*Institute Marina Biology NAS Ukraine*

# Macrophytobentos Manuals

# for Black Sea Monitoring

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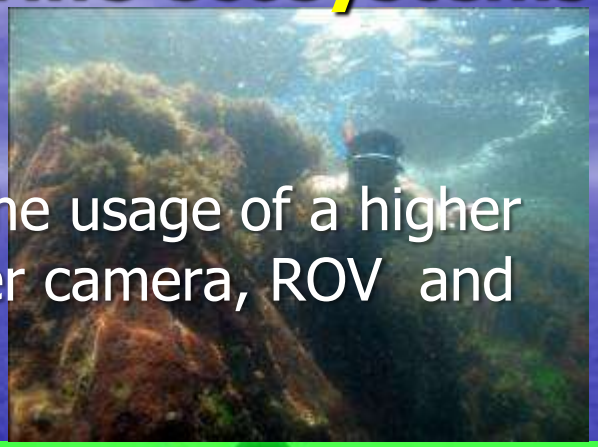
# Properties of the macrophyts under the monitoring of the coastal marine ecosystems

**Positives:**

- Structural-functional organization to reflects the first stage of environmental process - primary production
- Attached object - provides to assessment of the investigation water area
- Presented by large dominant species, which form an indicatory community - *Cystoseira, Zostera, Phyllophora*
- Sensitive structural-functional organization well reflects the variability of the environmental conditions
- Long life cycle to present an integrated response on the environmental status

# Properties of the macrophyts under the monitoring of the coastal marine ecosystems



**Negatives :**

- Submerging of the visual observation with the usage of a higher technology equipment (diver outfit, underwater camera, ROV and others)

- Expensive methods of sampling

- Destroy the nature stricture of community under the breaking waves on the upper horizons (loss of biomass)

# *Phytocenology* monitoring parameters of macrophytes community

- Floristic composition
- Percentage cover of macrophytes on the bottom
- Percentage ratio of species into phytocenouses
- Biomass
- Size structure of dominants

**MACROPHYTOBENTHOS**

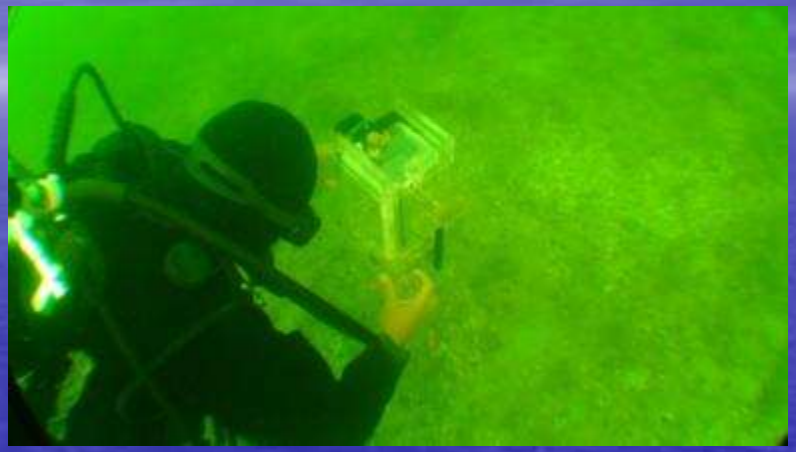
**Methods of sampling, treatment and estimation of parameters**

**G. G. Minicheva, 2008. –P.15** *www.**blacksea-commission**.org/*

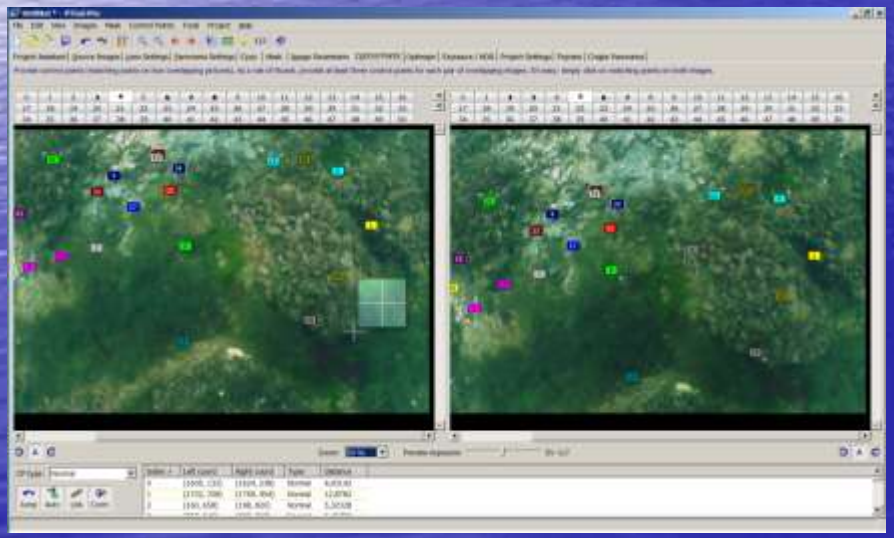
***The Odessa Branch of Institute of Biology of Southern Seas, National Academy of Sciences of Ukraine***

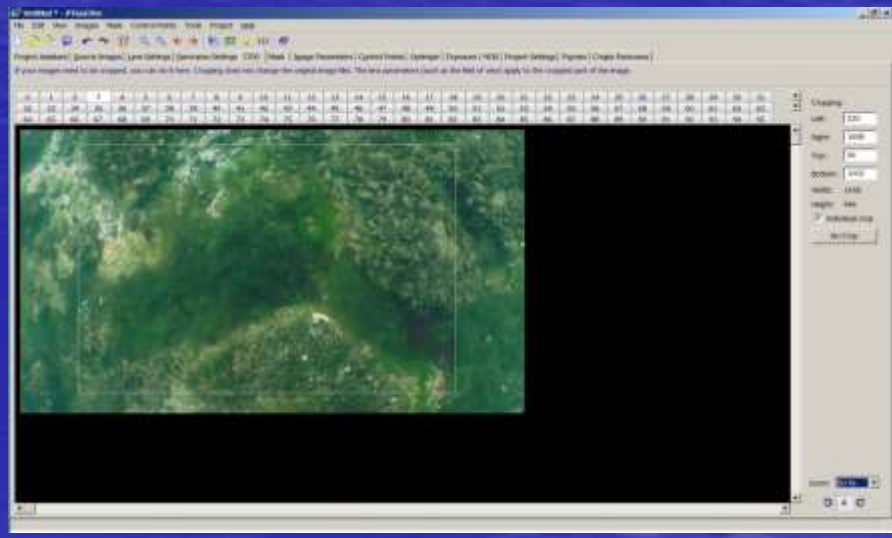
# Sampling from coast

# Survey of accounting treks



# Processing of the video



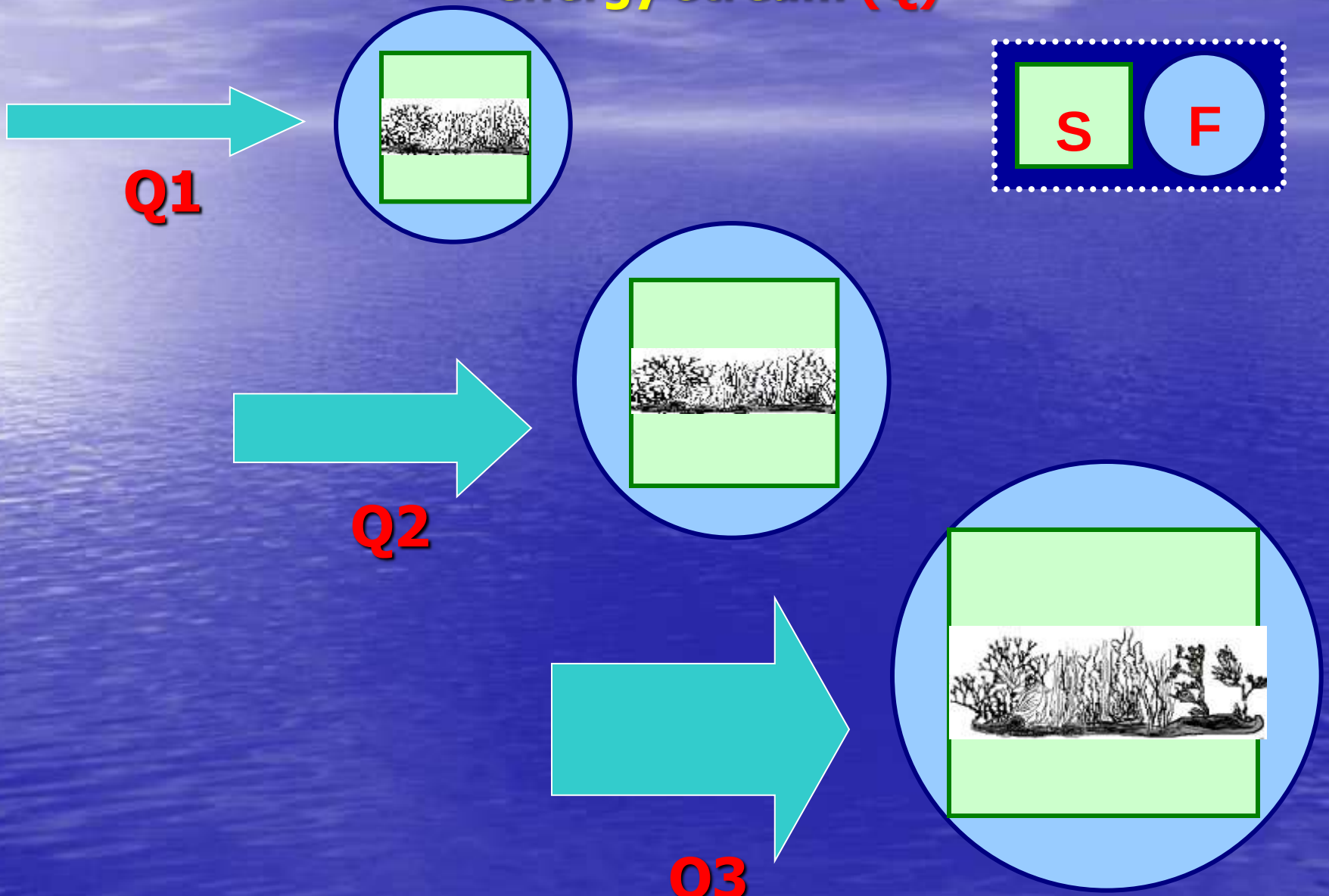


# *Morphofunctional* monitoring parameters of macrophytes community

- Specific surface of the population (S/W)p
- Specific surface of the community (S/W)cm
- Community surface index (SI cm)

**Minicheva G., Zotov A., Kosenko M. Methodical recommendations on the determination of a number of morphofunctional indexes of unicellular and multicellular forms of aquatic vegetation. GEF project for recovery of the ecosystem of the Black Sea. – Odessa. – 2003. – 32 p.**

# The structural-functional organization of aquatic vegetation (S/F) dependence from the substance and energy stream (Q)



# Stages of biological and ecological identification of species diversity

| Species diversity | Binary nomenclature *(C. Linnaeus, 1761)* | Theory «r» and «k» selection *(R. MacArthur, E. Wilson, 1967)* | Coefficient of envaromental activity *(G. Minicheva, 1990)* |
|---|---|---|---|
| • | *Spirulina tenuissima* | r - spices | 1200 |
|  | *Oscillatoria viridis* | r - spices | 424 |
|  | *Kilinia virgatula* | r - spices | 270 |
|  | *Pilaiella littoralis* | r - spices | 140 |
|  | *Urospora penicilliformis* | r - spices | 110 |
|  | *Cladophora albida* | r - spices | 85 |
|  | *Polysiphonia denudata* | k - spices | 56 |
|  | *Ceramium elegans* | k - spices | 26 |
|  | *Cystoseira barbata* | k - spices | 9 |
|  | *Fucus serratus* | k - spices | 3 |

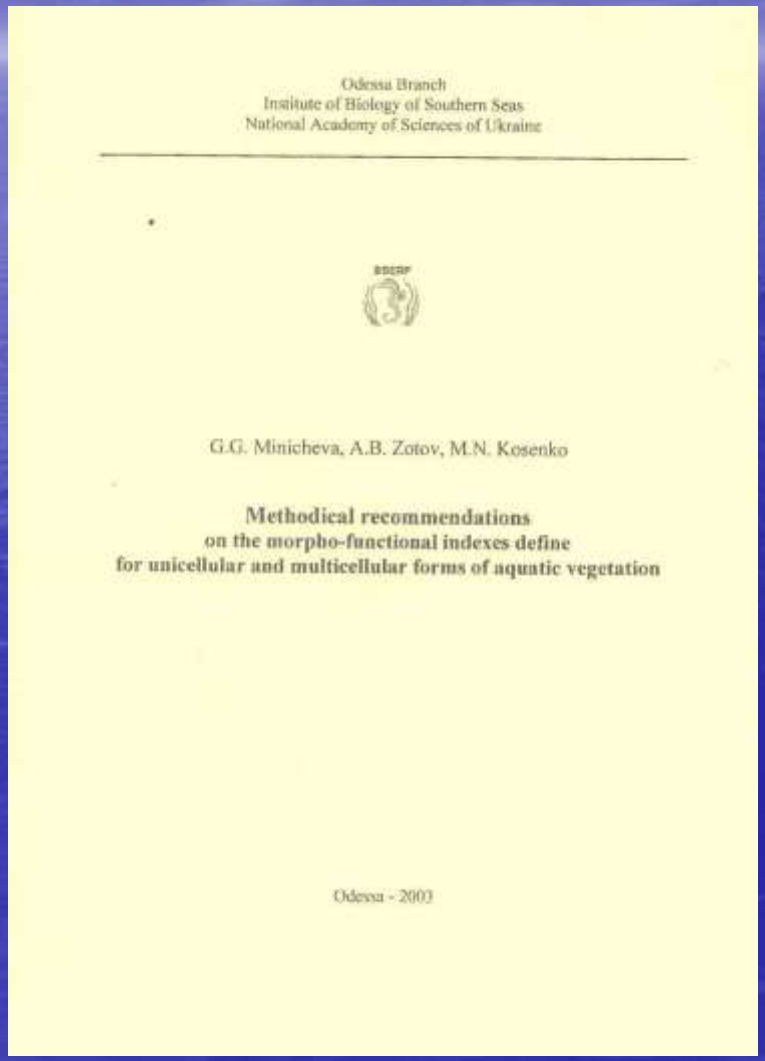
# Main rule of rearrangement a plant community at increase of production process

Under increase the substance and energy stream (Q) the large perennial autotrophic forms with a large talus and long life cycle were replaced by small filamentous or unicellular forms with a short life cycle and a high environmental activity

**<u>Maine advantage of morphofunctional approach</u> - all vital and size forms of the autotrophies are estimating by the common universal index –$S/W_p$ (specific surface of the population)**

# Methodical recommendations for the calculation of the morphofunctional indexes

## www.obibss.narod.ru



Odessa Branch
Institute of Biology of Southern Seas
National Academy of Sciences of Ukraine

G.G. Minicheva, A.B. Zotov, M.N. Kosenko

**Methodical recommendations**
**on the morpho-functional indexes define**
**for unicellular and multicellular forms of aquatic vegetation**

Odessa - 2003

# Participants of international training to determination of macrophyte's mophofunctional indexes (Odessa, 2004 )

*Black Sea Ecological Program, Project « Black Sea Ecosystem Recovery»*

# The value of specific surface of the Black Sea macrophytes' populations $(S/W)_p$

| Species | $(S/W)_p$ , m2.kg-1 |
|---|---|
| *Cystoseira barbata (Good et Wood.) Ag.* | 6.26 ± 0.40 |
| *Laurencia hibrida (DC.) Lenorm.* | 9.57 ± 0.45 |
| *Polysiphonia brodiaei (Dillw.) Grev.* | 11.38 ± 0.38 |
| *Gelidium latifolium (Grev.) Born. et Thur.* | 12.88 ± 0.80 |
| *Coralina officinalis L.* | 17.06 ± 1.01 |
| *Grateloupia dichotoma J. Ag.* | 20.54 ± 0.99 |
| *Ceramium rubrum (Huds.) Ag.* | 34.72 ± 1.36 |
| *Cladophora albida (Huds.) Kutz.* | 81.75 ± 4.48 |
| *Callithamnion granalatum (Ducl.) Ag.)* | 105.00 ± 8.10 |
| *Ectocarpus siliculosus (Dillw.) Lyngb.* | 123.10 ± 4.80 |
| *Kylinia virgatula (Harv.) Papenf.* | 299.37 ± 20.96 |
| *Erythrotrichia carnea (Dillw.) G.* | 335.74 ± 15.21 |

# Why is it useful to use additional morphofunctional parameters of macrophytes under monitoring?

# Advantages to use the morphofunctional indexes for monitoring

# Rearrangement the Mediterranean Basin's algaecomminity under the eutrophication

In the 1990s, as a result of eutrophication of the northern Adriatic Sea, the *Fucus versoides* community was substituted by the ephemeral (short cycled) species and by turf-like *Gelidium pussilum* mats.

*(Munda, 1993)*

Ecological activity, (S/W)p :

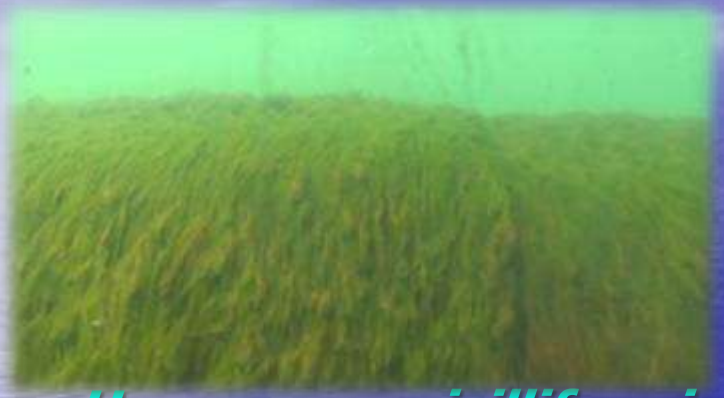
- Species of genus *Fucus* – 3-5 $m^2.kg^{-1}$
- Species of genus *Gelidium* – 15-20 $m^2.kg^{-1}$
- Ephemeral (short cycled) species ≈ 50-100 m2.kg-1.

# Estimation of the substituted dominant algae species under the increase of the organic matter and nutrients concentrations along the North-Western Mediterranean coast (by S. Pinedo, M.Garcia, M. Satta, M.Torres, E.Ballesteros, 2006) from the position of morphofunctional approach

| Loading stage | Genus alga | Coefficient of ecological activity (S/W, $m^2.kg^{-1}$) |
|---|---|---|
| I | Braun alga | |
| | *Cystoseira* | ~ 10 |
| II | Red alga | |
| | *Corallina* | ~ 20 |
| III | Green alga | |
| | *Ulva* | 35-40 |
| | *Enteromorpha* | 35-50 |
| | *Cladophora* | 40-80 |
| IV | Blue-green | |
| | *Oscillatoria* | 200-800 |
| | *Lyngbia* | |
| | *Phormidium* | |

# Change of the morphofunctional portrait (environmental activity of dominant species) on the monitoring polygon of the Odessa coast

April 2011



*Urospora penicilliformis* – S/W 119 $m^2.kg^{-1}$

August 2011

*Cladophora vagabunda* – S/W 47 $m^2.kg^{-1}$

*Porphyra leucosticta* – S/W 63 $m^2.kg^{-1}$

*Ceramium elegans* – S/W 26 $m^2.kg^{-1}$

# Use of the morphofunctional approach to estimation the ESC of coast marine ecosystem corresponding to WFD and MSFD

# Used methodology

**Key assessment principles of the WFD**

**Morphofunctional approach to estimation of the macrophytes**

# Estimation of the Ecological Status corresponds to requirements of the Water Framework Directive (EU Directive 2000/60 EC) and REFCOND (2003)

**Biological Quality Elements:**



| SC (Ecological Status Class) | EQR (Ecological Quality Ratio) |
|---|---|
| High | 1 |
| Good | 0.75 |
| Moderate | 0.5 |
| Poor | 0.25 |
| Bad | 0 |

**Ecological Evaluation Index (EEI)**
**is the main parameter**
**for estimation of the water ecosystem ecological status**

**EEI can be expressed with a classical or morphofunctional parameters of the macroalgae assessment**

Requirements to the indicators which are used as EEI:

- Reflection of the basic ecological function of Biological Quality Elements
- Sensitiveness to the anthropogenic load
- Comfortable for monitoring

# Possible options of the macrophytes indexes as EEI choice

| Concept | Classical botany | Morphological and functional groups | Surface parameters (Morphofunctional approach) |
|---|---|---|---|
| **Sours** | *Marine Strategy Framework Directive DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL (2008)* | *Orfanidis S, Panayotidis P, Stamatis N (2001,2003); Orfanidis S, Panayitidis P, Ugland K (2011)* | *Minicheva G (1998); Minicheva G, Zotov A, Kosenko M (2003)* |
| **Index** | ANNEX II Characteristic for angiosperm and macroalgae:<br>**- Species composition**<br>**- Biomass**<br>**- Annual/seasonal variability** | Coverage value of the:<br>**- ESG I (k-selected species) (IC, IB, IA)**<br>**- ESG II (r-selected species) (IIB, IIA)** | - **$(S/W)_p$** – absolute value for dominant species<br>- **$(S/W)_X$** – mathematical mean value for floristic composition<br>- **$(S/W)_\Sigma$** – summarized value for floristic composition |
| **Property** | **Reflected the biological structure** | **Reflected the ecological function on a high-quality level** | **Reflected the ecological function on a quantitative level** |

# High-quality and quantitative approaches of the macrophytes parameters' determination for EEI

| Species | Ecological Status Group (*S. Orfanidis, P. Panayitidis, K. Ugland, 2011*) | Environment activity (specific surface of population, S/Wp – $m^2.kg^{-1}$) (*G. Minicheva, 1998,2004*) |
|---|---|---|
| *Chondrus* | IC | 3.2 |
| *Lithophyllum* | IC | 4.1 |
| *Phyllophora* | IIA | 7.5 |
| *Systoseira* | IA | 9.5 |
| *Zostera* | IB | 10 |
| *Dillophys* | IIA | 11 |
| *Gelidium* | IIA | 14 |
| *Padina* | IB | 16 |
| *Corallina* | IIB | 24 |
| *Ceramium* | IIB | 26 |
| *Chaetomorpha* | IIB | 32 |
| *Ulva* | IIB | 36 |
| *Bryopsis* | IIB | 47 |
| *Cladophora* | IIB | 75 |
| *Bangia* | IIB | 85 |
| *Callithamnion* | IIB | 130 |
| *Ectocarpus* | IIB | 160 |
| *Acrochetum* | IIB | 280 |
| *Ceanobacteria* | IIB | 300-1200 |

# Morphofunctional indexes of macrophytobentos for to expressed the EEI

- ***Three Dominants Activity*** , $S/W_{3Dp}$

average value of the first Three Dominant Populations specific surface

- ***Community Activity (average),*** $S/W_{x\ com}$

average value of the all populations specific surface in the Community

- ***Phytosenouces Activity,*** $S/W_{ph}$

weighted factor of species (by biomass or cover) with different ecological activity in the phytosenouces;

- ***Phytosenouces Surface Index,*** $Si_{ph}$

total value of the phytosenouces algae surface

# Calculation formulas for the morphfunctional parameters

| Indexes | Calculation formula |
|---|---|
| *Three Dominants Activity*, $S/W_{3Dp}$ | $S/W_{3DP} = \frac{\sum 3(S/W)_{pi}}{3ni}$ |
| *Average Species Activity*, $S/W_{x}$ | $S/W_{xcom} = \frac{\sum (S/W)_{pi}}{ni}$ |
| *Phytosenouces Activity*, $S/W_{ph}$ | $S/W_{ph} = \sum \left(\frac{B_{pi} \times 100\%}{\sum B_{pi}} \times (S/W)_{pi}\right)$ or $S/W_{ph} = \sum \left(\frac{P_{pi} \times 100\%}{\sum P_{pi}} \times (S/W)_{pi}\right)$ |
| *Phytosenouces Surface Index*, $SI_{ph}$ | $SI_{ph} = \sum (B_{pi} \times (S/W)_{pi})$ |

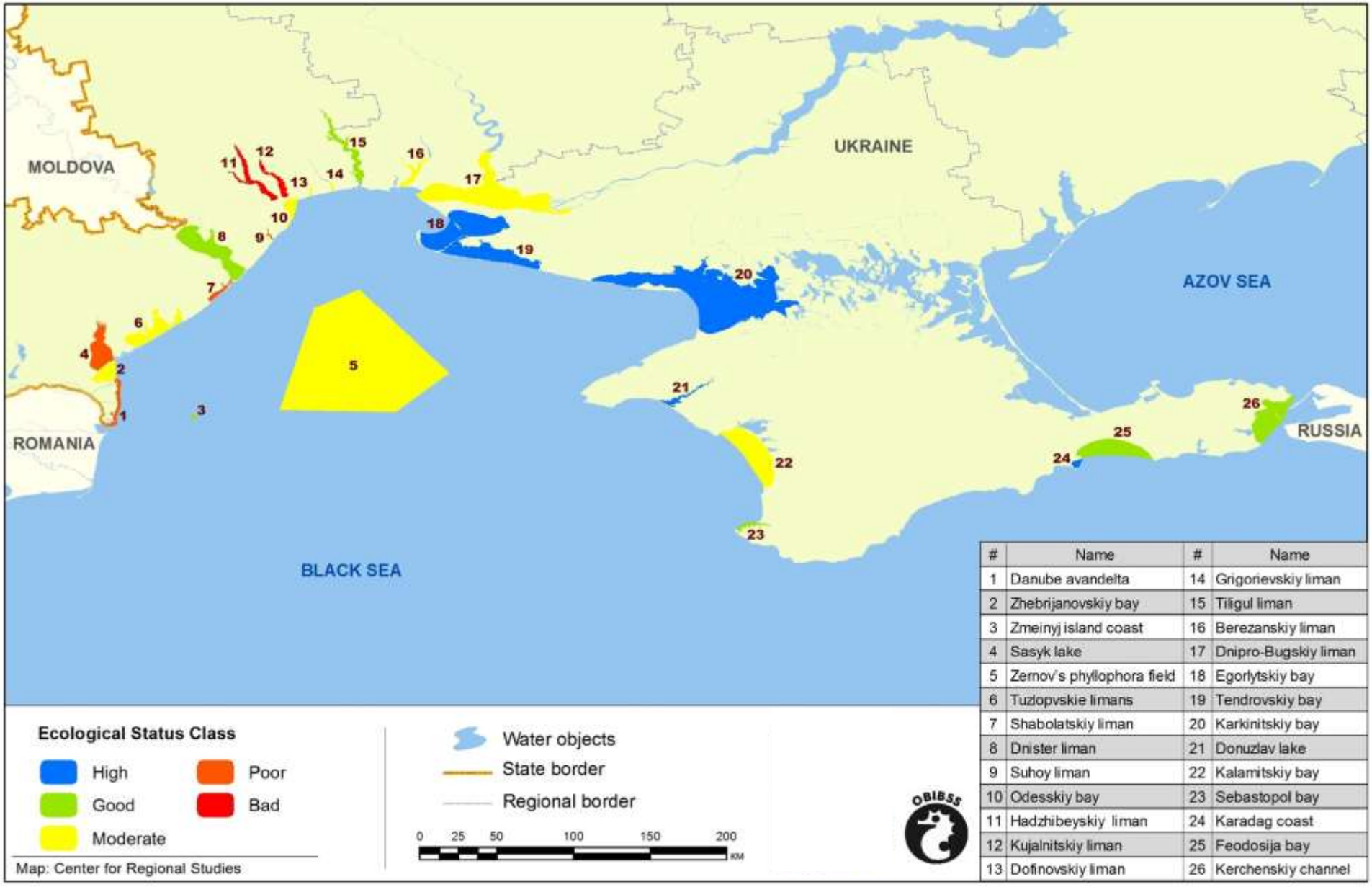
# Classification scheme for macrophyte's morphofunctional indexes

| ESC | EEI range | | | | | |
|---|---|---|---|---|---|---|
| | $(S/W)_{3Dp}$, $m^2.kg^{-1}$ | EQR | $(S/W)_x$ , $m^2.kg^{-1}$ | EQR | $SI_{ph}$ , units | EQR |
| **High** | $(S/W)_{3Dp} < 15$ | ≥ 0.82 | $(S/W)_x < 60$ | ≥0.98 | $SI_{ph} < 25$ | ≥ 0.93 |
| **Good** | $15 \leq (S/W)_{3Dp} \leq 30$ | 0.54 | $60 \leq (S/W)_x \leq 80$ | 0.79 | $25 \leq SI_{ph} \leq 40$ | 0.61 |
| **Moderate** | $31 \leq (S/W)_{3Dp} \leq 45$ | 0.37 | $81 \leq (S/W)_x \leq 120$ | 0.58 | $41 \leq SI_{ph} \leq 55$ | 0.41 |
| **Poor** | $46 \leq (S/W)_{3Dp} \leq 60$ | 0.25 | $121 \leq (S/W)_x \leq 200$ | 0.17 | $56 \leq SI_{ph} \leq 90$ | 0.22 |
| **Bad** | $(S/W)_{3Dp} > 60$ | ≥0 | $(S/W)_x > 200$ | ≥0 | $SI_{ph} > 90$ | ≥0 |

# Ecological status of the Ukrainian Black Sea water ecosystems corresponding to WFD standards

| Water ecosystem | Ecological Evaluation Index ($S/W_{3Dp}$) | Ecological Quality Ratio | Ecological Status Class |
|---|---|---|---|
| Tendrovskiy bay | 10.23 | 1 | High |
| Karkinitskiy bay | 11.71 | 0.92 | High |
| Donuzlav lake | 11.93 | 0.91 | High |
| Egorlytskiy bay | 12.45 | 0.89 | High |
| Karadag coast | 13.35 | 0.86 | High |
| Tiligul liman | 18.61 | 0.73 | Good |
| Feodosija bay | 19.68 | 0.71 | Good |
| Sebastopol bay | 22.28 | 0.66 | Good |
| Dnister liman | 23.43 | 0.64 | Good |
| Kerchenskiy channel | 24.18 | 0.62 | Good |
| Zmeinyj island coast | 25.70 | 0.60 | Good |
| Dofinovskiy liman | 32.00 | 0.51 | Moderate |
| Zernov's Phyllophora Field | 32.50 | 0.50 | Moderate |
| Tuzlopvskie limans | 32.57 | 0.50 | Moderate |
| Zhebrijanovskiy bay | 35.15 | 0.47 | Moderate |
| Grigorievskiy liman | 36.72 | 0.45 | Moderate |
| Odesskiy bay | 36.72 | 0.45 | Moderate |
| Kalamitskiy bay | 41.93 | 0.40 | Moderate |
| Dnipro-Bugskiy liman | 43.32 | 0.39 | Moderate |
| Berezanskiy liman | 44.65 | 0.37 | Moderate |
| Shabolatskiy liman | 45.65 | 0.36 | Poor |
| Suhoy liman | 46.82 | 0.35 | Poor |
| Denube avandelta | 54.18 | 0.30 | Poor |
| Sasyk lake | 62.06 | 0.24 | Poor |
| Kujalnitskiy liman | 119.00 | 0 | Bad |
| Hadzhibeyskiy liman | 209.36 | 0 | Bad |

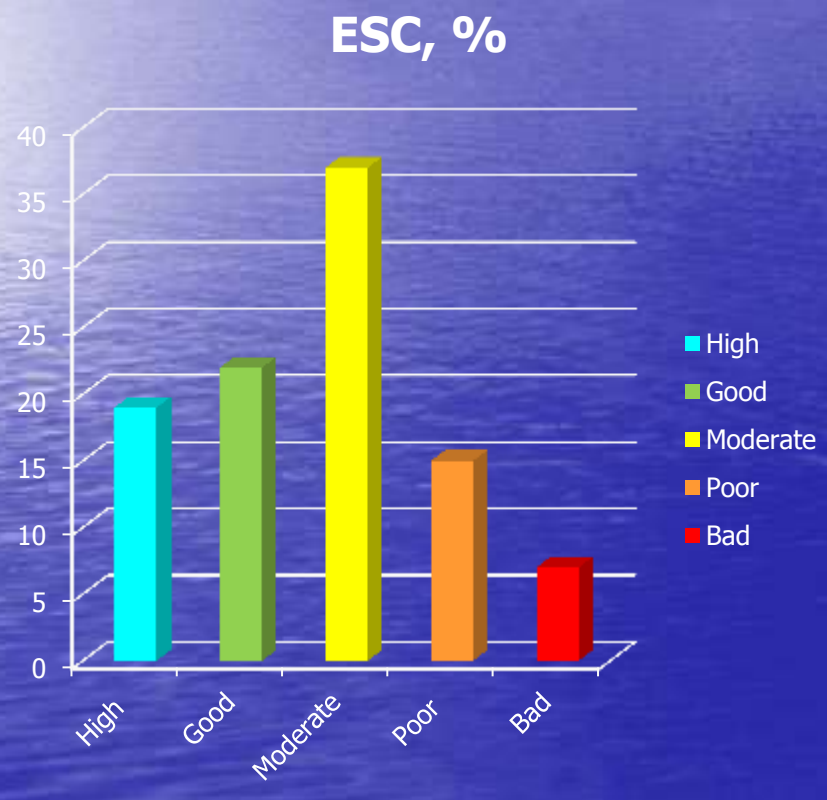
# Classification of the water bodies of the Black Sea Ukrainian part on basis of estimation of functional activity of macrophytobenthos' dominants in accordance to WFD requirements



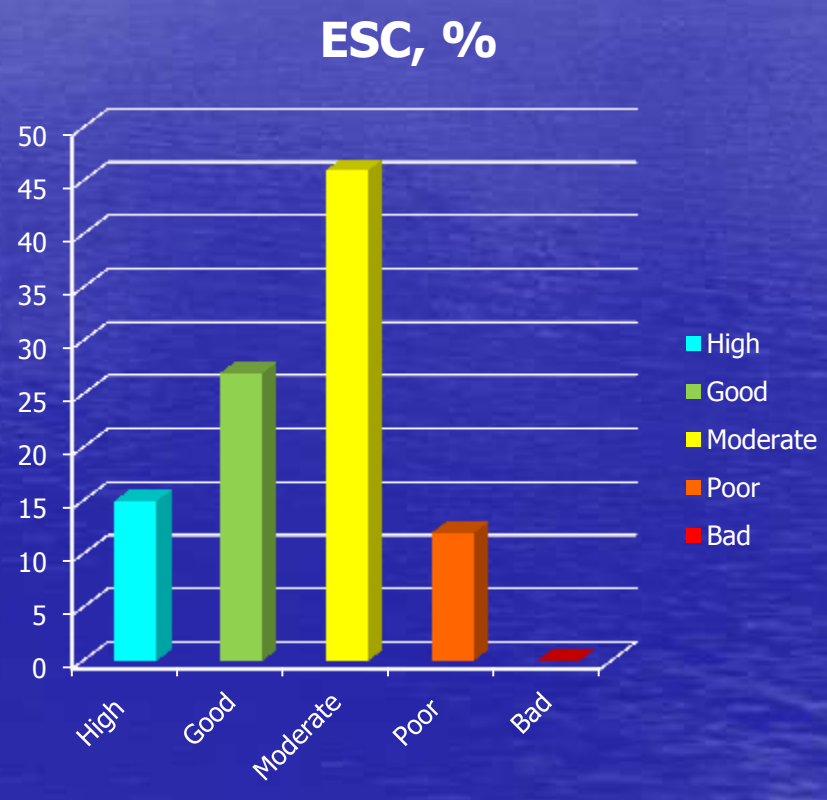

| # | Name | # | Name |
|---|---|---|---|
| 1 | Danube avandelta | 14 | Grigorievskiy liman |
| 2 | Zhebrijanovskiy bay | 15 | Tiligul liman |
| 3 | Zmeinyj island coast | 16 | Berezanskiy liman |
| 4 | Sasyk lake | 17 | Dnipro-Bugskiy liman |
| 5 | Zernov's phyllophora field | 18 | Egorlytskiy bay |
| 6 | Tuzlopvskie limans | 19 | Tendrovskiy bay |
| 7 | Shabolatskiy liman | 20 | Karkinitskiy bay |
| 8 | Dnister liman | 21 | Donuzlav lake |
| 9 | Suhoy liman | 22 | Kalamitskiy bay |
| 10 | Odesskiy bay | 23 | Sebastopol bay |
| 11 | Hadzhibeyskiy liman | 24 | Karadag coast |
| 12 | Kujalnitskiy liman | 25 | Feodosija bay |
| 13 | Dofinovskiy liman | 26 | Kerchenskiy channel |

# Comparison of the ESC structure for water bodies of the Black and Mediterranean Seas

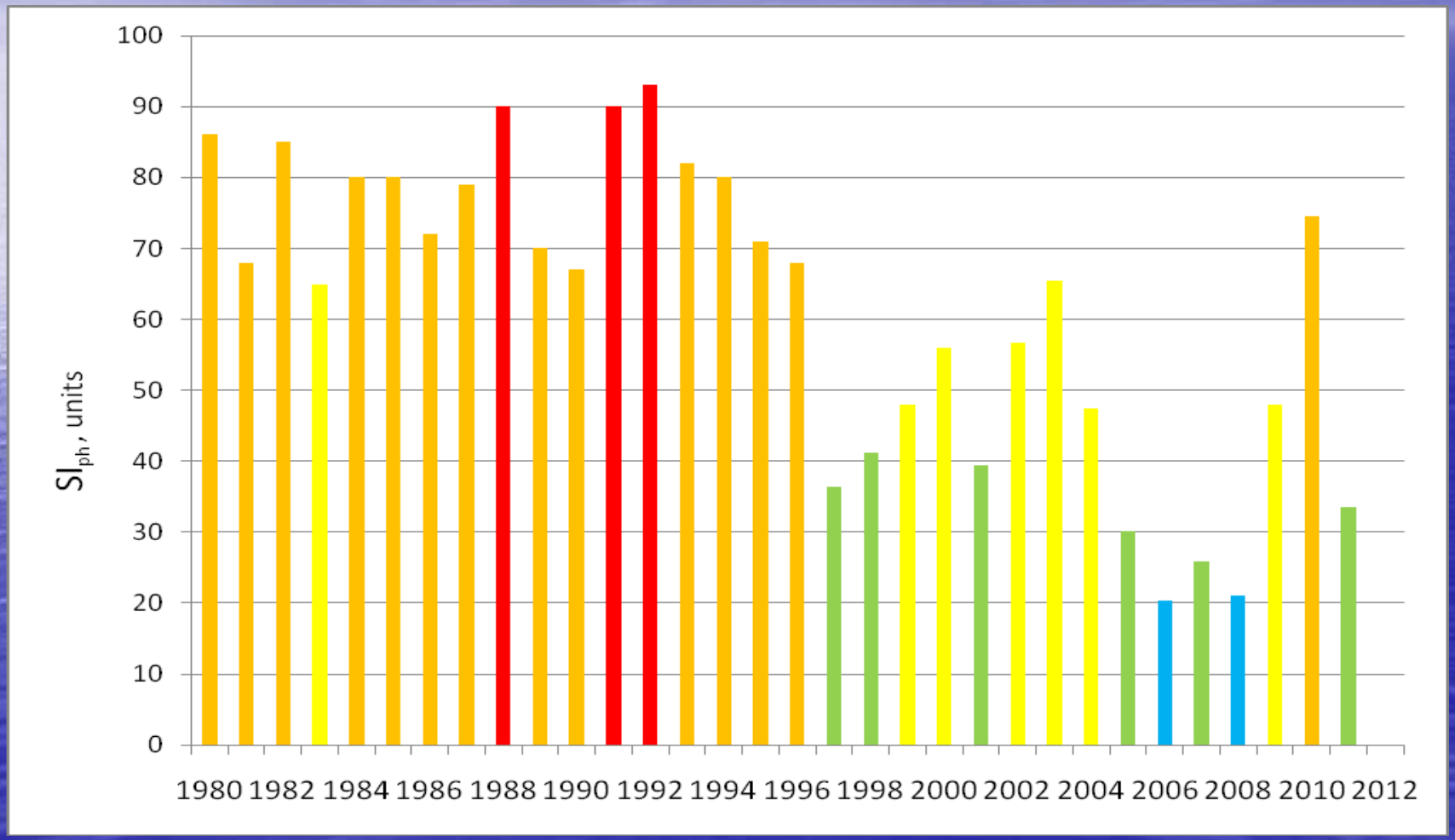
Northern Black Sea (27 areas of Ukrainian part), by G. Minicheva, 2011




Western Mediterranean (33 areas of Catalonia) by Ballesteros E., Torras X., 2006



# Long-term dynamic of ESC value for the Odessa coast (northwestern part of the Black Sea) resaved by use $SI_{ph}$ index.



# Methodical maintenance of macrophytobentos monitoring

| Подход | Продукт мониторинга | Существующие методики | Степень разработки методов | Степень внедрения |
|---|---|---|---|---|
| Фито-ценоти-ческий | Структурная организация макрофитобентоса | Methods of sampling, treatment and estimation of parameters G. G. Minicheva, 2008. –P.15 *www.blacksea-commission.org/* | +++++ | ++++ |
| Морфо-функциональный | Структурно-функциональная макрофитобентоса | Minicheva G., Zotov A., Kosenko M. Methodical recommendations on the determination of a number of morphofunctional indexes of unicellular and multicellular forms of aquatic vegetation. GEF project for recovery of the ecosystem of the Black Sea. – Odessa. – 2003. – 32 p. | ++++ | ++ |
| Оценочных индексов | Экологический Статус Класс морских прибрежных экосистем | Minicheva G. 2013. Use of the Macrophytes Morphofunctional Parameters to Asses Ecological Status Class in Accordance with the EU WFD. Marine Ecological Journal. -Vol.XII, № 3. –P. 5-21. | ++ | + |

| High | Good | Moderate | Poor | Bad |
|---|---|---|---|---|


Thank you for attention