EVOLUTION
OF COASTAL LAGOONS
OF SAKHALIN ISLAND

prof. Petr Brovko
Far Eastern Federal University, Vladivostok, Russia
2016
On Sakhalin North-East there is a long and low accumulative shore stretching for more than 200 km. Large lagoons, such as Piltoon (square 420 km²), Nabil (square 181 km²) and Chayvo (square 121 km²), and others are located here. They are separated from Sea of Okhotsk with sand bars up to 3-6 m in height. The lagoons are shallow with 1-4 m depth. Between them there are coastal zones (from 2 to 15 km long) with high cliffs and active coastal erosion. Cliffs retreat with velocity of 1-5 m a year. Coastal lagoons are connected with the sea by straits, where depths increase up to 6-8 m and high rates of tidal flows are noticed. Under the influence of these flows and waves lagoon straits are moving along the shore with the velocity up to 30 m a year. Rivers that flow into the coastal lagoons form deltas. Deltas growth leads to reduction of lagoons water area. Lagoons bottom is formed by the sands, aleurites and silts, where the biocenosis are forming in the conditions of low salinity. Significant areas are presented by wetlands, which is typical for coastal lagoons and estuaries. Fishing is widely developed in all coastal lagoons. Sakhalin coastal lagoons morphology and their evolution are studied during long-term fieldwork, made by literary sources and old maps from XIX-XX centuries.
Lagoon is part of the ocean, sea, lake, separated by accumulative forms (reefs, artificial structures) with different from the main water area hydrological regime, specific conditions of relief formation and sedimentation and development of unique biocenosis in the conditions of low or high salinity.
Satellite images (23.02.2012; 25.05.2014)

- The natural conditions of formation of the sea coasts
- S – subarctic conditions
- H - humid conditions
- 5 or 7 - the sea freezes
- (months)
The problem of lagoons classification was raised over half a century ago, by P.A. Kaplin. He wrote: "At the present time, there is need for a more complete and accurate definition of "lagoon" term, as well as the development of a rigorous geomorphological classification of lagoon formations. The classification must apparently be based, in the first place, on the genesis of the bank, separating a lagoon from the main reservoir" (Kaplin, 1957, p. 110).
V.P. Zenkovich (1970), analyzing the conditions of formation of coastal strata of silt sediments, distinguishes several types of "traps" for the fine particles, and among them: conventional lagoon, lagoons with a torn barrier, estuaries and riases, separated with bars, coral lagoons, deltas and associated lagoons and lakes.
Nichols and Allen (1981) single out 4 types of lagoons: lagoons-estuaries, opened lagoons, partially-closed and closed lagoons. From the first to the last type, the connection with the sea diminishes, and the role of wave influence increases on the dynamics of accumulative forms separating lagoons from the sea.
Chinese authors on the coast of China, describe bays-lagoons, semi-closed and closed lagoons. In the first of them, all sedimentation processes including biogenic sedimentation, have broad connection with the sea. Semi-closed lagoons are connected with the sea by tidal channels and possess increased or decreased salinity. There is a domination of fine bottom sediments. In closed lagoons with straits, cut off by alluvium, coastal vegetation actively develops (Li Congxian, Chen Gang, 1986).
Lagoon distribution in terms of their shape is also of interest. The shoreline contour of a water body may be linearly stretched, elongate, rounded, segmental triangular or rectangular as a result of the evolution of coastal processes. Thus, segmental lagoons are found on the abrasive bay/coast in the northwestern part of the Okhotsk Sea (Ikit Lagoon) and rectangular ones are located on a fiord-type coast (Severnaya Lagoon, Bering Sea). Spit-blocked estuaries are often triangular (Starka Lagoon, Sea of Japan).
The evolution of the coastal lagoons

- Lagoons separated from the sea by bars, spits, sand bars tend to change the contour of the coast and decreasing water areas by filling with river, sea, aeolian and other sediments.

- Evolution of water areas may go different ways depending on the predominance of one or another factor.
Different types of changes in the coastline lagoons
d - the growth of river deltas in the lagoons
Выявление динамики берега по АФС разных лет
f - the formation of the cone of carrying out when the storm breaks bars
Urk t lagoon
(23.09.1973 и 26.09.2011)
g – the growth of tidal deltas
Straits in the lagoons
Cape Ayash on the map (1972) and satellite image (2007)
Tropto lagoon
(annual and seasonal changes of the strait)
Keutu lagoon
Ekhabi lagoon
Tunaicha Lagoon. Krasnoarmeisk Strait

1990

2013
Nyivo lagoon

The movement of the lagoon strait to the north

1882

2012
The movement of the Piltun lagoon strait to the south at a speed of 30 m/year (1920, 1972, 2006 years)
Slepikovsky, lighthouse
Economic use of lagoons
Lagoon coasts are widely represented in the Far East. The place with their most presentation is Sakhalin Island, where lagoon coasts occupy the fifth part (20%) of the entire island coastal line, which is 2670 km. However, lagoon development is related to several types of economic activity: the production of fish and seafood (Baikal, Busse, Pomr’, Nyivo, Dagi), transport communications (Nabil’, Tauro), oil and gas (Odoptu, Pil’tun, Chayvo), the development of sand deposit (Keutu), medicine mud (Izmenchivoye). Lagoon coasts are one of the most common types of the recreation-geomorphologic systems that can be developed on Sakhalin Island.
Drilling rig «Yastreb»
(Chayvo lagoon)
Runways of airfields on the lagoon coasts
Размещение объектов аквакультуры и рекреации в лагуне (проект)

Условные обозначения:
- Антарктический
- Алеутский
- Береговая линия
- Населенные пункты
- Границы политических границ
- Экологические и природные ресурсы
- Окрестности
- Ареалы: обитательные для культивирования
- Установки для выращивания
- Устройства для морских гребешков
- Естественные
- Площадки экспериментальных исследований

Лагуна расположена на юге Мурманской низменности и сформирована в среднем-позднем голоцене в результате отчленения баром мелководного залива. Соединена протокой Аракуль с пресноводными озерами и устьем реки Аракуль. Площадь лагуны 43 км², средняя глубина 2.8 м.

Донные осадки лагуны формируются при участии нескольких источников. Приливными течениями из залива Аракуль в лагуну поступают мелкозернистый песок, а выносится более крупный. Центральную часть лагуны (до 40%) занимают алебастр и мелкоzerosитные илы, сформированные вдоль берегов широкой полной песчаной бровки. Фракции 0.1-0.25 мм. В эрозионных валах развиты песчано-гравийные осадки с разрушенными детритом, живыми двустворчатыми моллюсками и обрастаниями.

Биоценоз лагуны исключительно разнообразен. Здесь обитают дальневосточный тритон, тихоокеанская устрица, приморский тритон, мидии, травяной краб и др. Зимой ведут подводный образ жизни. Наибольшую ценность имеет красная водоросль, анфельция (Ahnfeltia plicata var. jovichiensis Kato et Matsumura), широко используется в пищу в рыбопромышленной, текстильной и бумажной промышленности. Запасы водорослей были значительно подорваны в 20-60-е годы прошлого века, а сейчас роли анфельции медленно восстанавливаются.

Лагуна Буссе является памятником природы, самым перспективным водоемом для садки морских культур. Восстановлены зоопланктон и макрофиты, объекты системы экологического туризма на юге Сахалина.
Border (red line) of the expected “Tunaychinskiy” national park. (Yellow and white squares – are natural monuments and attractive tourist objects).
National parks in the regional atlases
The evolution of lagoons is associated with the Holocene transgression, during which time they came into existence. As evidenced by well studied coastal-marine depositions, large seawater bodies, separated by sand banks and morphologically close to modern lagoons, started to form at higher sea level in the sub-boreal period. During subsequent sea level fluctuations above the modern level, the inner shoreline contour of lagoons was reshaping. Some water bodies are already at the post-lagoon stage, being partly or fully filled with alluvial, marine, eolian, or biogenic depositions.
New island and new strait (2003) on the East Sakhalin (breakthrough of the bar during the storm; Dagi lagoon)
Zenkovich island and Vladimirov strait
names in honor of Russian scientists
Second new strait (2009)!
Third Strait - ?
(a few years later)

Russian saying: once is happenstance, twice is coincidence; three times is a pattern
Tunaicha Lagoon Expedition, July 2016

Sampling water (top)
Therapeutic mud. Depth 42 m (bottom)
Tunaicha Laguna

A - the salinity of the water on the surface (2-4‰)
B - the salinity of the water at the bottom (12-18 %)
Conclusion

- Evolution of lagoons leads generally to a reduction in their size and overall area within the present coastal zone. However, this trend has, ceteris paribus, continued only at a stable level. Modern rise in global sea level suggests that the scheme can be different in each case.

- Erosion of coastal bars, up to their disappearance, the formation of new straits in different regions may lead to a different outlook - the transition from lagoon to the sea bay.
This road leads to the future!

The sea comes!
Thank you for your attention!