3 tube decimal dilution test (using MPN).
Conditionally approved/restricted	Factors determining this period are known, predictable and are not so complex as to preclude a reasonable management approach. A management plan must be developed for every conditionally approved/restricted area. When 'open' for shellfish harvesting for direct human consumption, the water quality in the area must comply with the limits as specified for 'Approved' area. When 'closed' for direct consumption but 'open' for harvesting for relaying or depuration, the requirements of 'Restricted' area must be met. At times when the area is 'closed' for all harvesting, then the requirements of 'Prohibited Areas' apply.
Restricted	Faecal coliform median/geometric mean of water sample results must not exceed 70/100 ml and the estimated 90th percentile must not exceed 85/100 ml (using Membrane Filtration) or 88/100 ml and the estimated 90th

CLASS	REQUIREMENTS*
	percentile must not exceed 260/100 ml for a 5 tube decimal dilution test, or 300/100 ml for a 3 tube decimal dilution test (using MPN) Total coliform median/geometric mean of water sample results must not exceed 700/100 ml and the estimated 90th percentile must not exceed 2300/100 ml for a 5 tube decimal dilution test, or 3300/100 ml for a 3 tube decimal dilution test (using MPN)
Prohibited area	No requirements specified

*: *The implementation and interpretation of the microbiological limits are subject to some understanding of statistical shortcomings which are discussed in further detail in US FDA, 2003)*

6.5 RECOMMENDED WATER QUALITY GUIDELINES: RECREATION

6.5.1 Approach and Methodology

In terms of water quality, the following key aspects are important in relation to recreational use of coastal waters:

- Aesthetics
- Protection of human health relating to toxic substances
- Protection of human health relating to microbiological contaminants.

For the BCLME region, it is recommended that water quality guidelines for recreational areas be provided for aesthetic quality (narrative), as well as for microbiological indicators. With reference to toxic substances, it is recommended that suitable *Drinking water quality guidelines* be consulted to make preliminary risk assessments in areas where these substances are expected to be present at levels that pose a risk to human health (following the example of the WHO, 2003). Drinking-water quality guidelines relate, in most cases, to lifetime exposure following consumption of 2 litres of drinking-water per day. For recreational water contact, an intake of 200 ml per day—100 ml per recreational session with two sessions per day—may often be reasonably assumed (this approach may, however, not apply to substances of which the effects are related to direct contact with water, e.g. skin irritation) (refer to Section 4, Chapter 2).

For aesthetics, it is proposed that the narrative guidelines from South Africa be adopted (DWAF, 1995b) (Table 6.2).

As for microbiological indicators, it is recommended that both *E. coli* and Enterococci (faecal streptococci) be used as indicator organisms. The reasoning is that, although Enterococci is considered to be most suitable for marine waters, instances have been documented in which *E. coli* may be more suitable, e.g. where faecal pollution originates from a waste stabilisation pond (WSP). Also, in South Africa, *E. coli* (faecal coliforms) have been used as indicator organisms for several years and it will therefore be crucial to run a dual system, for continuity. In this regard, research undertaken by the WHO indicated that *E. coli* to Enterococci ratios ranging from 2 to 3 reflect equal risk (CEC, 2002).

It is also recommended that, instead of using 'single' target values that classify a beach either 'safe' or 'unsafe', a range of target values be derived corresponding to different levels of risk. As it is envisaged that there will not be sufficient epidemiological data from the BCLME region to customise values for the region, it is recommended that the risk-based target values of the WHO (2003) be adopted (Table 6.11).

TABLE 6.11: Recommended water quality guidelines for microbiological indicator organisms versus risk rates for coastal areas in the BCLME region

CATEGORY	95th PERCENTILE OF ENTEROCOCCI per 100 ml*	ESTIMATED RISK PER EXPOSURE
A	<40	<1% gastrointestinal (GI) illness risk <0.3% acute febrile respiratory (AFRI) risk
B	40 – 200	1–5% GI illness risk 0.3–1.9% AFRI risk
C	201 – 500	5–10% GI illness risk 1.9–3.9% AFRI risk
D	> 500	>10% GI illness risk >3.9% AFRI risk

6.5.2 Protocol for Implementation

It is recommended that the BCLME region adopt a beach classification system, rather than the traditional approach of classifying recreational waters as either safe or unsafe (based on a percentage compliance with a faecal indicator organism). With reference to water quality, the classification should be based on both a sanitary survey, as well routine microbiological surveys. The classification rating should be re-evaluated on an annual basis (refer to Section 4, Chapter 4).

An example of a sanitary survey checklist is provided in the document of the New Zealand Minister of Environment (2003) (www.mfe.govt.nz/publications/water/microbiological-quality-jun03/).

In this regard, it is recommended that the classification system of the WHO (2003) and New Zealand (New Zealand Minister of Environment, 2003) be adopted, as it is currently the most widely used worldwide (Table 6.12).

NOTE

In the microbial water quality assessment, the sampling programme should be representative of the range of conditions in the recreational water environment while it is being used and a sufficient number of samples should be collected. The precision of the estimate of the 95th percentile is higher when sample numbers are increased. For example, the number of results available can be increased significantly by pooling data from multiple years, unless there is reason to believe that local (pollution) conditions have changed. For practical purposes, data on at least 100 samples from a 5-year period and a rolling 5-year data set can be used for water quality assessment purposes.

TABLE 6.12: Recommended classification system for recreational areas in coastal areas of the BCLME region

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="5">Microbiological Quality Assessment Category
(95th percentile enterococci/100 ml – refer to Table 6.11)</td></tr>
<tr><td>A
(<40)</td><td>B
(41-200)</td><td>C
(201-500)</td><td>D
(>500)</td><td>Exceptional circumstances</td></tr>
<tr><td rowspan="6">Sanitary Inspection Category</td><td>Very Low</td><td>Very good</td><td>Very good</td><td>Fair</td><td>Follow-up</td><td rowspan="5">Action</td></tr>
<tr><td>Low</td><td>Very Good</td><td>Good</td><td>Fair</td><td>Follow-up</td></tr>
<tr><td>Moderate</td><td>Good</td><td>Good</td><td>Fair</td><td>Poor</td></tr>
<tr><td>High</td><td>Good</td><td>Fair</td><td>Poor</td><td>Very poor</td></tr>
<tr><td>Very high</td><td>Follow-up</td><td>Fair</td><td>Poor</td><td>Very poor</td></tr>
<tr><td>Exceptional circumstances</td><td colspan="5">Action</td></tr>
</table>

In addition to a classification system, it is also recommended that a day-to-day management system be adopted. In this regard, the New Zealand approach is considered to be most useful (New Zealand Minister of Environment, 2003) (Figure 6.2).

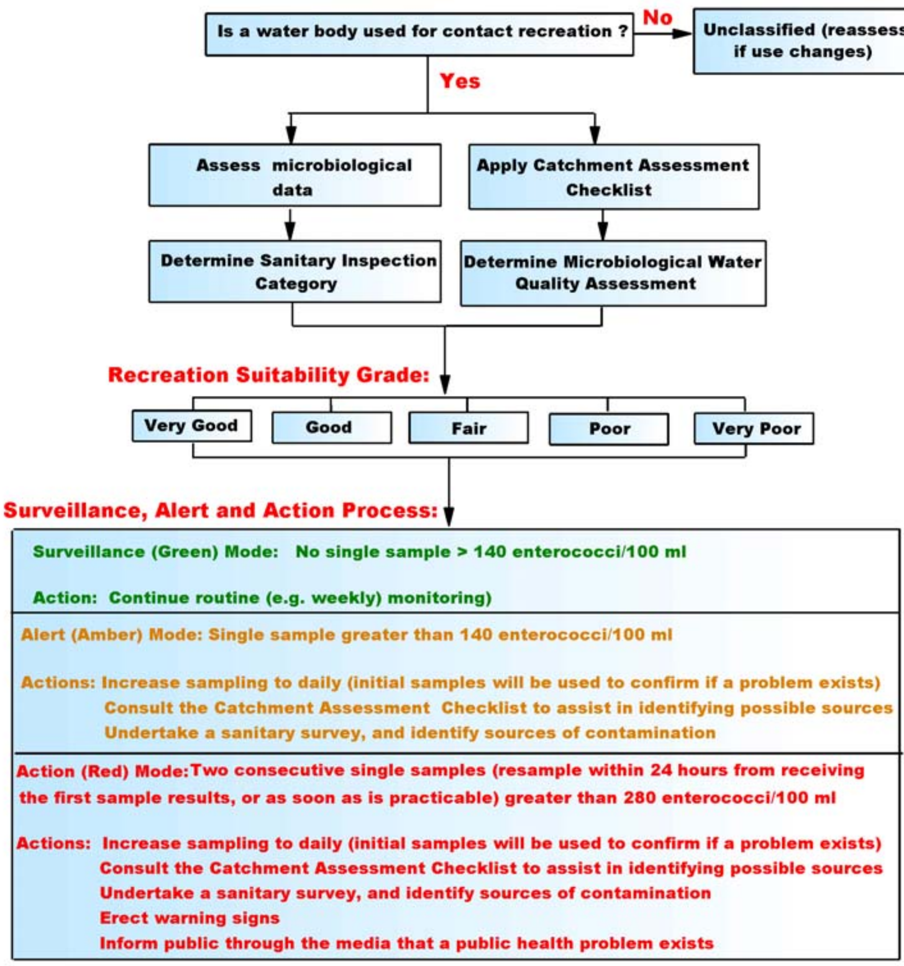


Figure 6.2: Grading, surveillance, alert and action process for the management of recreational use of marine waters recommended for the BCLME region

Where beaches are earmarked as (international) tourist destinations, authorities are encouraged to subscribe to the Blue Flag Initiative, not only to provide safe beaches, but also as marketing tool (FEE, 2004).

SECTION 7.
THE WAY FORWARD

The main purpose of this project was to develop a set of recommended water and sediment quality guidelines for a range of biogeochemical and microbiological quality variables in order to sustain natural ecosystem functioning, as well as support designated beneficial uses, in coastal areas of the BCLME region. A further aim was to recommend best practice protocols for the implementation (or application) of these quality guidelines in the management of the coastal areas in the BCLME region.

The above were achieved through a critical review of international water and sediment quality guidelines and of international best practice in terms of the implementation of quality guidelines in the management of coastal areas (Sections 1 to 5).

The recommended set of water and sediment quality guidelines for coastal areas of the BCLME regions (Section 6) was distilled from what was considered international best practice, but what would also be practical and applicable to the coastal areas of the BCLME region. As information is developed further for specific conditions in the BCLME region, these guidelines may be modified, following the principle of adaptive management.

An important secondary objective was to get acceptance from key stakeholders in the three countries on the proposed guidelines and protocols. This was achieved through work sessions held in each of the three countries to which key stakeholders were invited. At the work sessions, the proposed guidelines and protocols were introduced and participants were given the opportunity to provide their input. This was followed by training workshops in each of the three countries, where key stakeholders were given preliminary training in the application quality guidelines in the context of a marine water quality management framework.

The quality guidelines and protocols were also included in an updatable web-based information system that was developed jointly for this project and BCLME Project BEHP/LBMP/03/01 - *Baseline assessment of sources and management of marine pollution*.

The following points relate to the way forward:

- The recommended guidelines still need to be **officially approved and adopted** by responsible authorities in each of the three countries. It may well be that individual countries require further refinement or adjustment of these guidelines to meet requirements that might be specific to their own countries.

In the case of South Africa, the *South African Water Quality Guidelines for Coastal Marine Waters* (DWAF, 1995b) will still stand as the country's official guidelines. However, although the 1995 documents provide extensive background information, necessary for the application of water quality guidelines that are still valid, the recommended guideline values for different variables are essentially still the same as when proposed in 1984 (Lusher, 1984; RSA DWAF, 1992). It is therefore recommended that the South African water quality guidelines be re-evaluated by the relevant authorities, taking into account latest international practice. The outputs from this study can also be used as a starting point in this regard.

- The quality guidelines and protocols developed as part of this project **form an integral part of the management framework for land-based marine pollution sources** (developed as part of another BCLME project – BEHP/LBMP/03/01). The project's particular link to the framework is through the establishment of environmental quality objectives.

  In the interim, until such time as a management framework and quality guidelines have been incorporated in official government policy, it is proposed that the quality guidelines developed as part of this project, together with the proposed management framework (referring to Project BEHP/LBMP/03/01), be applied as preliminary tools towards improving the management of the water quality in coastal areas of the BCLME region.

- In adopting official water and sediment quality guidelines, it is recommended that preferred **analytical methods** for different chemical and microbiological variables also be included. Although techniques should be scientifically sound, it is also important that constraints with regard to infrastructure and analytical facilities within each of the three countries be taken into account. In this regard, analytical scientists with relevant expertise in marine analytical techniques need to be consulted (as this aspect was not within the scope of the current project).

NOTE:

The following literature can be consulted for details on analytical procedures pertaining to marine environmental samples:

- *Grasshoff et a.l (1999) – Methods of seawater analysis*
- *Strickland and Parsons (1972) – A practical handbook of seawater analysis*
- *Jones and Laslett (1994) – Methods for analysis of trace metals in marine and other samples*
- *Waldock et al. (1989) - The determination of total tin and organotin compounds in environmental samples*
- *Kelly et al. (2000) - Methods for analysis for hydrocarbons and polycyclic aromatic hydrocarbons (PAH) in marine samples*

- The **updatable web-based information system** (temporary web address www.wamsys.co.za/bclme), which was developed as part of this project, can be a very useful decision-support and educational tool for marine water quality management in the coastal areas of the BCLME region. However, its usefulness in the future will rely strongly on the system being maintained and updated regularly. It is therefore important that a dedicated 'administrative home' for the system be provided once this project is terminated. In the short to medium term, it is recommended that one or more of the BCLME offices within the three countries take on this responsibility.

- Although training workshops did form part of this project, they targeted only a limited number of stakeholders in each of the three countries. To facilitate wider capacity building in the BCLME region on management of marine pollution in coastal areas, it is strongly recommended that the output of this project be included in a **training course**. In this regard, the *Train-Sea-Coast/Benguela Course Development Unit* is considered the ideal platform through which to develop and present such training (www.ioisa.org.za/tsc/index.htm).

SECTION 8.
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