# COASTAL CURRENTS

The most part of a coastal zone of the Black sea is opened, that is has no geomorphologic constraint in the form of deep semi-closed gulfs, island circuits and underwater thresholds for interaction with deep-sea area. It is favoured also with rather small width of a continental shelf ($\sim 10^{0}$-$10^{1}$ km) in the Black Sea, except for its northwest part.

At the same time, there are certain hydrodynamical restrictions of free water exchange between coastal and deep-sea zones. Coastal line and exclusively abrupt continental slope on external border of a coastal zone of the Black sea make its hydrodynamical regime very differing from deep-sea. The continental slope and shelf have very large normal to a coast gradients of background potential vorticity $Q = (\zeta + f)/H$, where $\zeta$ - relative vorticity of currents in the given point, f - Coriolis parameter or so-called planetary vorticity, H – water depth (Pedlosky, 1982). Isolines Q here almost coincide with isobaths. In turn, stationary trajectories of large-scale currents adhere isolines Q. Therefore average position of the Main Rim Current - MRC and connected with it the main thermohaline frontal zone - MFZ in the Black sea coincides with position of a continental slope (Blatov et al., 1984). Thus, MFZ ia a natural hydrodynamical and thermodynamic border of a coastal zone in the Black sea.

Hydrodynamical borders of the Black sea coastal zone on the internal (coastal) and external (shelf-break) sides are the reasons of obvious prevalence here the so-called coastal trapped (shelf) waves – CTW (Brink, 1991) above others dynamic processes, generating coastal currents with the periods more then inertial (about 17 hours in the Black sea). Main properties of CTW are: i) strict orientation of orbital wave currents along shore and reversive change of their directions (fig. 1) with the periods from day to about weeks, ii) alongshore phase moving of CTW in a cyclonic direction (that is from left to right if to look from coast), iii) alongshore wave length of tens-first hundreds kilometers. In horizontal fields of temperature, salinity, dynamic topography and other characteristics CTW have form of alongshore extended closed (or almost closed, that is meanders) anomalies of alternating signs with alongshore sizes of the order of half of CTW length (fig. 2), that is some tens kilometers.
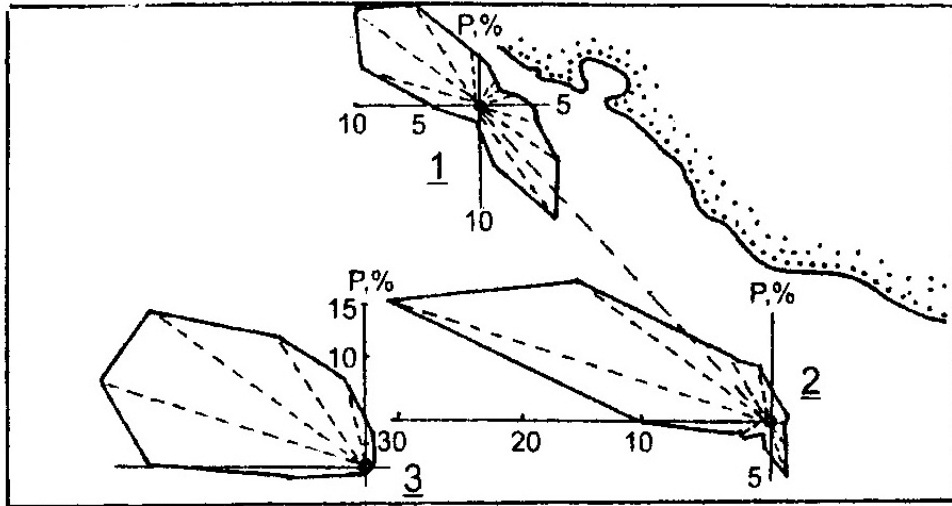
Fig. 1 - Typical roses (repeatability, %) directions of currents in a coastal zone and zone of MRC at the Caucasus coast of the Black sea in area of Gelendzhik. After Kryvosheya et al., 1998.
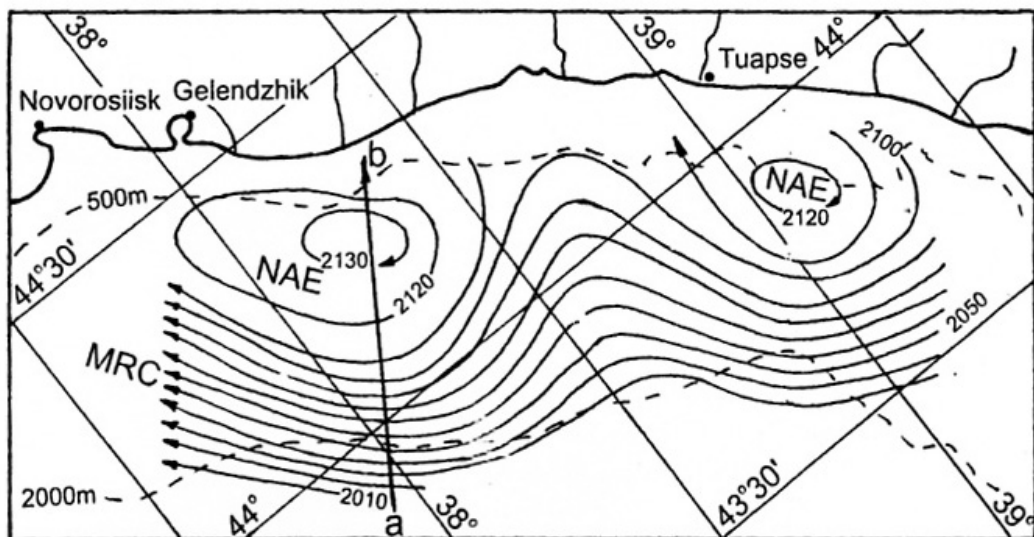


Fig. 2 - Typical field of surface dynamic topography relative 300 dbar at the Caucasus coast of the Black sea in area of Gelendzhik. October 1994. After Kryvosheya et al., 1998.

CTW are generated by any forcings, capable to displace water mass onshore/offshore on along shore extent at least in some tens kilometers (Brink, 1991). It can make alongshore wind or meander large-scale current, also as they generate coastal upwelling or downwelling. The last two often are an initial phase of the CTW life cycle. In turn, CTW translate alongshore the areas of upward and downward coastal water motion from areas of its direct wind forcing.

The coastal zone of the Black Sea is on the right relative direction of MRC, that is in the field of anticyclonic background relative vorticity, connected with lateral shift (that is reduction to coast) velocity of MRC. Therefore here anticyclonic segments of CTW thermohaline anomalies are shown more strongly, than cyclonic. Considering their closed character they are often wrongly interpreted as alongshore anticyclonic synoptic eddies trains (e.g. Kryvosheya et al., 1998, ets). Though synoptic eddies and CTW belong to the one class (mesoscale) of water motions, their properties are very various (Ivanov and Yankowsky, 1992). In particular, synoptic eddies cannot be generated and exist in a narrow coastal zone, such as in the Black sea (Pedlosky, 1982, Brink, 1991, Blatov et al., 1984, Ivanov and Yankovsky, 1992).

The departures from this picture are may be due to large coastal and bottom topography irregularities, where CTW are scattered and dissipied to small-scale vorticities (Brink, 1991, Ivanov and Yankovsky, 1992). At least the Caucasus Coast from Novorossiisk to Sochi have not such an irregularities.

In gravitational range of sea water variability (with the periods less then inertial) the edge waves are the most significant free oscillations generated in the coastal zone (Ivanov and Yankovsky, 1992). For all other water motions the coastal zone is an area of its destruction (dissipation).

The basic traditional problems of research of coastal currents in the Black Sea are: i) statistics of their directions and velocitys on various sites of a coastal zone and in various seasons of year, ii) parameters synoptic variability of currents, iii) its connection with a wind and other external forcing. Below are presented some generalized results of these problems investigations.

Note we keep the original terminology of cited papers. So the term "nearshore anticyclonic eddy" (NAE) is equivalent to CTW in cases of discussion of currents near Caucasus coast.

The some examples of the main statistics of coastal current (mean current direction, mean current velocity, and current stability index – a relation of mean current velocity to its standard deviation) are presented in tables 1-5 for some Black Sea coastal regions (Hydrometeorology, 1991). The point of observations are shown on fig. 3.
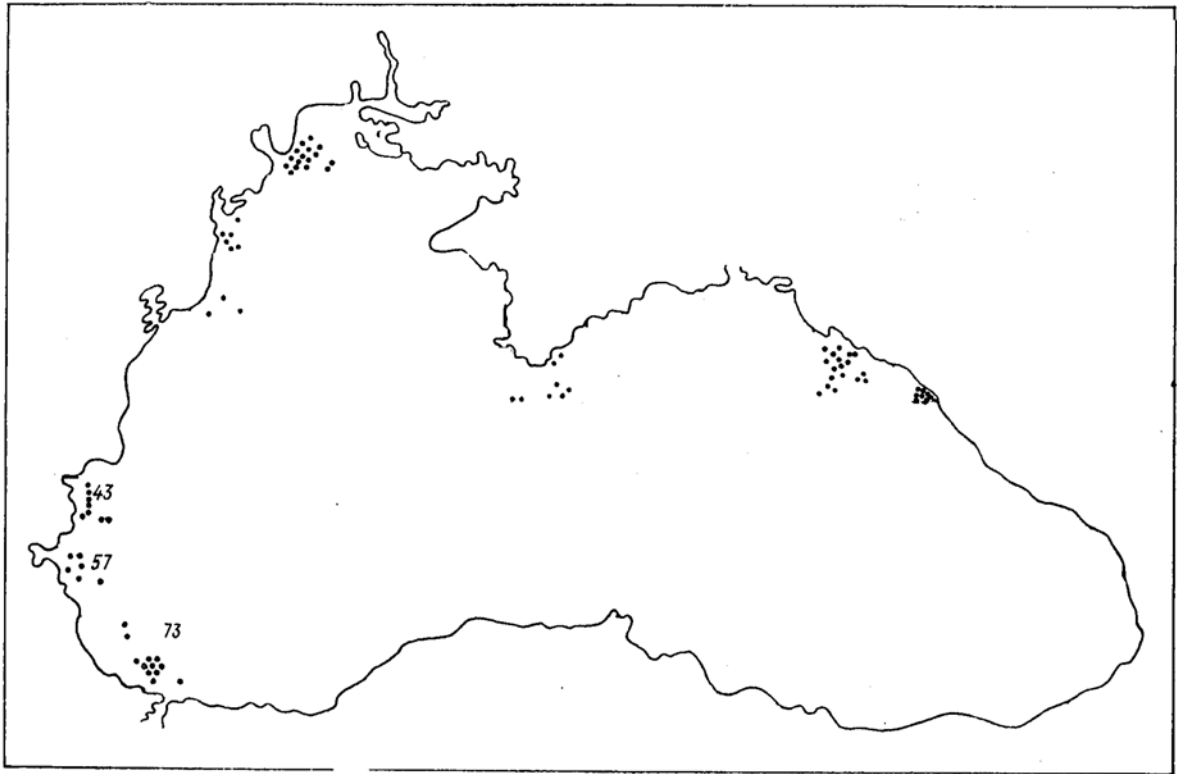
Fig. 3 – Positions of the moored autonomous current observations in the Black Sea, which presented in tables 1-5. After Hydrometeorology, 1991.

In common, in the shelf zone the velocity of currents and their directions are variable, depending on season and on synoptic wind situation. They are influenced by the intensity of MRS and its meanders too. The mean current velocity (stability index) is descending (ascending) function of averaging time (duration of current records).

Along west coast of the shallow north-west part of the Black Sea (table 1) the currents are directed mostly to southern compass sectors (cardinal points). The mean velocity of currents is usually between 0.05 to 0.30 m s$^{-1}$, maximal one is up to 1 m s$^{-1}$. The current stability index is usually less than 50% for record with duration >10 day.

In the shelf zone of the deep-water area of the Black Sea between MRC and steep shore lines at depths over 20-40 m, the mean velocity of currents is usually between 0.05 to 0.30 m s$^{-1}$. Their general direction usually follows the cyclonic direction of MRC. In July-August, when MRC force decreases and its meandering becomes more pronounced, its mean velocity decreases and its direction becomes more variable. It often declines from the main vector of MRC flow, sometimes turning to the opposite direction. Therefore, the nearshore currents along steep coasts with short shelf usually have two reciprocal directions: one cyclonic and one anticyclonic, offshore current direction is unimodal (Fig. 2) and velocity is much more stable.

4

In the Western coastal zone of the Black Sea the general current directions is southward and south-westward (table 2, fig. 4), mean velocity – 0.10-0.40 m s$^{-1}$.
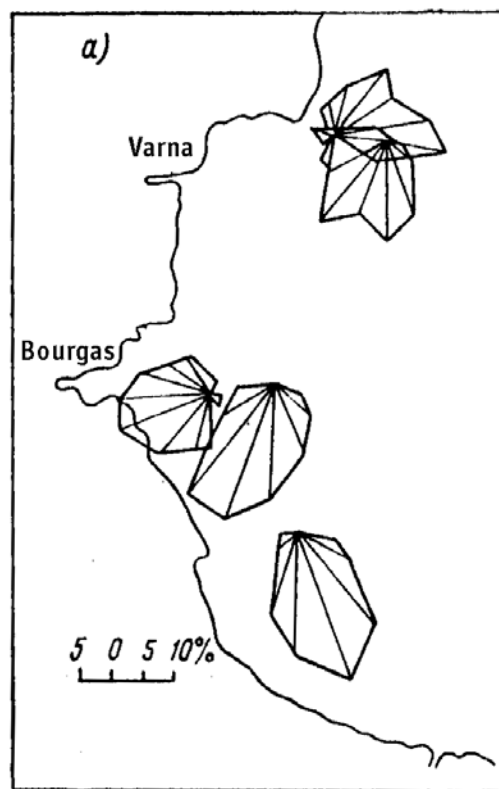


Fig. 4 – Current directions roses in the Western coastal zone of the Black Sea (16-26.07.1981, 10 m level). After Hydrometeorology, 1991

Results from a 7-days long measurements of sea current in September 1999 in the Bourgas Bay, the widest bay on the western part of the Black Sea, show a presence of two-layer, oppositely directed movements with mean velocity of ~ 0.10 m s$^{-1}$ (Trukchev at al., 2004). The motion character is determined basically by the wind field and by the local orographic factors. Due to the influence of wind variability the currents in the observed area are strongly variable and unstable.

The bay-scale circulation is estimated to be predominantly of cyclonic type; anticyclonic eddies are sporadically generated on the periphery of the main cyclone eddy. The surface currents reach velocity of 0.16 m s$^{-1}$ in the surface layer during calm, the motions of the northern part are more intensive than of the southern. A good correlation between the direction of wind and sea surface current obviously exists. With a relative wind velocity decrease the breeze circulation can be displayed very distinctly.

It is shown that, depending on the wind direction, cyclonic and anticyclonic types of circulation could be generated in the western part of the bay, the so-called Small Bourgas Bay. These results correlate with the current scheme constructed from remote sensing data.

In Bosphorus region current statistics (table 3) and roses (fig. 5) are presented at point relatively far from coast (>20 km), therefore the mean velocity and its stability are more then in two preceding regions. In close vicinity of the Bosphorus Strait the currents have inward (south-western) direction in upper 50 m layer with mean velocity up to 0.30-0.50 m s$^{-1}$ and outward direction in thin bottom layer along curvilinear submarine canion (with direction varied from north-eastern to noth-western) with velocity up to >1 m s$^{-1}$ (Oguz, 2005)
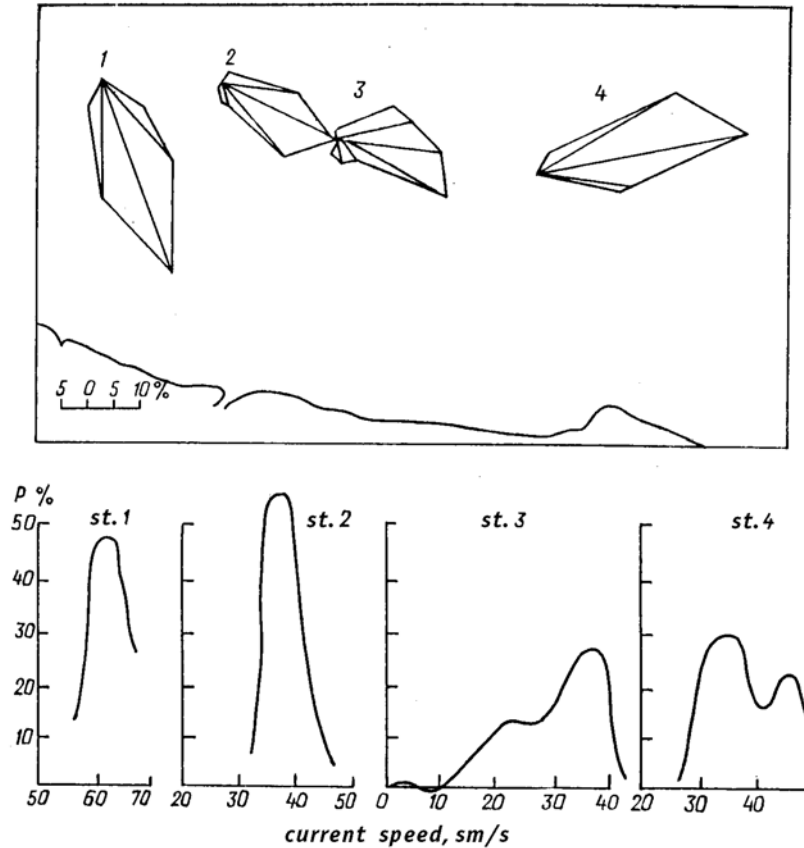


Fig. 5 – Current directions roses in the Bosphorus region of the Black Sea (16-17.07.1972, 25 m level). After Hydrometeorology, 1991

Near the Caucasus coast the dominating current vectors are nort-western (300-350°) and south-eastern (120-160°) (table 4, fig. 2). Such a changing orientation of coastal currents is especially pronounced during summer-autumn (fig. 6).

The results of experimental investigations of coastal currents hydrophysical fields in eddy structures (meanders and NAE) within the MRC zone (Krivosheya et al, 1998) are shown that these eddy structures travel along the shore in the direction of the MRC. An average phase velocity of these eddy structures was determined to be about 0.04-0.05 m s$^{-1}$ in summer. Such eddies enhance water exchange between the nearshore and the central part of the basin.
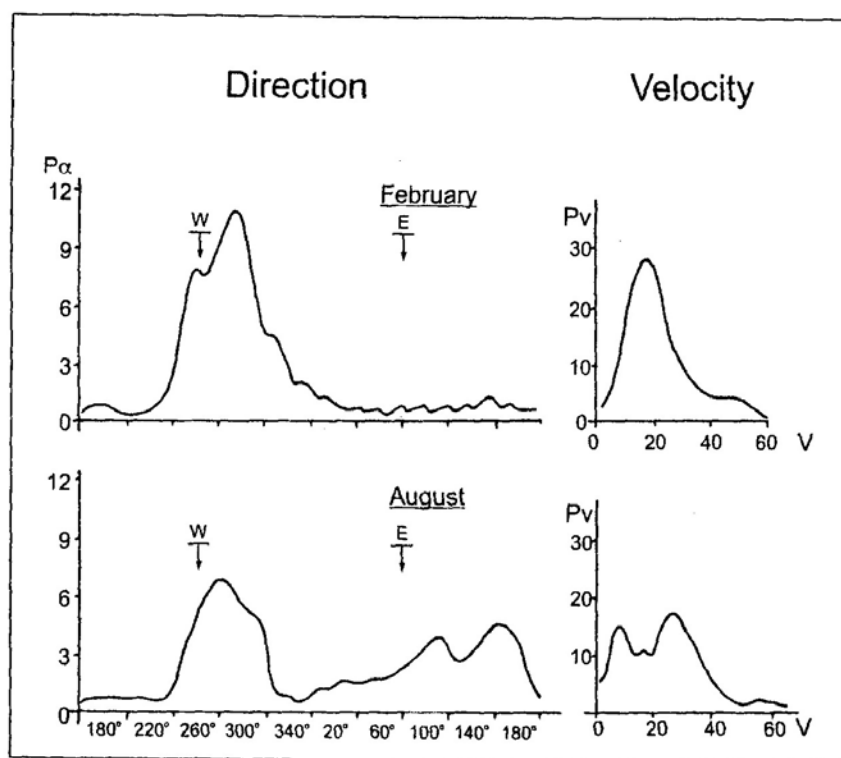
Fig. 6 – Probabilities of current directions and velocity in the Caucasus coastal zone of the Black Sea (70 m level). After Ovchinnikov et al, 1986

In autumn 1994 the special observational studies of mesoscale structures in the MRC zone were performed in the north-eastern part of the Black Sea. During the first stage of investigations from 11-th to 20-th of September, the interdisciplinary oceanographic survey was performed in Russian EEZ between 36°15' and 39°15 E. Basically, station grid was (20x22 nm) with finer resolution in the nearshore zone (approximately, 10 nm along the sections and 12-15 nm along the 500 m depth contour). Hydrological measurements and sampling were made down to 500 db isobaric interface.

During the second phase of measurements, from September 30 to October 7, two interdisciplinary oceanographic surveys were made. The first survey (30.09-04.10.94) was carried out within the whole survey area (59 stations), the second (05-07.10.94) was in the north-western part of the region (28 stations). In the first survey the stations were placed along 30-mile sectios normal to the shore. In this case the distances between the sections varied from 8 to 12 miles. The distances between the stations were 3-4 miles on the shelf and 5-7 miles in the deep part of the polygon. The second survey was performed in the western part of the polygon where previously found NAE was observed. During this survey the sections were 5 miles apart and stations 3-6 miles apart. Eight parameters were measured: temperature,

salinity, density, transparency, back scattering of the light, oxygen and chlorophyll-A concentrations, and pH.

The intensive water circulation and its appreciable space variability were observed during autumn of 1994 in the Russian sector of the Black Sea. The MRC was meandering, and two NAEs were located on the coastal side of the meanders (fig. 2). Near Novorossiisk, a cyclonic meander of the RC was located, the second cyclonic meander was contoured to the south-east of Gelendzhik.

The dynamical situation within the survey area changed essentially during the period between two phases of investigations. Within five days between these two surveys, the NAE covered the distance of 10 miles in the north-westward direction, which gives its phase velocity of about 0.04 m s$^{-1}$. In this way, a clear indication of a specific eddy migration was obtained. Furthermore, the velocity of the same eddy from Tuapse region into the region of Gelendzhik increased to 0.05 m s$^{-1}$.

It may be supposed that meanders and NAE which are permanently observed near the Caucasus coast are usually generated near the shore of Georgia due to interaction of the RC with rough bottom relief and migrate towards Kerch Strait.

As it is seen from the fig. 7 that crosses NAE, south-eastward water transport is observed near the shore. The core of this current is 5-6 nm off the coast. In this case the maximal velocities (0.20-0.25 m s$^{-1}$) are observed at the depths of 40-80 m. The core of the north-westward current is 20-23 nm off shore. Maximal velocity of this flow is 0.40-0.45 m s$^{-1}$ in the upper 25 m layer.
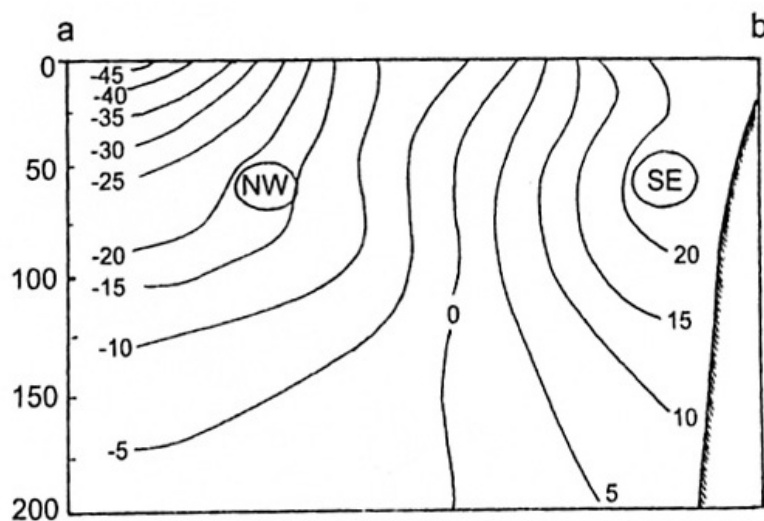


Fig. 7 – Cross-section of geostrophic current velocity ($10^{-2}$ m s$^{-1}$) normal to the a-b line on fig. 2. After Krivosheya et al, 1998.

Numerous surveys in different years and seasons indicate that 2-4 and, sometimes 5 NAEs are present near this section of the coast about 240 miles long. All of them are moving at the same direction as the MRC. Some of them dissipate, other keep on moving with anticyclonic meanders and become larger (up to 25 - 50 km in diameter).

In coastal zone south of Crimea obsevation points in table 5 have positions nearest to shore relative other regions. Therefore mean velocity and its stability index not so large here as in Bosphorus region. But the cyclonic current direction have in Crimea region high repeatness (65-70%) all the year round (Boguslavsky at al., 1995). CTW forced by atmospheric synoptic processes were detected on the shelf and slope near souternmost coast of the Crimea by analysis of current masurements made diring July 1991 at seven points. They have period 10-13 day, alongshore length of orbital (almost reverse) motions cells – 20-25 km and cross-shore one – 4-5 km, orbital speed – about 0.05 m s$^{-1}$.

**Reference**

Blatov et al. - Блатов А.С. Булгаков Н.П., Иванов В.А., Косарев А.Н., Тужилкин В.С. Изменчивость гидрофизических полей Черного моря. - Л.: Гидрометеоиздат, 1984, 240 с.

Boguslavsky at al. - Богуславский С.Г., Иванов В.А., Янковский А.Е. Особенности режима основного черноморского течения у берегов Крыма. // Мор. гидрофиз. журн., 1995. № 3. - С. 36-45.

Brink K.H., Coastal-trapped waves and wind-driven currents over the continental shelf // Annual Review of Fluid Mechanics, 1991. Vol.23. – P. 389-412.

Hydrometeorology - Гидрометеорология и гидрохимия морей СССР, т. IУ. Черное море. Вып.1. Гидрометеорологические условия. – Л.: Гидрометеоиздат, 1991. - 340 с.

Ivanov and Yankovsky - Иванов В.А., Янковский А.Е. Длинноволновые движения в Черном море. - Киев: Наукова Думка, 1992. - 112 с.

Krivosheya V.G., Nyfeller F., Yakubenko V.G., Ovchinnikov I.M., Kosyan R.D., Kontar E.A. Experimental studies of eddy structures within the Rim Current Zone in the North-Eastern part of the Black Sea / In: Ecosystem modeling as a management tool for the Black Sea. Vol. 2 / Eds L.I.Ivanov, T.Oguz, NATO ASI. Ser. 2. Environmental Security. V.47. - Dordrecht, The Netherlands: Kluwer Acad. Publ., 1998. - P. 131-144.

Oguz T. Hydraulic adjustments of the Bosphorus exchange fow // Geophys. Res. Lett., 2005. V. 32. L06604, doi 10.1029/2005GL022353.

Ovchinnikov et al.- Овчинников И.М., Титов В.Б. Кривошея В.Г. Новые данные о временной изменчивости течений по результатам многолетних измерений со стабилизированного буя на шельфе Черного моря // Докл. АН СССР, 1986. Т. 286. № 5. - С. 1250-1254.

Pedlosky J. Geophysical Fluid Dynamics. – New York, Springer-Verlag,, 1982. 692 p.

Trukhchev D., Ivanov D., Ivanova D., Patzireva T., Avramov A., Rabie A., Hydrophysical study of Bourgas Bay. Results from oceanographic survey in September // Comptes rendus de l'Academie Bulgare des sciences, 2004. Vol. 57. No 2. - P. 35-40.

Белокопытов В.Н., Саркисов А.А., Щуров С.В. Течения прибрежной зоны на участке Крымского полуострова от мыся Сарыч до поселка Кацивели / В кн.: Экол. безопасн. прибреж. и шельф. зон и компл. исп. ресурсов шельфа: Сб. науч. тр. – Севастополь: МГИ НАН Украины, 2003. Вып. 8. - С. 64-68.

Богуславский С.Г., Иванов В.А., Янковский А.Е. Особенности режима основного черноморского течения у берегов Крыма. // Мор. гидрофиз. журн., 1995. № 3. - С. 36-45.

Богуславский С.Г., Кузнецов А.С., Казаков С.И. Особенности режима течений у южного берега Крыма // Тр. на Института по океанология Българска академия на науките, 2005. Т. 5. – С. 25-34.

Иванов В.А., Кубряков А.И., Михайлова Э.Н., Шапиро Н.Б. Формирование и эволюция вихревых образований, обусловленных стоком рек на северо-западном шельфе Черного моря / В кн.: Иссл. шельф. зоны Азово-Черн. бассейна. Сб. науч. тр.– Севастополь: МГИ НАН Украины, 1995. - С. 147-167.

Иванов В.А., Кубряков А.И., Любарцева С.П., Михайлова Э.Н., Шапиро Н.Б. Моделирование некоторых особенностей гидрологических и экологических ситуаций в районе о. Змеиный. / В кн.: Природные условия взморья реки Дунай и острова Змеиный. Современное состояние экосистемы. / Ред. В.А. Иванов, С.В. Гошовский. - Севастополь: МГИ НАН Украины, 1999. - С. 184-208.

Иванов В.А., Кубряков А.И., Любарцева С.П., Михайлова Э.Н., Шапиро Н.Б. Моделирование гидрофизических процессов в морских прибрежных регионах // Мор. гидрофиз. журн., 2004, № 2. - С. 8-28.

Иванов В.А., Янковский А.Е. Взаимосвязь мезомасштабных процессов с условиями среды Черного моря // Мор. гидрофиз. журн., 1988, № 2. - С. 44-50.

Иванов В.А., Янковский А.Е. Теоретические параметры захваченных волн в Черном море / В сб.: Компл. океаногр. иссл. Черного моря. - Севастополь: МГИ АН УССР, 1989. - С. 37-50.

Иванов В.А., Янковский А.Е. Характеристики захваченных волн в шельфовой зоне Южного берега Крыма // Океанология, 1991, Т. 31. № 2. - С. 200-206.

Иванов В.А., Янковский А.Е. Оценка влияния рельефа дна и средних течений на параметры шельфовых волн // Изв. АН СССР, Физ. атм. и океана, 1991. Т. 26. № 6. – С. 152-160.

Иванов В.А., Янковский А.Е. Влияние гидрологических условий в шельфовой зоне Южного берега Крыма на свойства захваченных берегом волн. / В кн.: Гидрофиз. и гидрохим. иссл. Черного моря. - Севастополь: МГИ НАН Украины, 1992. - С. 58-65.

Кривошея В.Г. Особенности режима течений у Российского побережья Черного моря // Наука Кубани, 2000. № 4. – С. 15-20.

Кривошея В.Г., Москаленко Л.В., Титов В.Б. К вопросу о режиме течений на шельфе у северо-кавказского побережья Черного моря. // Океанология, 2004. Т. 44. № 3. - С. 358-363.

Кривошея В.Г., Овчинников И.М., Титов В.Б., Удодов А.И., Лаптев С.Ю. Динамика вод и изменчивость температуры воды у северо-кавказского побережья Черного моря. // Океанология, 1996. Т. 36. № 3. - С. 355-363.

Кривошея В.Г., Овчинников И.М., Титов В.Б., Якубенко В.Г., Скирта А.Ю. Меандрирование Основного черноморского течения и формирование вихрей в северо-восточной части Черного моря летом 1994 г. // Океанология, 1998. Т. 38. № 4. - С. 546-553.

Кривошея В.Г., Титов В.Б., Овчинников И.М., Москаленко Л.В., Скирта А.Ю., Монахов В.В. Новые данные о режиме течений на шельфе северо-восточной части Черного моря // Океанология, 2001. Т. 41. № 3. - С. 325-334.

Кубряков А.И., Любарцева С.П., Михайлова Э.Н., Шапиро Н.Б. Ветровая циркуляция и оценка элементов экосистемы / В кн.: Природные условия взморья реки Дунай и острова Змеиный. Современное состояние экосистемы. / Ред. В.А. Иванов, С.В. Гошовский. - Севастополь: МГИ НАН Украины, 1999. - С. 74-79.

Овчинников И.М., Титов В.Б., Кривошея В.Г. Прибрежные течения / В кн.: Техногенное загрязнение и процессы естественного самоочищения Прикавказской зоны Черного моря. - М.: Недра, 1996. С. 168-188.

Титов В.Б. О распределении скорости поверхностного течения в районе Северо-Кавказского побережья Черного моря // Океанология, 1985. Т. 25. № 3. - С. 408-413.

Титов В.Б. О Синоптической и мезомасштабной изменчивости термохалинных характеристик в северо-восточной части Черного моря. // Мор. гидрофиз. журн., 1990. № 2. - С. 45-53.

Титов В.Б. Статистические характеристики и изменчивость течений на западном шельфе Черного моря. // Мор. гидрофиз. журн., 1991. № 2. - С. 41-47.

Титов В.Б. О роли вихрей в формировании режима течений на щельфе Черного моря и в экологии прибрежной зоны // Океанология, 1992. Т. 32. № 1. - С. 39-48.

Титов В.Б. Морфометрические параметры и гидрофизические характеристики прибрежных антициклонических вихрей в Черном море // Метеорол. и гидрол., 2002. № 4. - С. 67-73.

Титов В.Б. Характеристики Основного черноморского течения и прибрежных антициклонических вихрей в Российском секторе Черного моря // Океанология, 2002. Т. 42. № 5. - С. 668-676.

Титов В.Б., Кривошея В.Г. Москаленко Л.В. Режим течений в Российском секторе Черного моря. // В сб.: Комплексные исследования северо-восточной части Черного моря / Ред. А.Г. Зацепин, М.В. Флинт. – М.: ИО РАН, 2002. - С. 48-55.

Титов В.Б., Овчинников И.М., Кривошея В.Г., Савин М.Т. Статистический анализ изменчивости течений и ветра на шельфе Кавказского побережья Черного моря. // Водные ресурсы, 1983. Т. 10. № 1. - С. 120-129.

Титов В.Б., Савин М.Т. Изменчивость придонных течений на северо-восточном шельфе Черного моря. // Океанология, 1997. Т. 37. № 1. - С. 50-55.

Титов В.Б., Савин М.Т. Спектральные характеристики течений и температуры воды в придонном слое на черноморском шельфе России // Океанология, 1997. Т. 37. № 5. - С. 689-697.

Фомин В.В., Алексеев Д.В., Иванча Е.В., Черкесов Л.В. Исследование гидродинамических полей в северо-западной части Черного моря, возникающих при прохождении циклона // Докл. НАН Украины, 2004. № 5. – С. 137-142.

Girgvliani A., Marri E., Numerical modeling of the dynamics of the eastern Black Sea coastal zone with consideration of mobile coastline // J. Georgian Geophys. Soc., 2000. Vol. 5B. - P. 21-27.

Kose E., Eruz C., Guneroglu A., Erkebay S., Gulten Y., Simulation of coastal currents and river discharges in the south-eastern Black Sea // Indian J. Mar. Sci., 2003. Vol. 32, N 3. – P. 194-204.

Trukhchev D., Ivanov D., Ibrayev R., Ivanova D., Patzireva T., Rabie A., Hydrophysical study of Bourgas Bay. Modelling the synoptic circulation patterns // Comptes rendus de l'Academie Bulgare des sciences, 2004. Vol. 57. No 3. - P. 29-34.

Trukhchev D., Ivanov D., Ibrayev R., Ivanova D., Patzireva T., Ganev K., Rabie A., Hydrophysical study of Bourgas Bay. Environmental study for the port of Bourgas expansion project // Comptes rendus de l'Academie Bulgare des sciences, 2004. Vol. 57. No 10. - P. 29-34.

Unluata U., Oguz T., Latif M.A., Ozsoy E., Sur H.I. On physical oceanography of the Turkish straits. // In: The physical oceanography of sea straits. Ed NATO/ASI Series. – Deventer: Kluwer Acad. Press. The Netherlands, 1989.

**Table 1 - Statistics of coastal currents in North-Western Region of the Black Sea**
**(After Hydrometeorology, 1991)**

| Latitude, N | Longi-tude, E | Distance from coast, km (depth, m) | Start date (duration, days) of observation | Obser-vation level, m | Mean current direction, ° | Mean current velocity, $10^{-2}$ m/s | Current stability, % |
|---|---|---|---|---|---|---|---|
| 44°49' | 29°54' | 30.1 (46) | 23.11.1972 (5) | 10 | 3 | 30,1 | 19,3 |
| | | | | 20 | 190 | 21,1 | 3,6 |
| 44°56' | 30°25' | 60.5 (54) | 23.11.1972 (5) | 10 | 188 | 21,3 | 52,3 |
| | | | | 20 | 182 | 16,6 | 28,6 |
| 45°20' | 29°50' | 5.8 (21) | 11.03.1965 (17) | 5 | 21 | 17,8 | 37,9 |
| | | | | 18 | 2 | 4,3 | 32,7 |
| 45°20' | 30°00' | 17.8 (26) | 11.03.1965 (16) | 5 | 96 | 11,7 | 19,9 |
| | | | | 10 | 108 | 11,2 | 27,1 |
| | | | | 22 | 155 | 4,9 | 33,4 |
| 46°19' | 30°41' | 0.9 (10) | 11.09.1970 (8) | 3 | 218 | 14,8 | 55,4 |
| | | | | 7 | 46 | 6,3 | 47,2 |
| 46°17' | 30°46' | 7.2 (20) | 11.09.1970 (8) | 3 | 208 | 15,5 | 85,6 |
| | | | | 17 | 115 | 6,2 | 72,2 |
| 46°12' | 30°44' | 9.7 (25) | 13.10.1966 (10) | 10 | 173 | 9,2 | 65,1 |
| | | | | 20 | 154 | 14,8 | 78,6 |
| 46°20' | 30°53' | 11.3 (27) | 13.10.1966 (10) | 10 | 160 | 8,4 | 48,6 |
| | | | | 20 | 143 | 6,9 | 45,5 |

**Table 2 - Statistics of coastal currents in Western Region of the Black Sea**
**(After Hydrometeorology, 1991)**

| Latitude, N | Longi-tude, E | Distance from coast, km (depth, m) | Start date (duration, days) of observation | Obser-vation level, m | Mean current direction, ° | Mean current velocity, $10^{-2}$ m/s | Current stability, % |
|---|---|---|---|---|---|---|---|
| 43°20' | 28°35' | 9.0 (58) | 09.02.1973 (2) | 10 | 146 | 16 | 57 |

| | | | | 25 | 347 | 12 | 12 |
|---|---|---|---|---|---|---|---|
| 43°06' | 29°10' | 63.0 (1400) | 10.02.1973 (10) | 15 | 237 | 30 | 91 |
| | | | | 25 | 181 | 36 | 22 |
| 43°09' | 28°51 | 37,8 (430) | 18.07.1972 (1) | 15 | 217 | 18 | 67 |
| | | | | 25 | 172 | 6 | 18 |
| 43°09' | 29°15' | 63.0 (1600) | 18.07.1972 (1) | 15 | 240 | 37 | 96 • |
| | | | | 25 | 234 | 38 | 98 |
| 42°29' | 28°05' | 28.8 (66) | 20.07.1981 (3) | 5 | 223 | 22 | 68 |
| | | | | 10 | 239 | 24 | 72 |
| | | | | 25 | 306 | 35 | 64 |
| 42°30' | 28°20' | 43,2 (96) | 20.07.1981 (3) | 5 | 195 | 24 | 80 |
| | | | | 10 | 194 | 37 | 82 |
| 43°01' | 28°10' | 21,6 (35) | 07.10.1977 (11) | 20 | 217 | 32 | 35 |
| | | | | 10 | 230 | 32 | 45 |
| 42°57' | 28°27' | 46,8 (96) | 12.10.1977 (7) | 10 | 3 | 24 | 81 |

**Table 3 - Statistics of coastal currents in Bosphorus Region of the Black Sea**

**(After Hydrometeorology, 1991)**

| Latitude, N | Longi-tude, E | Distance from coast, km (depth, m) | Start date (duration, days) of observation | Obser-vation level, m | Mean current direction, ° | Mean current velocity, $10^{-2}$ m/s | Current stability, % |
|---|---|---|---|---|---|---|---|
| 41°53' | 31°04' | 63.0 (1570) | 12.07.1972 (12) | 25 | 73 | 38 | 97 |
| 41°56' | 29°06' | 72.0 (1380) | 16.07.1972 (12) | 25 | 144 | 38 | 89 |
| 41°48' | 29°28' | 64,8 (1920) | 16.07.1972 (12) | 25 | 101 | 31 | 77 |
| 41°56' | 28°44' | 59,4 (470) | 17.07.1972 (13) | 25 | 157 | 63 | 94 |
| 41°29' | 29°02' | 30,6 (89) | 30.09.1974 (3) | 10 | 303 | 36 | 69 |
| ' | | | (3) | 25 | 250 | 16 | 28 |
| 41°27' | 29°06' | 36.0 (95) | 15.03.1978 (4) | 5 | 70 | 25 | 30 |
| | | | (2) | 10 | 79 | 25 | 22 |
| 41°28' | 29°06' | 37,8 (95) | 25.03.1978 (2) | 5 | 100 | 40 | 59 |
| | | | (2) | 10 | 105 | 28 | 65 |

**Table 4 - Statistics of coastal currents in Caucasus Region of the Black Sea**

**(After Hydrometeorology, 1991)**

| Latitude, N | Longi-tude, E | Distance from coast, km (depth, m) | Start date (duration, days) of observation | Obser-vation level, m | Mean current direction, ° | Mean current velocity$10^{-2}$ m/s | Current stability, % |
|---|---|---|---|---|---|---|---|
| 44°31' | 37°58' | 3.8 (230) | 27.08.1969 (9) | 5 | 4 | 11.9 | 48 |
| 44°32' | 37°54' | 8.8 (500) | 27.08.1969 (9) | 5 | 323 | 14.6 | 66 |
| 44°29' | 37°52' | 10.0 (1200) | 10.08.1962 (2) | 10 | 51 | 2.7 | 26 |
| 44°30' | 38°02' | 7.5 (52) | 12.08.1962 (2) | 25 | 272 | 9,7 | 48 |
| 44°28' | 37°54' | 17.5 (1380) | 18.10.1964 (13) | 10 | 310 | 33,4 | 64 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 44°14' | 38°04' | 25.0 (13) | 18.10.1964 (6) | 10 | 350 | 31,1 | 85 |
| 44°27' | 37°54' | 20.0 (1350) | 03.10.1963 (2) | 10 | 320 | 33,0 | 10 |
| | | | | 25 | 296 | 26,9 | 94 |
| 44°27' | 37°53' | 16.3 (1340) | 03.10.1963 (8) | 10 | 308 | 26,7 | 93 |
| | | | | 25 | 309 | 11,5 | 89 |
| 44°27' | 37°54' | 17.5 (1340) | 26.11.1963 (6) | 10 | 274 | 28,1 | 34 |
| | | | | 25 | 163 | 17,8 | 25 |
| 43°36' | 39°32' | 12.5 (100) | 13.04.1963 (7) | 10 | 4 | 3,3 | 19 |
| 43°35' | 39°31' | 13.8 (220) | 13.04.1963 (7) | 10 | 280 | 9,0 | 27 |
| | | | | 25 | 226 | 9,7 | 24 |
| 42°12' | 40°50' | 66.3 (1640) | 16.03.1974 (5) | 50 | 309 | 24,4 | 67 |
| 42°12' | 41°21' | 30.3 (1000) | 16.03.1974 (6) | 25 | 334 | 42,9 | 97 |

**Table 5 - Statistics of coastal currents in Crymean Region of the Black Sea**

**(After Hydrometeorology, 1991)**

| Latitude, N | Longi-tude, E | Distance from coast, km (depth, m) | Start date (duration, days) of observation | Obser-vation level, m | Mean current direction, ° | Mean current velocity, $10^{-2}$ m/s | Current stability, % |
|---|---|---|---|---|---|---|---|
| 44°33' | 33°24' | 1,8 (51) | 15.04.1973 (12) | 15 | 232 | 12,0 | 38,7 |
| | | | (6) | 25 | 259 | 22,4 | 17,0 |
| 44°30' | 33°23' | 7,9 (90) | 15.04.1973 (5) | 10 | 294 | 14,8 | 31,1 |
| | | | (11) | 15 | 255 | 13,2 | 14,3 |
| 44°33' | 33°24' | 1,8 (53) | 18.06.1973 (10) | 10 | 326 | 20,8 | 24,3 |
| | | | (10) | 25 | 315 | 17,6 | 71,5 |
| 44°30' | 33°23' | 7,9 (93) | 18.06.1973 (10) | 10 | 320 | 25,2 | 48,3 |
| | | | (10) | 15 | 324 | 24,7 | 53,0 |
| 44°26' | 33°19' | 13,7 (125) | 03.07.1973 (14) | 25 | 310 | 18,1 | 47,1 |
| 44°17' | 33°03' | 41,4 (1820 | 02.07.1973 (14) | 15 | 293 | 22,3 | 63,6 |
| | | | (14) | 25 | 278 | 21,9 | 69,8 |