ENSEMBLE METHOD FOR ASSESSMENT OF MARINE ENVIRONMENT QUALITY

G.Monakhova, Russia, Dagestan State University
E.Chuiko, Russia, North Caspian Directorate for Provision at Sea / Technical Ensurance
L.Degtyareva, Russia, Caspian Research Institute for Fisheries
M.Voynova, Russia, Caspian Marine Scientific Research Center

I. INTRODUCTION

The "ensemble" described in this research includes methods for quality assessment (estimation) of marine water and bottom sediments used in the Caspian Marine Scientific Research Center (KaspMNIZ) for the estimation of marine environment quality in the areas of HC search, prospecting and extraction in the Caspian Sea. Some of these methods were developed in the Center.

II. ENSEMBLE METHOD

The following parameters are used as a criterion (C_k) to estimate the quality of marine water and bottom sediments:

- **a) maximum permissible concentration (MPC, C_l) of pollutants (P)**
- **b) background concentration of pollutants (C_f) and the difference between it and MPC ($\Delta_{lf} = C_l - C_f$)**
- **c) typical concentration of pollutants (C_t) and the difference between it and MPC ($\Delta_{lt} = C_l - C_t$);**
- **d) characteristic concentration of pollutants (C_{ch}) and the difference between it and MPC ($\Delta_{lch} = C_l - C_{ch}$)**

At the first stage of the marine environment estimation the actual concentration of the i^{th} pollutant in the j^{th} point of the spatial - temporal continuum is compared to the criterion of marine quality estimation (we offer to denote the result of this comparison as D_{ij}) (table 1).

Table 1

Methods used for comparing pollutants actual concentration with the criteria of marine environment quality estimation

##	Criterion	Comparison method
1	C_l	C_{ij} / C_l
2	C_f	C_{ij} / C_f
3	C_t	C_{ij} / C_t
4	C_{ch}	C_{ij} / C_{ch}
5	Δ_{lf}	$(C_{ij} - C_f) / (C_l - C_f)$
6	Δ_{lt}	$(C_{ij} - C_t) / (C_l - C_t)$
7	Δ_{lch}	$(C_{ij} - C_{ch}) / (C_l - C_{ch})$

At the second stage the obtained values Dij are averaged for the time series (T) and/or spatial field (S) by calculating the mean arithmetic (Xi) or mean geometric (Gi) value for each pollutant substance separately. This mode of averaging has been chosen because D_{ij} can take positive, zero and negative values and to compact the distribution of D_{ij}. (table 2).

Table 2

A unified scale for interpreting mono-criterion estimates into multi-criteria estimates

Verbal assessment	Score estimate	Variation intervals G_i			
		G_i to C_l	G_i to C_f	G_i to Δ_l*	
				If $C_l > \Delta_l$	If $C_l < \Delta_l$
Clean	0	$G_i \le 1.0$	$G_i \le 2.0$	G_i** ≤ 1.0	$G_i \ge 1.0$
Moderately polluted	1	$1.0 < G_i \le 2.0$	$2.0 < G_i \le 3.0$	$1.0 < G_i \le 2.0$	$-1.0 \le G_i < 1.0$
Polluted	2	$2.0 < G_i \le 3.0$	$3.0 < G_i \le 4.0$	$2.0 < G_i \le 3.0$	$-1.0 \le G_i < -3.0$
Dirty	3	$3.0 < G_i \le 5.0$	$4.0 < G_i \le 5.0$	$3.0 < G_i \le 5.0$	$-3.0 \le G_i < -5.0$
Very dirty	4	$G_i > 5.0$	$G_i > 5.0$	$G_i > 5.0$	$G_i < -5.0$

Note: Δ_l* means Δ_{lf} or Δ_{lt} or Δ_{lch}; ** G_i here can take negative values

The following stage is the calculation of the multi-criteria estimate $\mathbf{E_k}$ value, where the scores obtained by different methods are summarized and divided by the number of the methods applied.

To completely estimate marine environment quality, we recommend to introduce three types of E values :

1	2	3
• $E_1 = E_{ki}/n$	• $E_2 = E_{ki}/N$	• $E = \max E_{ki}$

where n – is the total number of factors; N – is the number of factors, which $E_{ki} > 1$; max E_{ki} – is the maximum value of E_{ki}.

The results of the ensemble assessment (estimation) of the marine environment can be best presented as a matrix, which columns are criteria and rows are pollution factors. The number of criteria should be at least 3 and the number of factors - at least 5. The results (estimates) of the ensemble assessment are fractional. To compare verbal quality assessment and fractional and integer estimates (table 2) we use the scale presented in table 3.

Table 3

Scale for interpreting marine environment quality assessments and estimates

Quality class	Verbal quality assessment	Fractional quality estimate
First	Clean environment	Less than 0.50
Second	Moderately polluted environment	ranging from 0.51 to 1.50
Third	Polluted environment	ranging from 1.51 to 2.50
Fourth	Dirty environment	ranging from 2.51 to 3.50
Fifth	Very dirty environment	More than 3.50

III. APPLICATION OF THE METHOD

As an example, table 4 shows the results of ensemble assessment (estimation) of the marine water quality at the North-Caspian area in the spring of 2002.

Table 4

The results of ensemble assessment (estimation) of marine water quality at the "North-Caspian area" in the spring of 2002

Parameter	Criteria estimation			E_{ki}
	$G_i - C_l$	$G_i - C_f$	$G_i - \Delta_{lf}$	
Oil products	3	1	1	1.67
HCCH sum	0	0	0	0.00
DDT sum	0	4	0	1.33
Zinc	0	0	0	0.00
Nickel	0	0	0	0.00
Copper	0	0	0	0.00
Lead	0	2	0	0.67
Cadmium	0	0	0	0.00
E_1				0.46
E_2				1.22
E_3				1.67

In our opinion, the estimation of marine environment quality should be used for regulating anthropogenic load (in this case, the total pollution of the water area). The reduction of the load is required if $E_2 > 1.50$ and/or $E_3 > 2.50$. Urgent measures should be taken if $E_2 > 2.50$ and/or $E_3 > 3.50$.