Kelp of Laminaria (Saccharina) thickets recovery in dependence on abiotic and biotic environments

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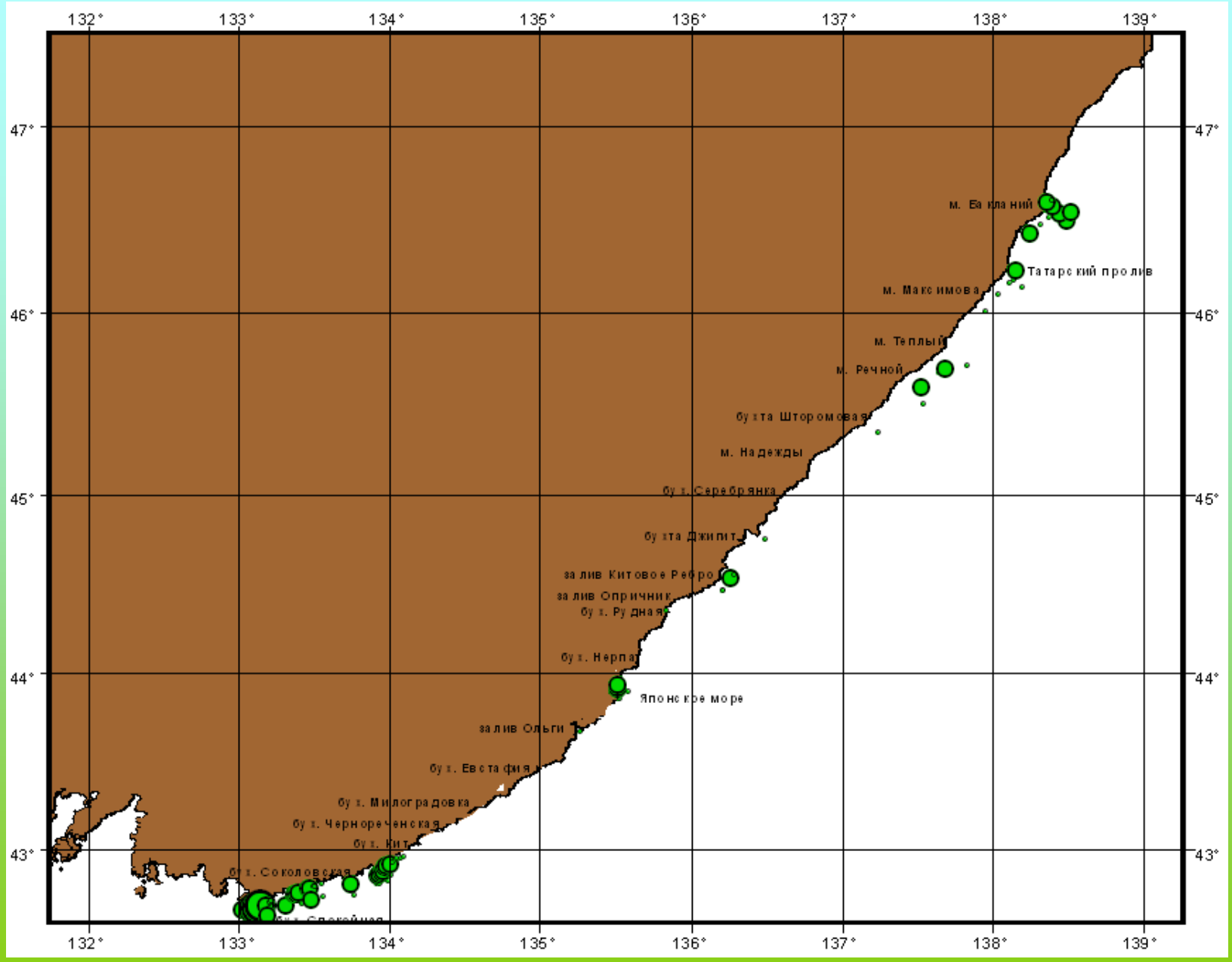
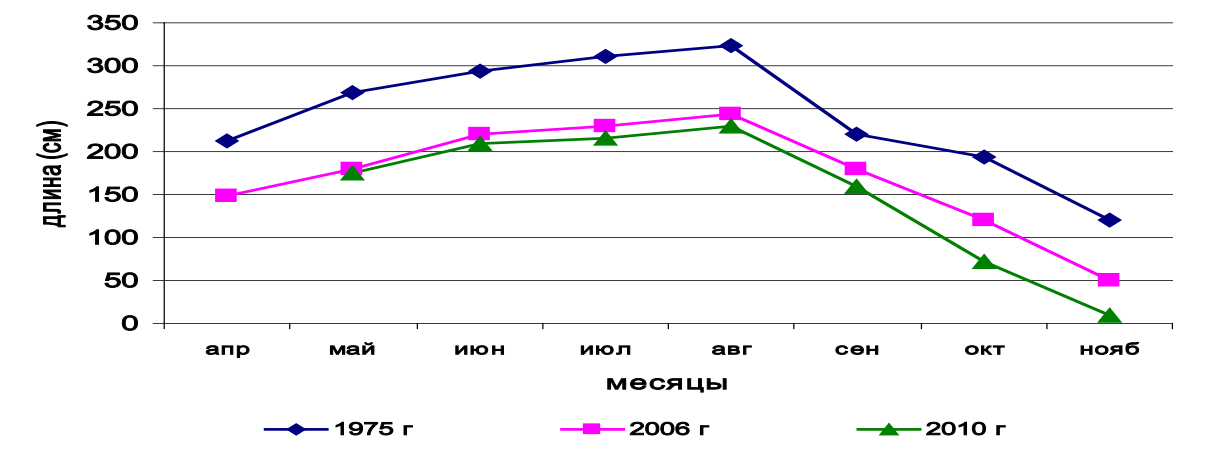
Field of Laminaria (Saccharina) as algae belt

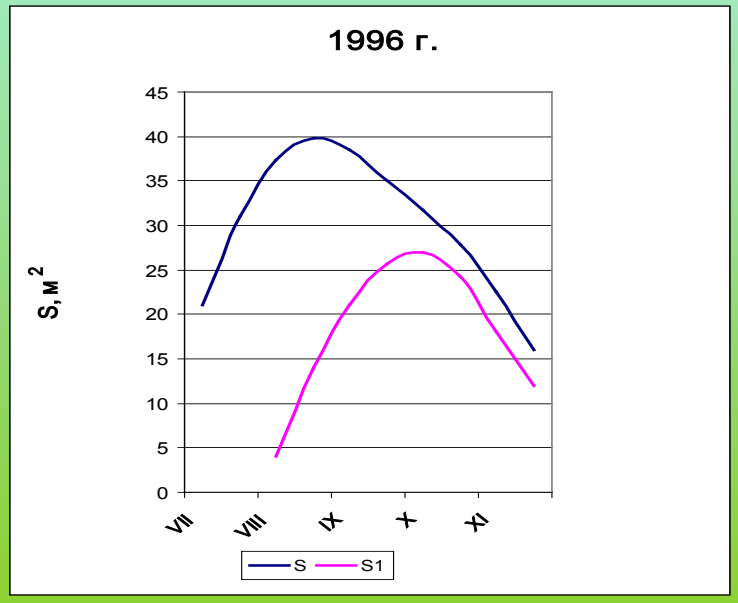
Distribution of Laminaria fields at Primorye coast (Japan Sea)

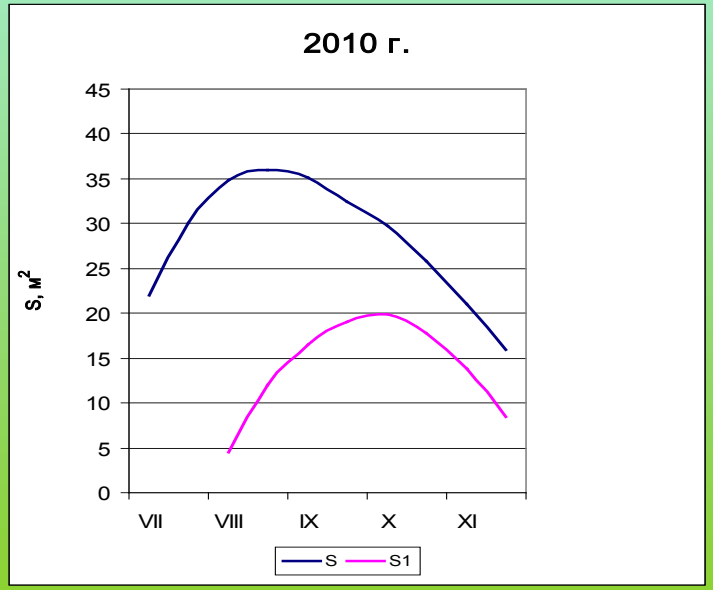


Changes of the Laminaria biological parameters



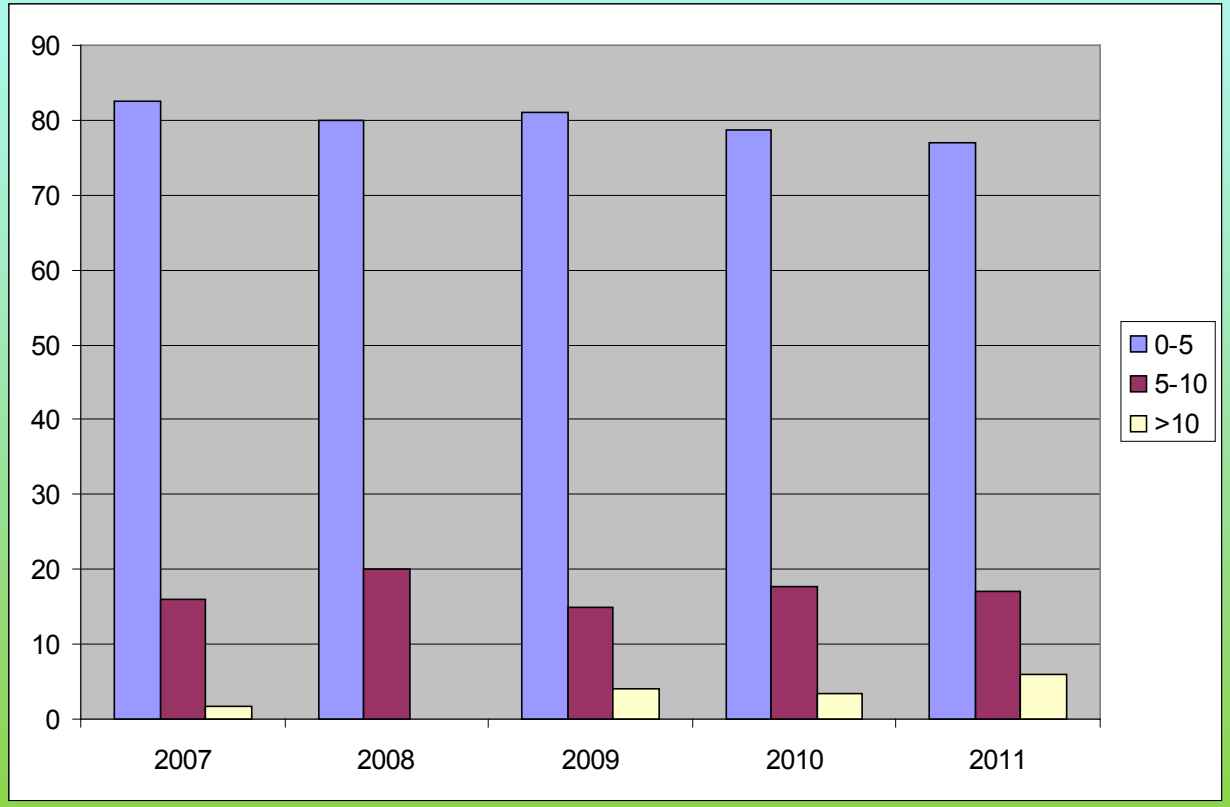
Seasonal dynamics of the Laminaria thalli length in 1975, 2006, and 2010





Correlation between entire surface of the Laminaria leaves (S) and the sporiferous surface (S1) in 1996 and 2010

Bathymetric distribution of Laminaria thickets at Primorye coast in recent times



Grazing of Laminaria by sea urchins

Program for Laminaria fields restoration

Block 1.

Understanding the reasons of Laminaria fields shrinking

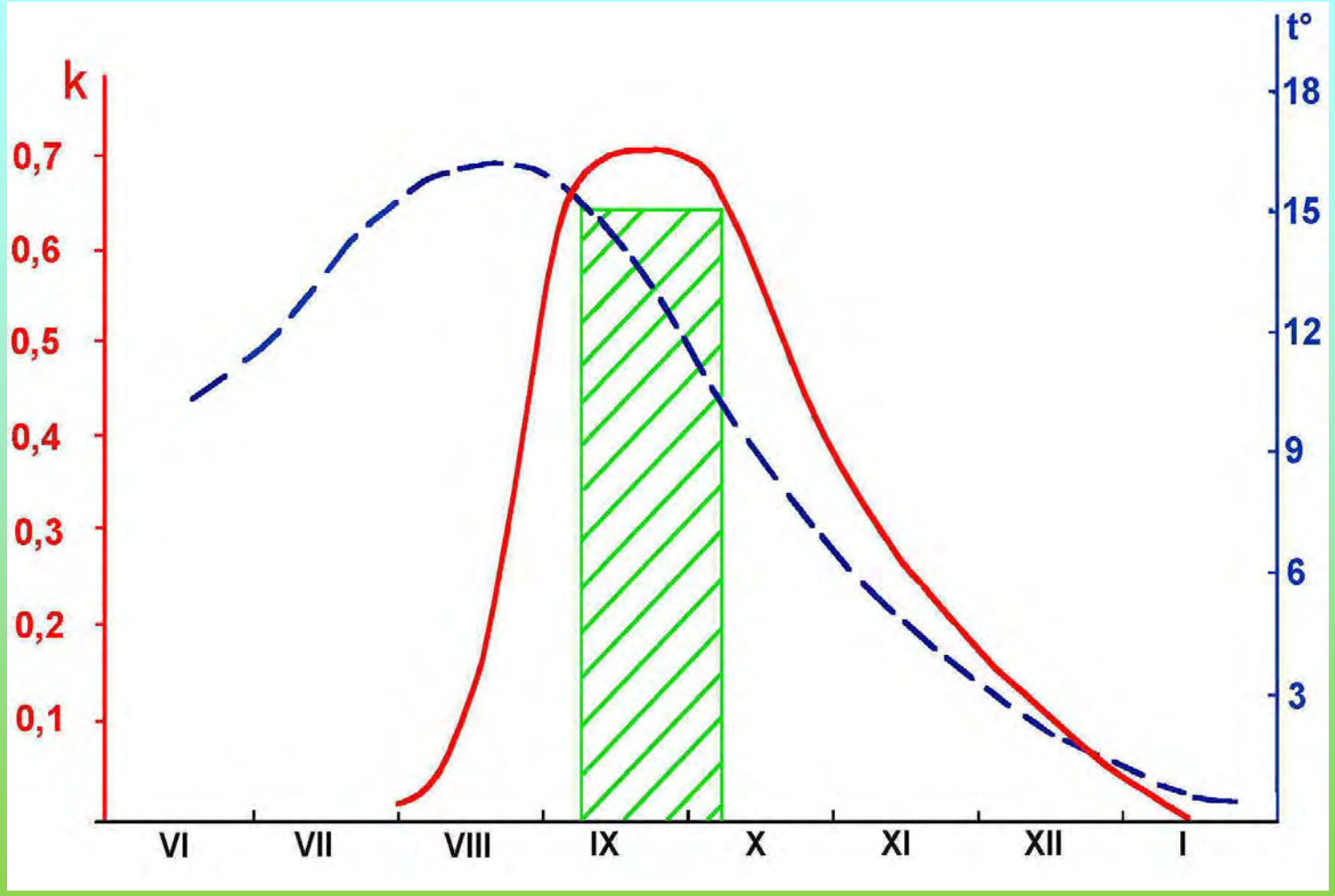
- *studies of environmental influence on life cycle of Laminaria (length of periods with optimal conditions for its early stages development)*
- *studies of anthromogenic impacts on the firlds – overlandings in the years of insufficient reproduction, worsening of nutrients supply because of the coast deforestation and lowering the organic detritus flux from the coast*

Block 2.

Measures:

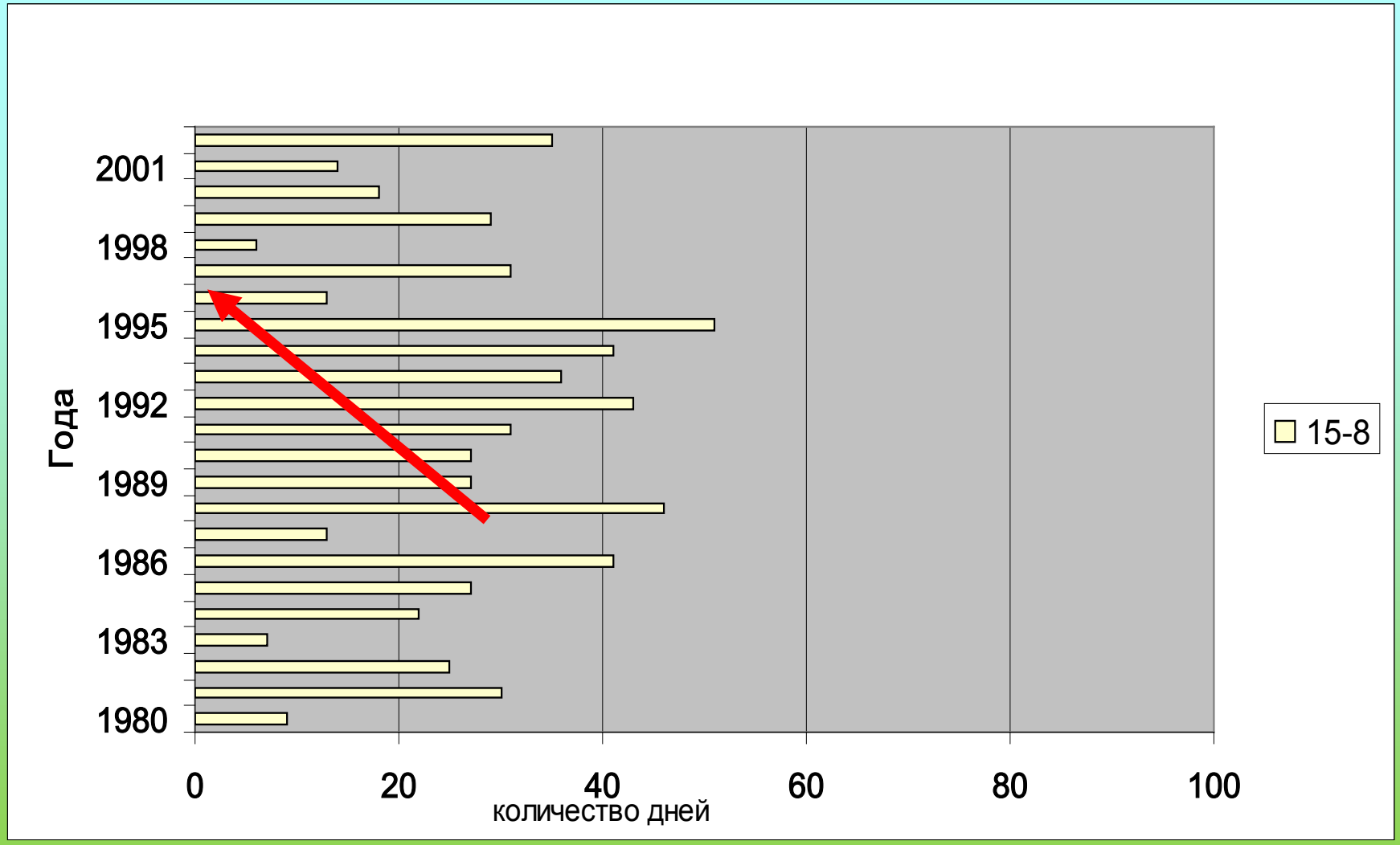
- *coastal zone surveys to find the sites appropriate for restoring Laminaria fields*
- *developing of biotechnology for using the restored fields as feeding grounds for sea urchins*
- *studies of meso-scale water circulation in the areas of Laminaria fields restoration*
- *detail studies of Laminaria taxonomy for selection the best forms for reproduction*

Optimal conditions for Laminaria reproduction



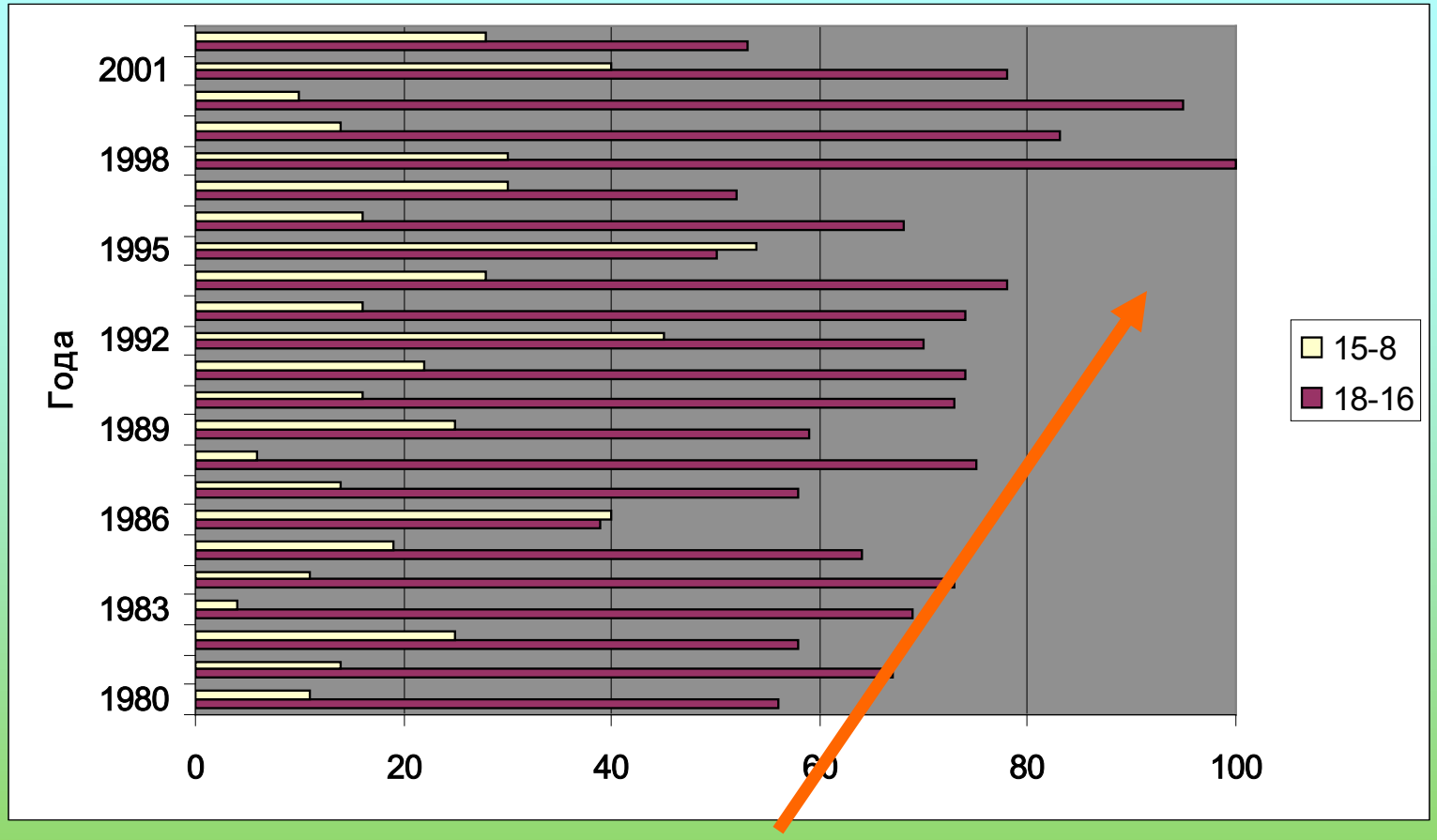
Dynamics of sporogenic tissue development (k, solid line) in dependence on water temperature (t, dotted line) at Primorye coast.  *- the period, optimal for spore sowing*

Long-term changes of conditions for Laminaria reproduction



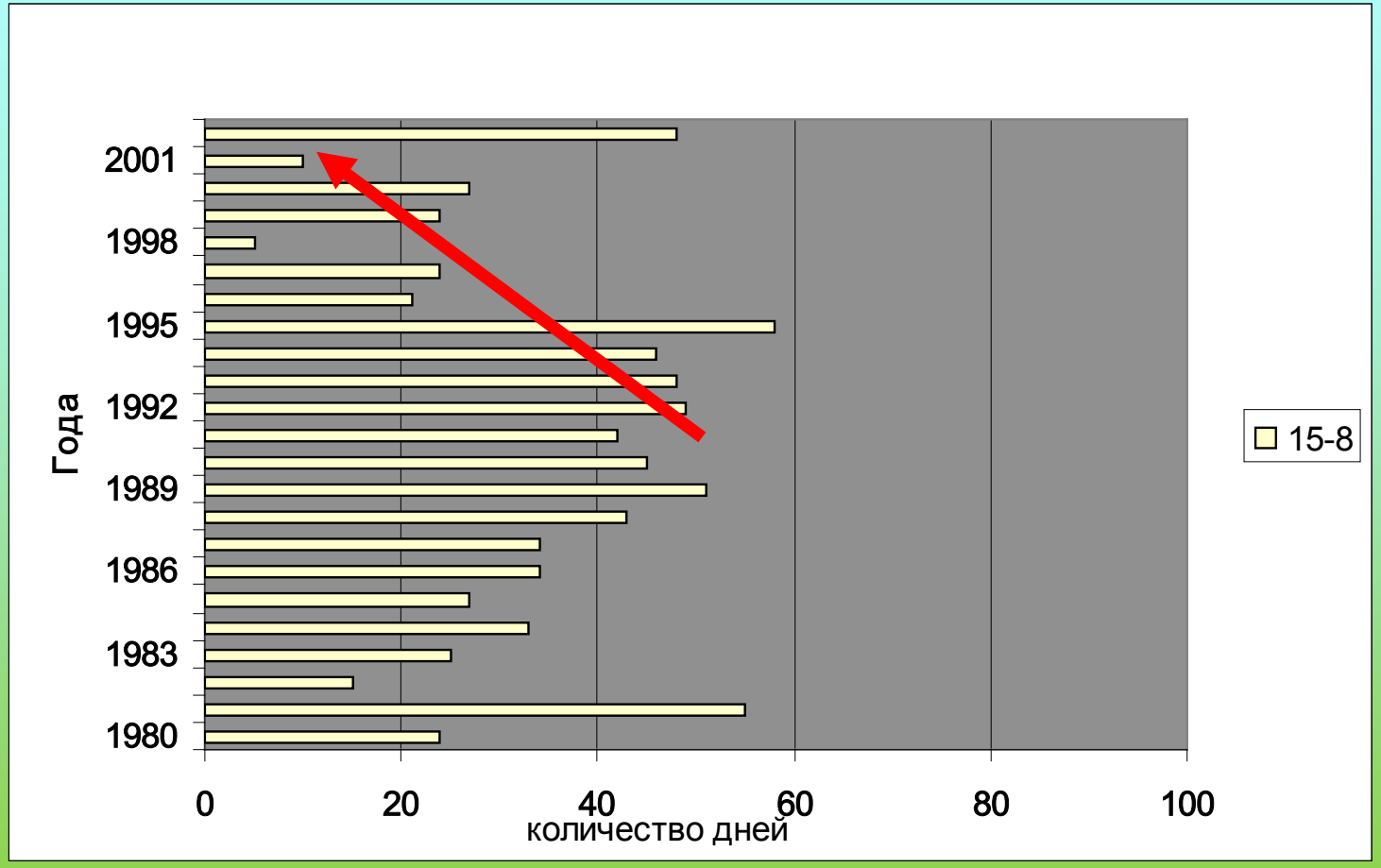
Length of the period (days) with the water temperature between 15° and 8°C favorable for Laminaria zoospores growth and their gametophytes development at the southern Primorye coast. Tendency to shortening of the optimal period is observed in the last two decades

Long-term changes of conditions for Laminaria reproduction



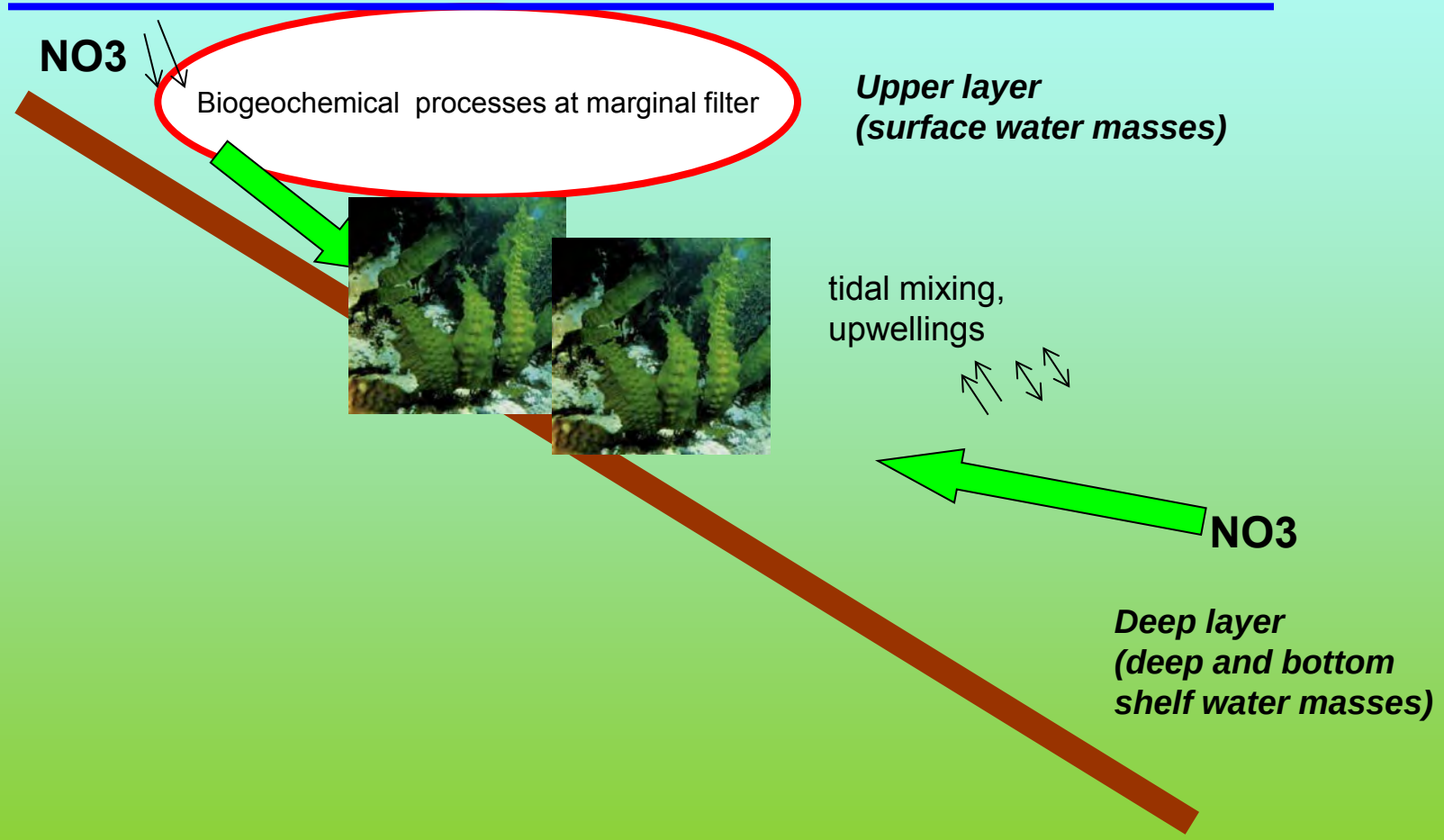
Length of the periods (days) with the water temperature between 15^{o} and 8^{o}C favorable for Laminaria zoospores growth and their gametophytes development (light bars) and with the water temperature above 16o that unfavorable for gametophytes (dark bars) at Peter the Great Bay. Tendency to lengthening of the unfavorable period is observed in 1980-1990s

Long-term changes of conditions for Laminaria reproduction

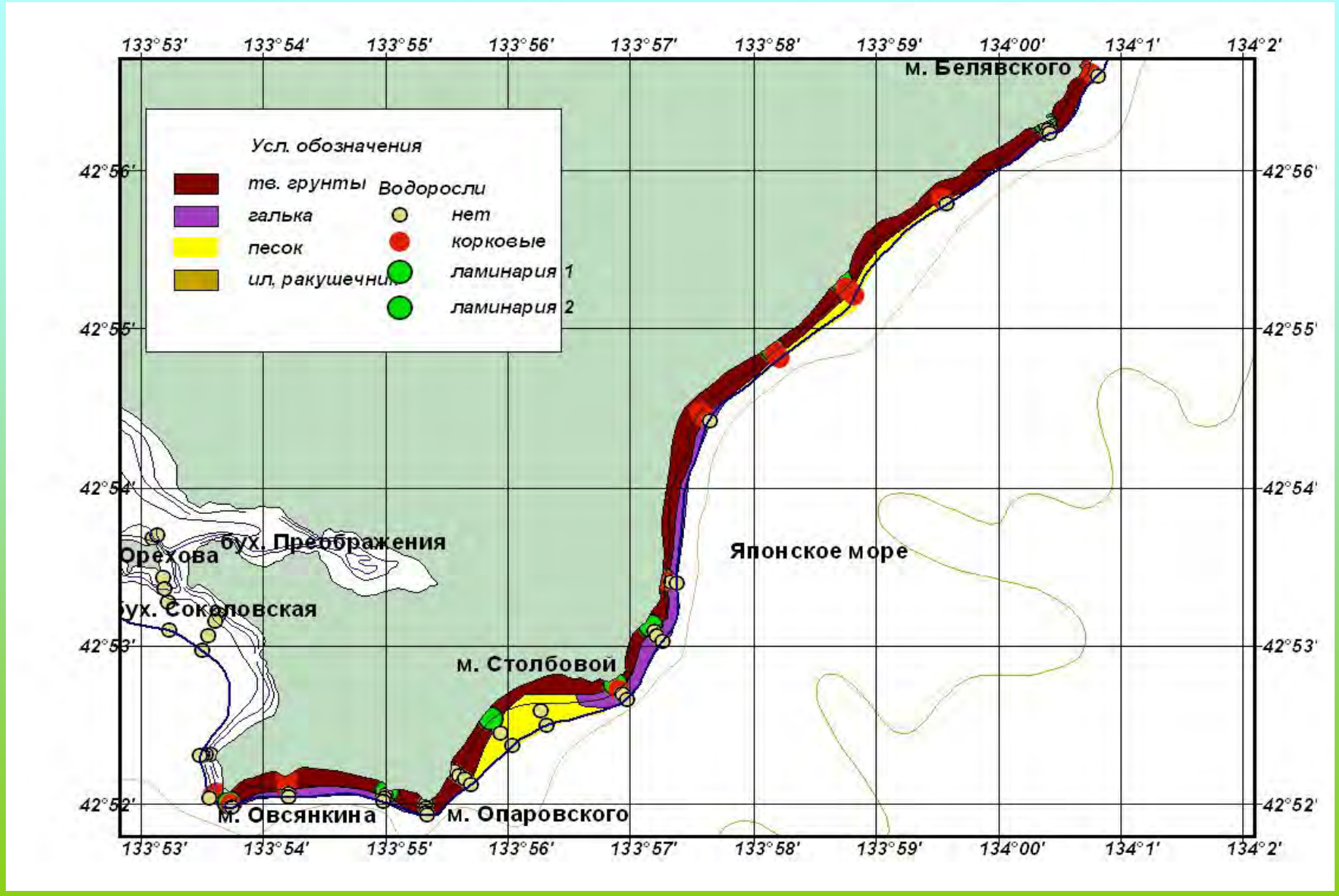


Length of the period (days) with the water temperature between 15° and 8°C favorable for Laminaria zoospores growth and their gametophytes development at the nothern Primorye coast. Tendency to shortening of the optimal period is observed in the last two decades

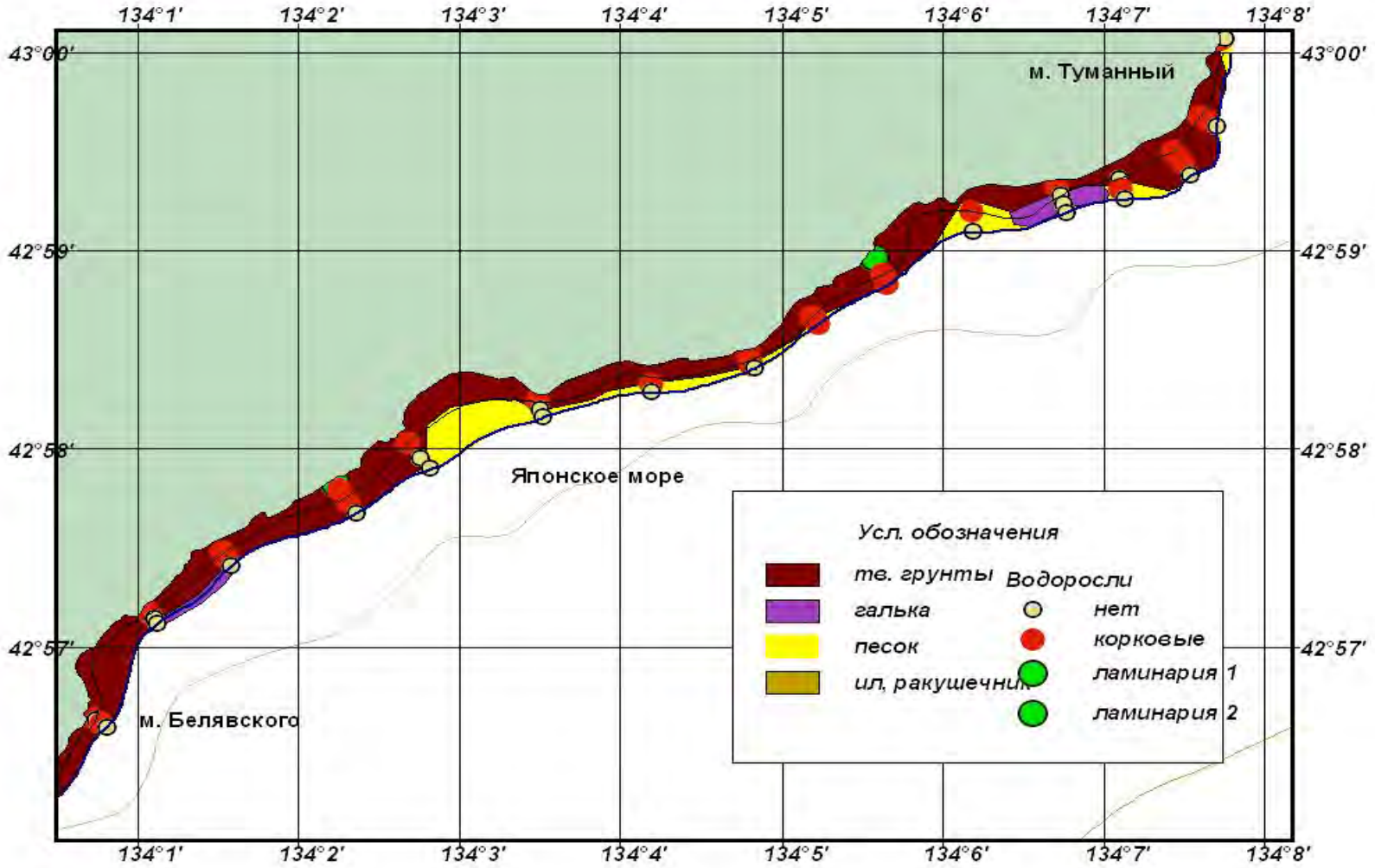
Possible sources of nutrients for Laminaria growth on Primorye shelf in summer-fall season



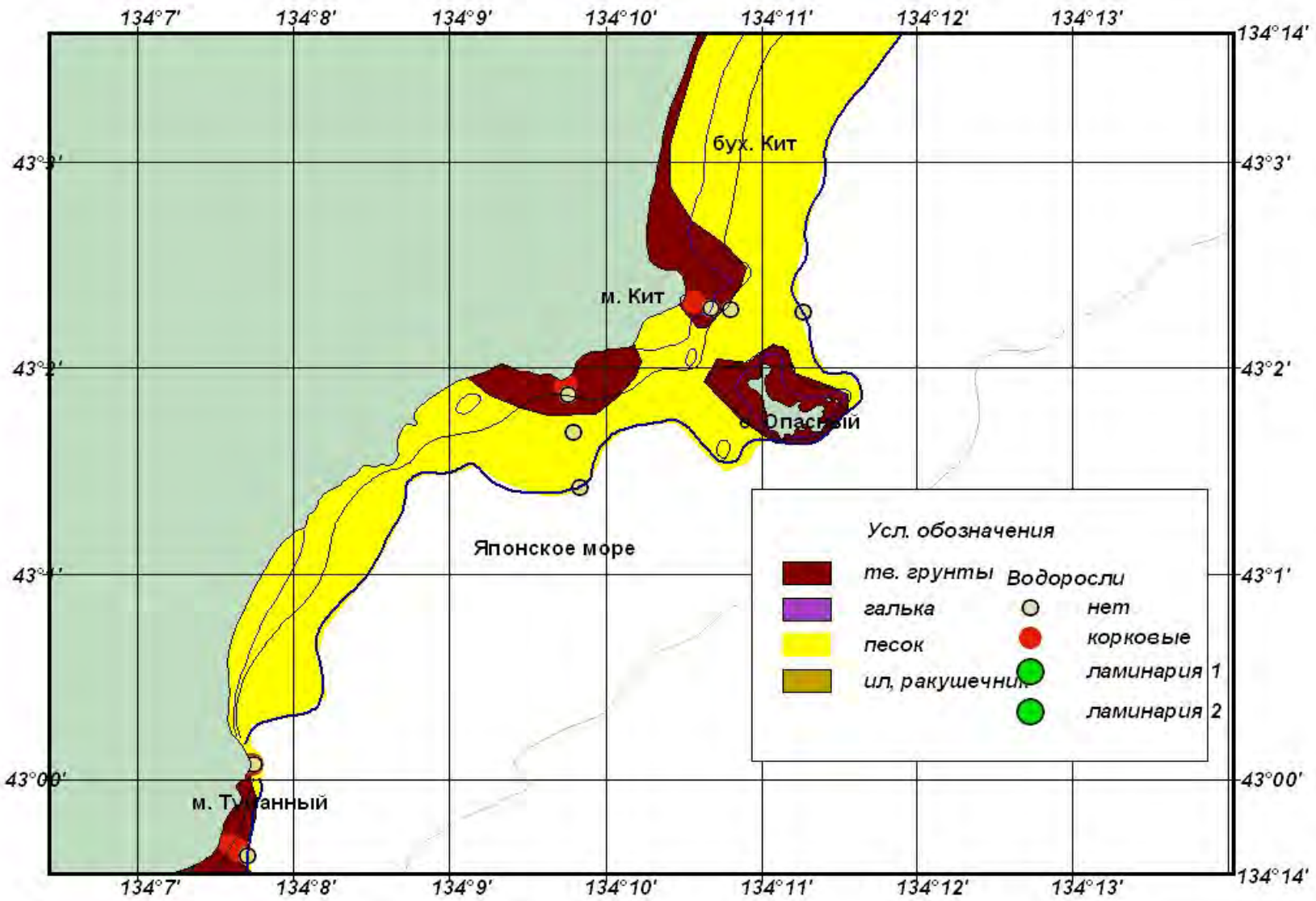
Bottom sediments and plants composition at Primorye coast from Cape Ovsyankin to Cape Belyakovsky (southern Primorye)



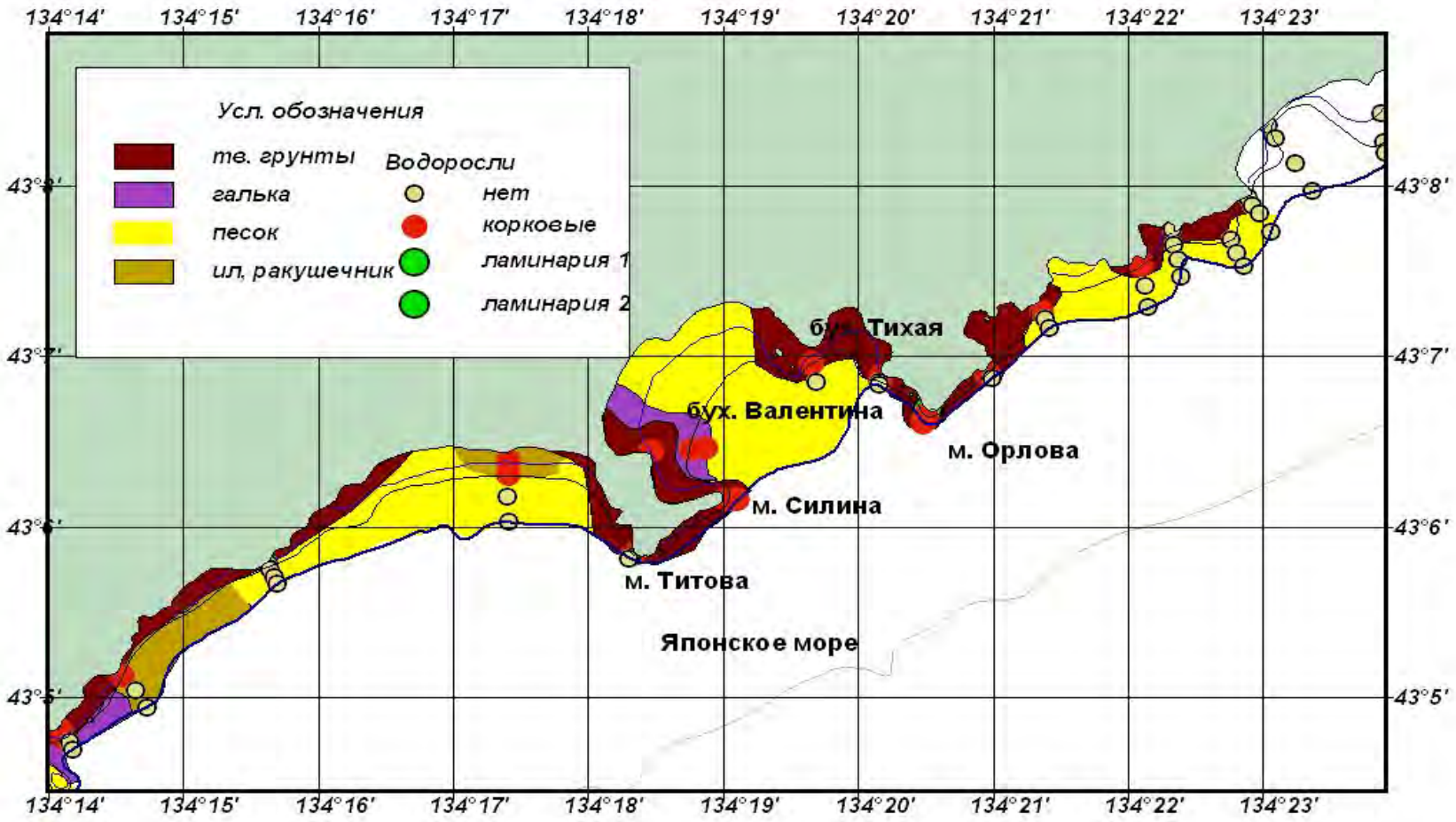
Bottom sediments and plants composition at Primorye coast from Cape Belyakovsky to Cape Tumanny (southern Primorye)



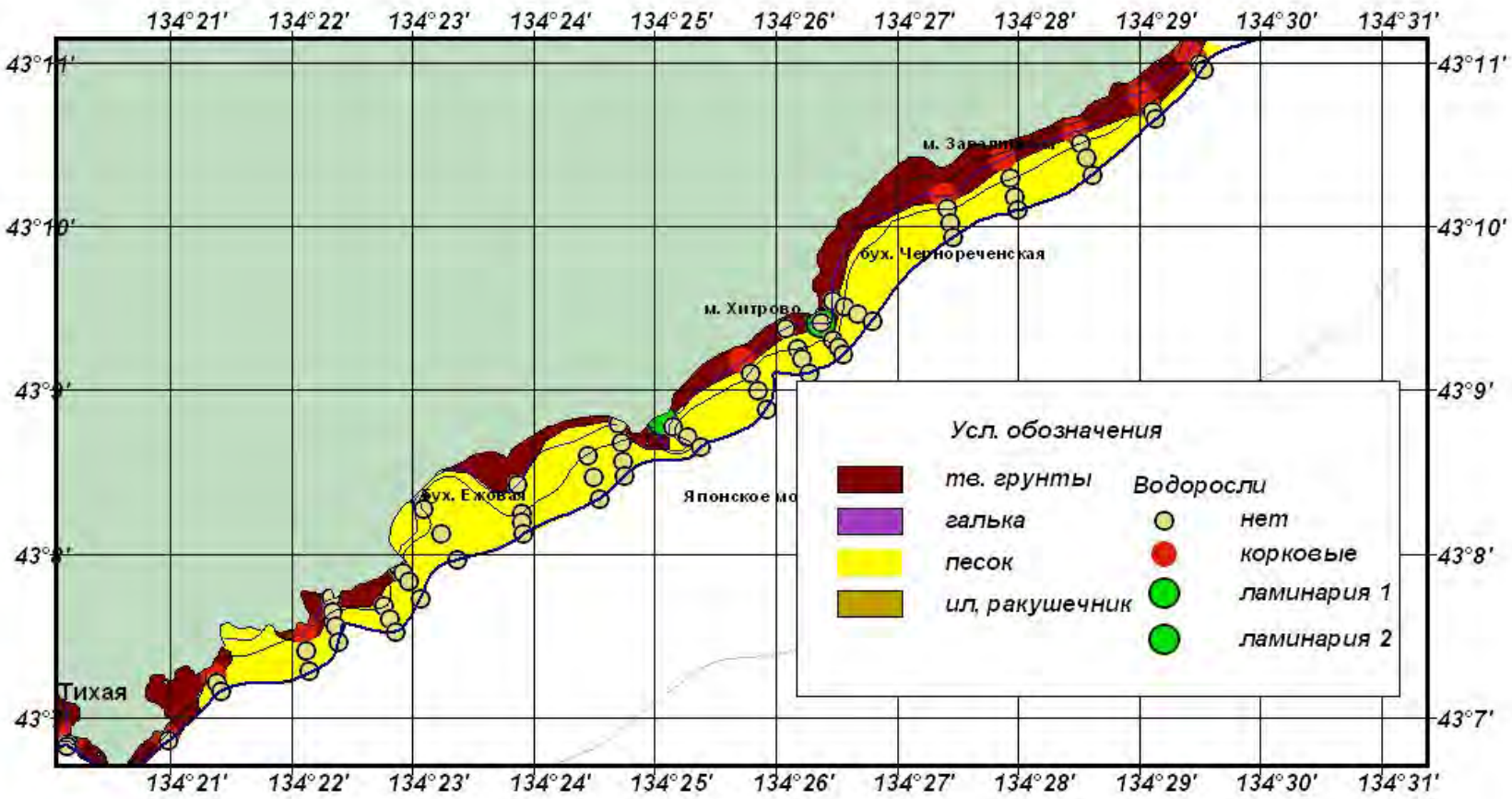
Bottom sediments and plants composition at Primorye coast from Cape Tumanny to the Kit Bay (southern Primorye)



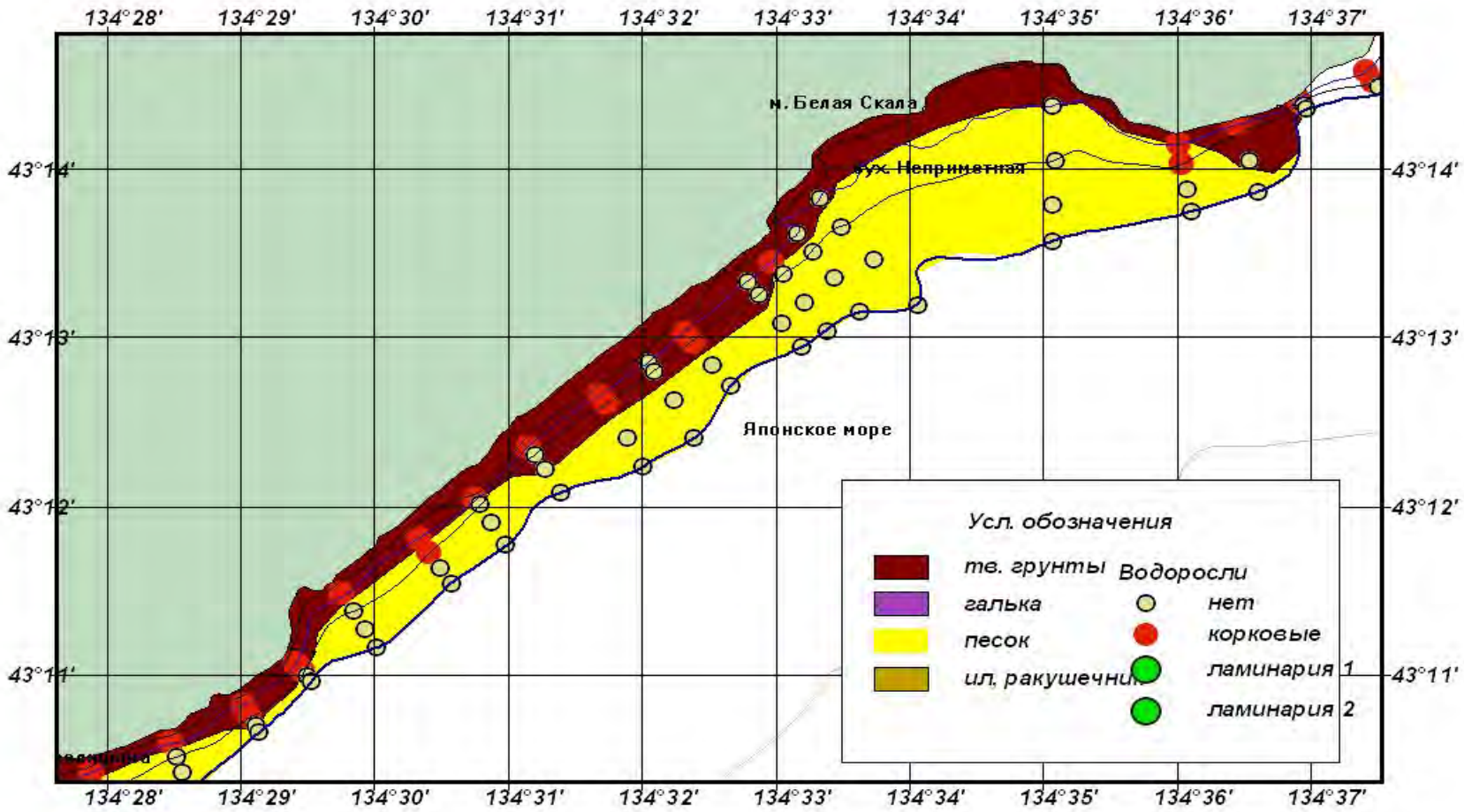
Bottom sediments and plants composition at Primorye coast from the Kit Bay to Cape Orlov (southern Primorye)



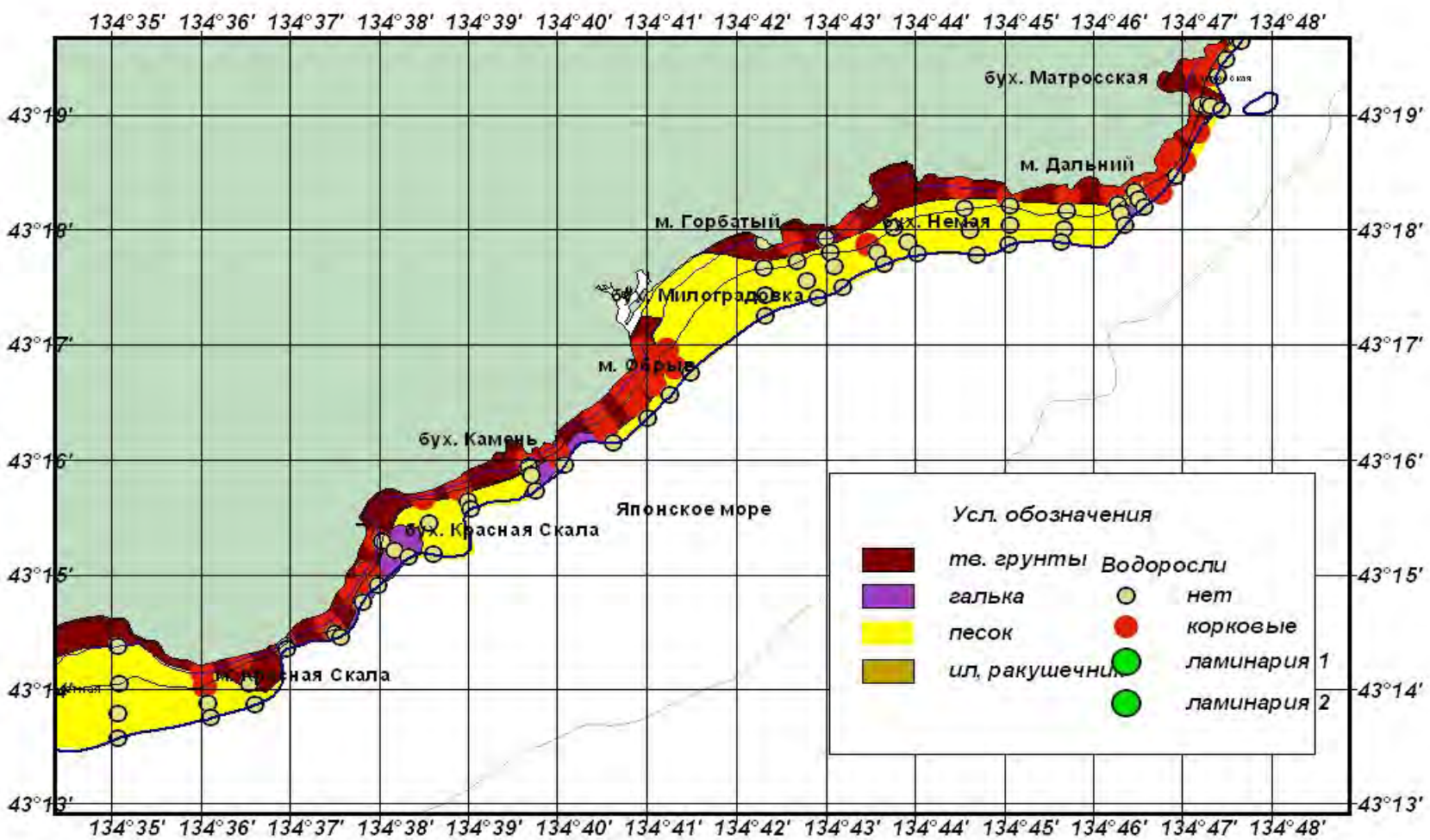
Bottom sediments and plants composition at Primorye coast from Cape Orlov to Cape Zavalishin (southern Primorye)



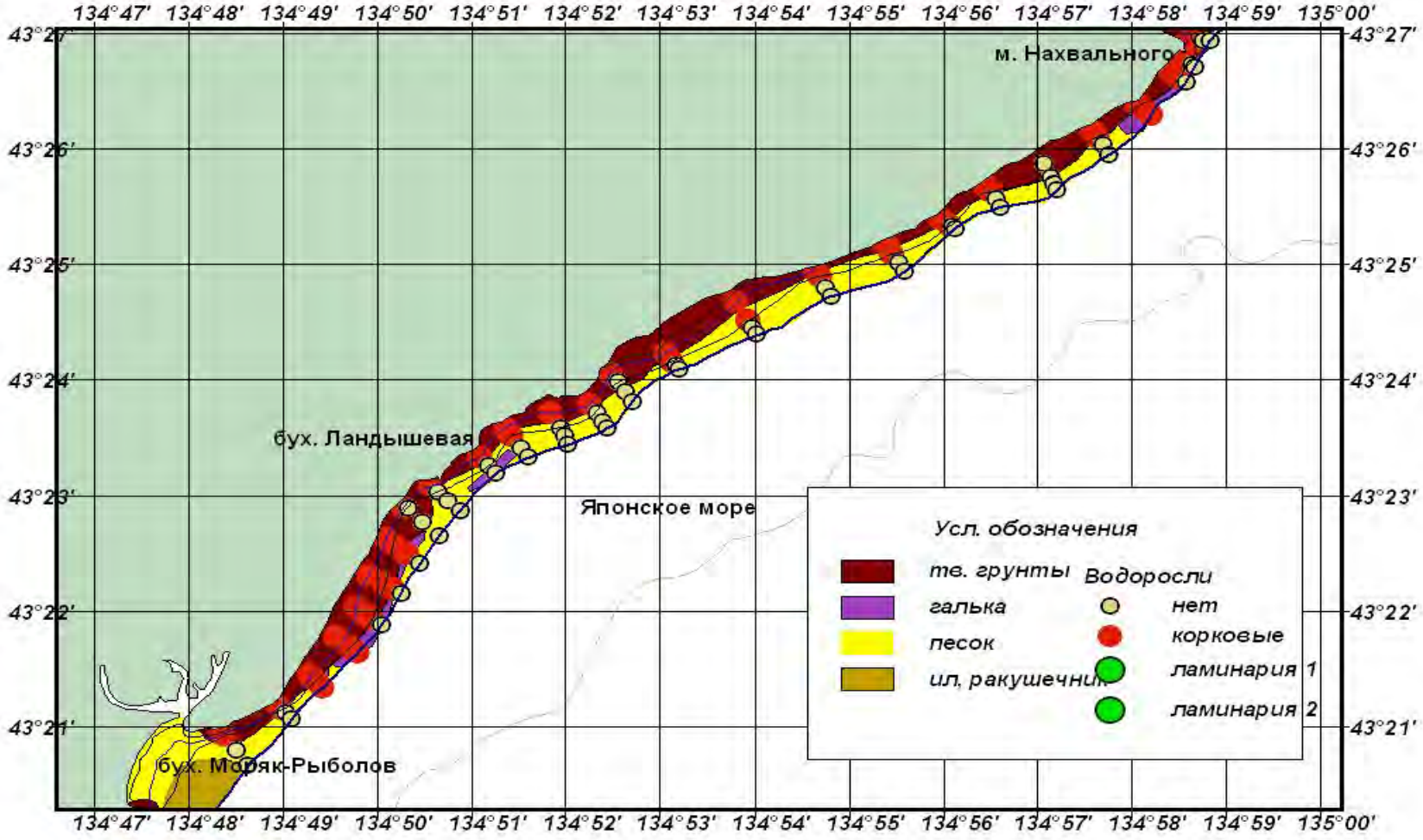
Bottom sediments and plants composition at Primorye coast from Cape Zavalishin to the Neprimetnaya Bay (southern Primorye)



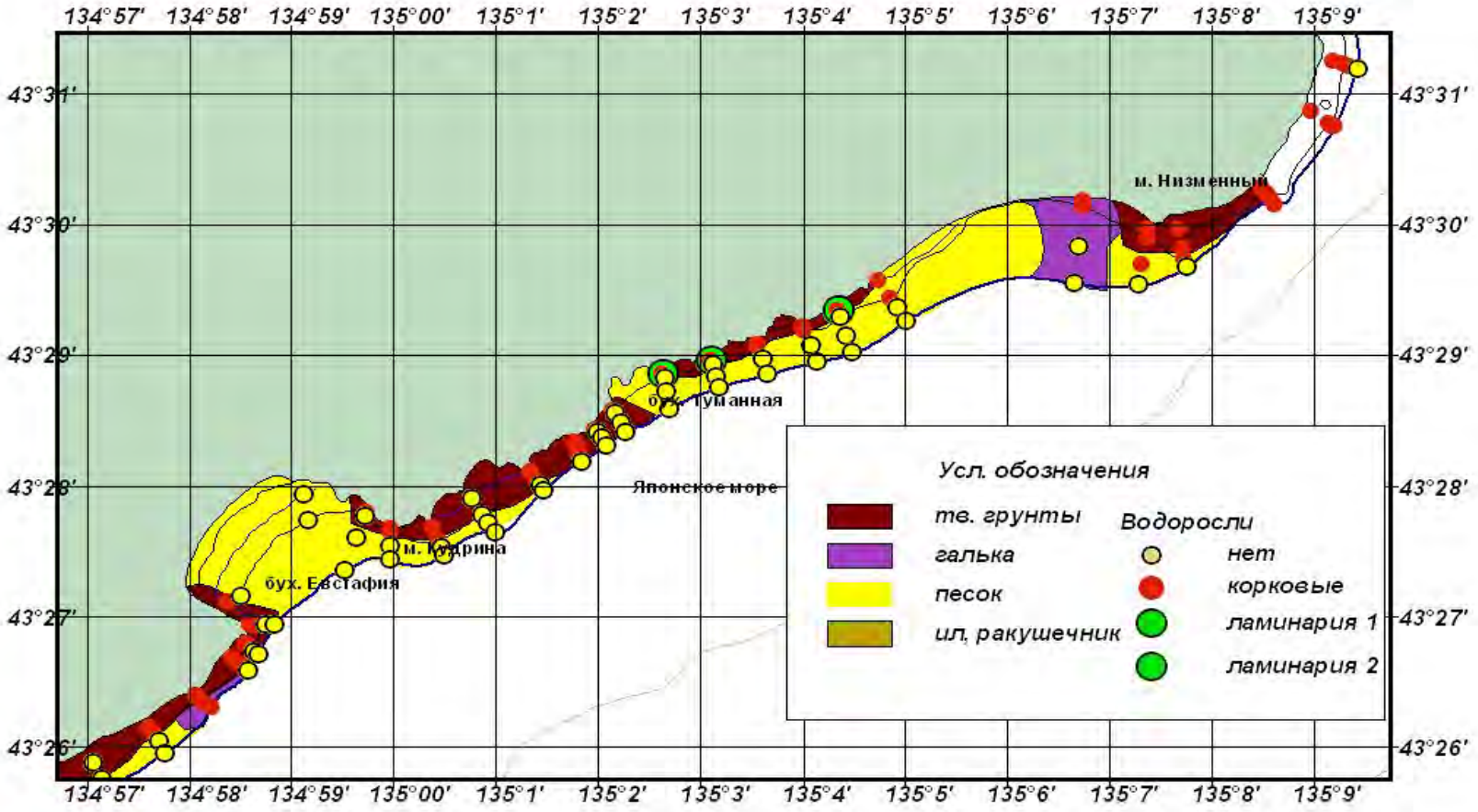
Bottom sediments and plants composition at Primorye coast between the Neprimetnaya Bay and Moryak-Rybolov Bay (southern Primorye)

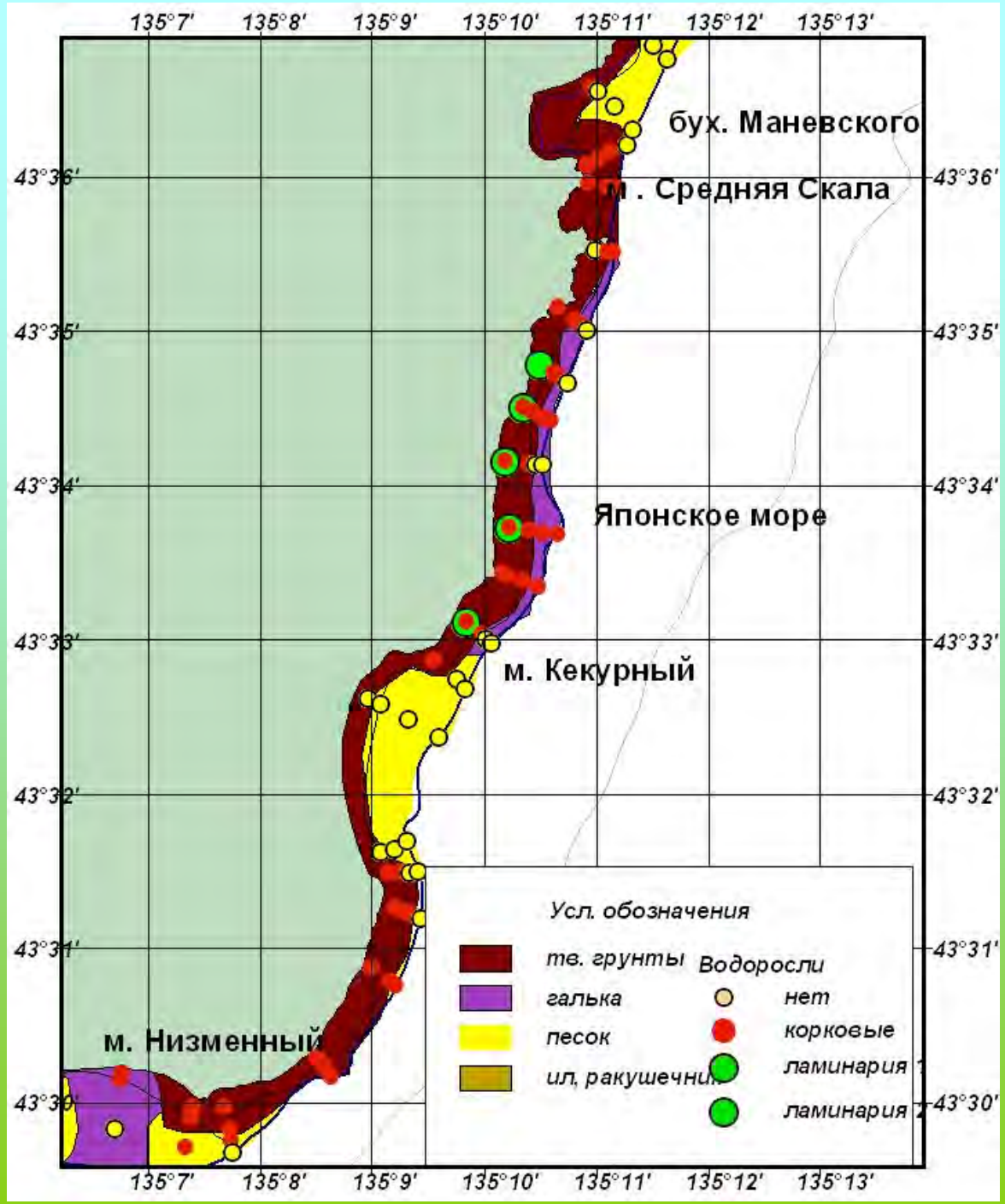


Bottom sediments and plants composition at Primorye coast from the Neprimetnaya Bay to Cape Nahvalny (southern Primorye)



Bottom sediments and plants composition at Primorye coast from Cape Nahvalny to Cape Nizmenny (southern Primorye)





Bottom sediments and plants composition at Primorye coast from Cape Nizmenny to the Manevsky Bay (southern Primorye)

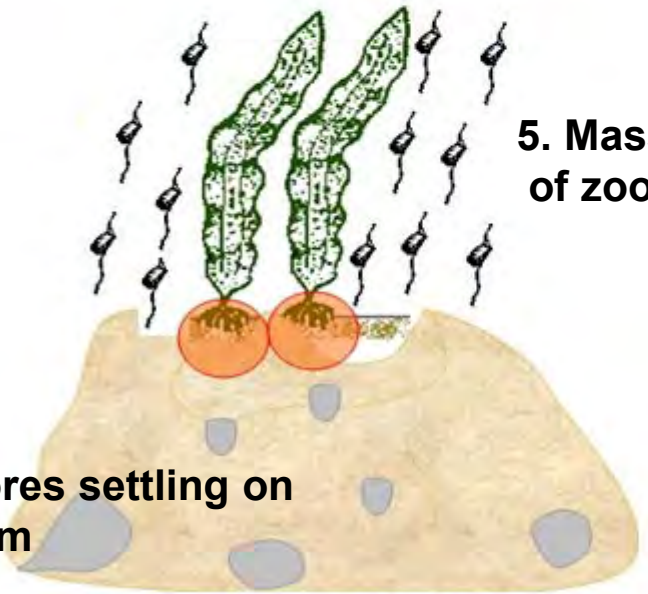
The main algorithm of biotechnology for Laminaria thickets restoration

1. Thalli landing

2. Thalli transport ashore

3. Thalli drying

4. Thalli arrangement at the bottom



5. Mass outcome of zoospores

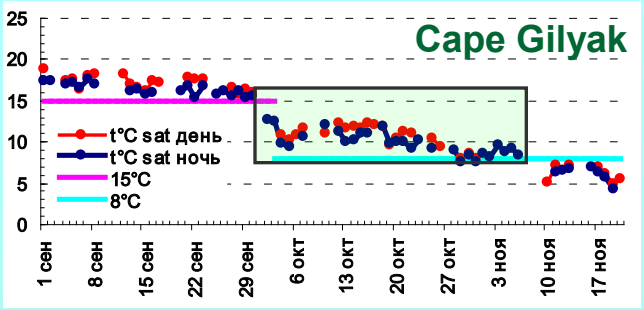
6. Zoospores settling on substratum

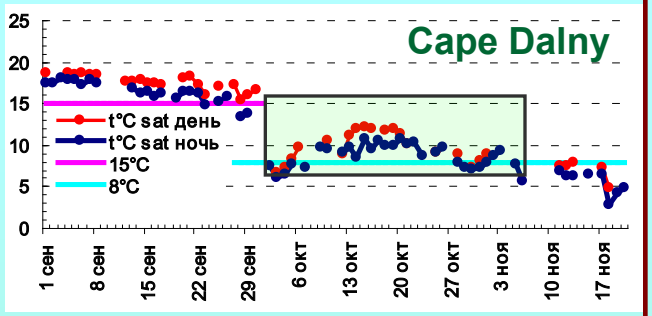
Transport of Laminaria parental thalli to the sites of zoospores seeding

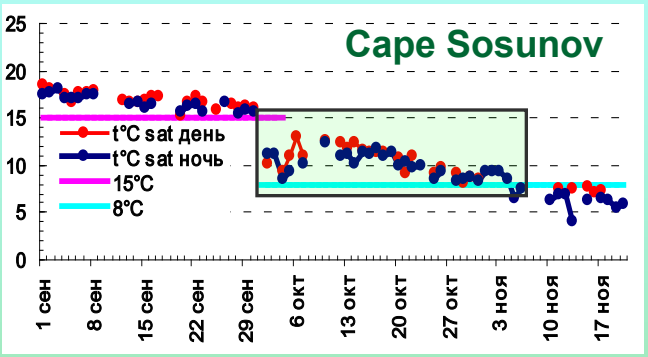
Laminaria landed from the restored field

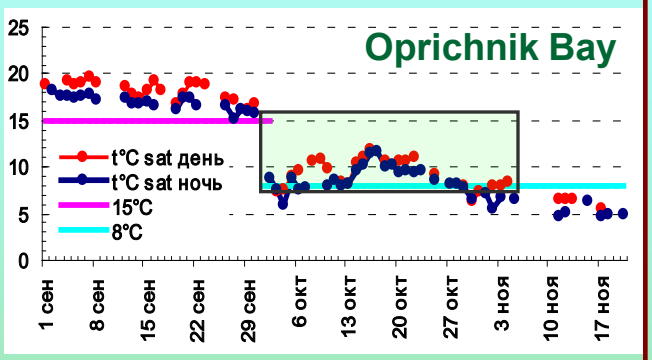
Drying of Laminaria thalli landed from the restored field in the Valentine Bay

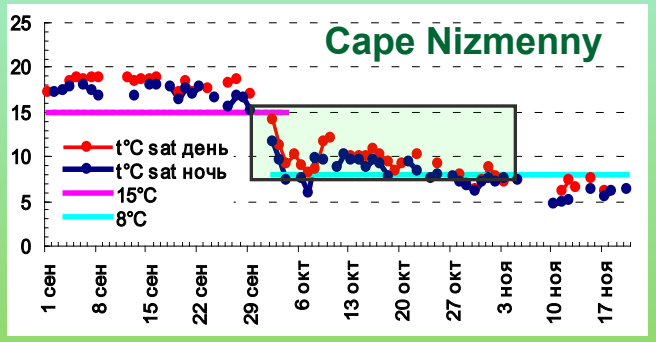
- **The developed technology of Laminaria fields restoration includes both permanent recommendations (how to select the thalli for reproduction, when and how to transport them, how to stimulate them for mass seeding of zoospores, how to arrange the stimulated thalli on the sea bottom, and some others) and the recommendations varying in dependence on environmental variability that should be monitored for good harvesting.**

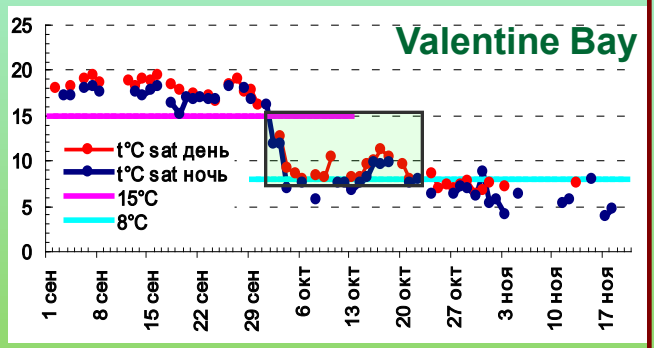


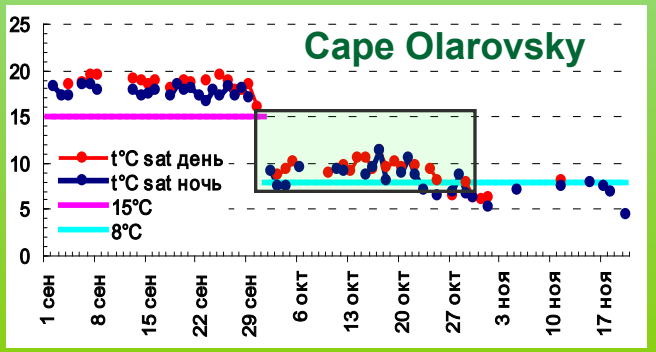


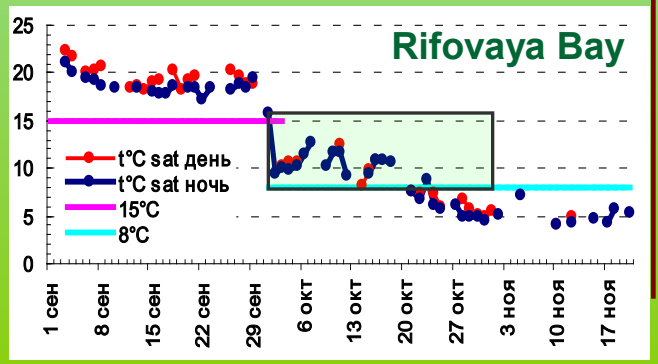












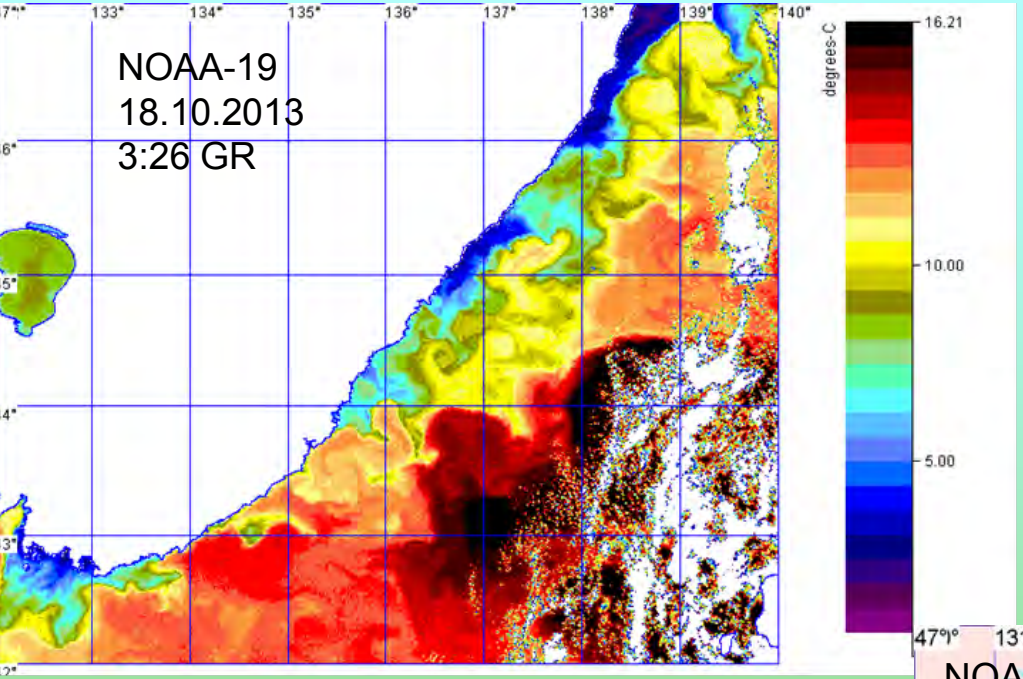
Typical sea surface temperature at Primorye coast in fall season (by satellite data)

SST changes along Primorye coast from September 1 to November 20, 2015 (day and night satellite data)

Length of the periods with conditions optimal for development of Laminaria early stages (SST 15-8°C) (by satellite data)

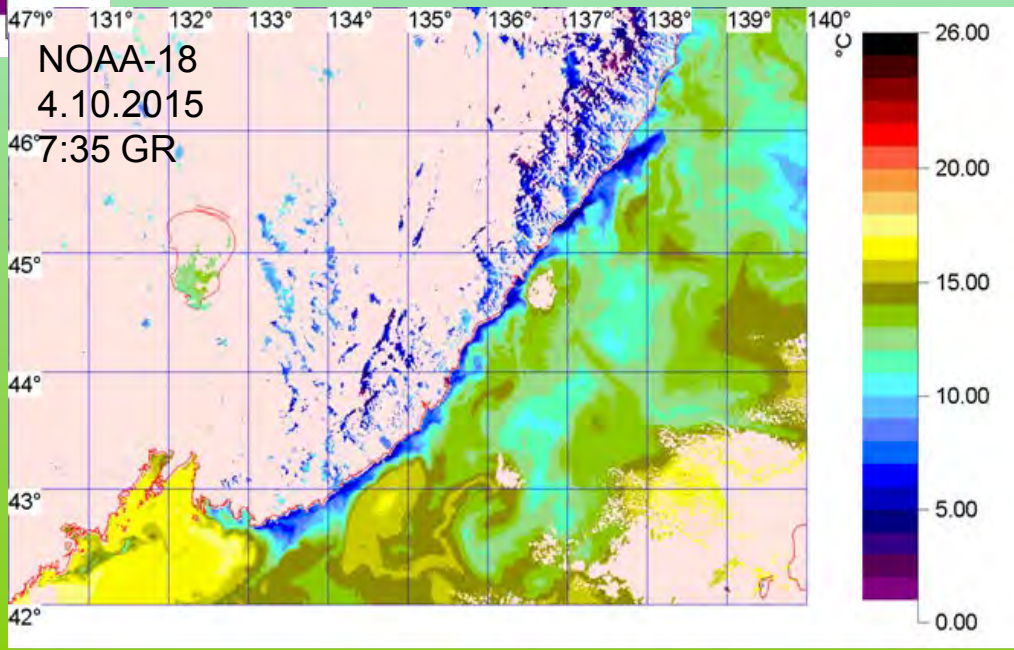
Area	2011 (days)	2012 (days)	2013 (days)	2014 (days)	2015 (days)	2016 (days)
Cape Gilyak	33	33	10	29	36	30
Cape Sosunov	36	33	10	20	34	32
Cape Dalny	36	33	9	31	30	28
Oprichnik Bay	27	34	7-10	34	27	25
Cape Nizmenny	18	26	34	24	24	26
Valentine Bay	15	36	37	24	12	24
Cape Olarovsky	17	30	42	21	21	24
Rifovaya Bay	12	18	38	24	18	no data

Typical oceanographic conditions at Primorye coast in October (on the data of AVHRR satellite scanner)

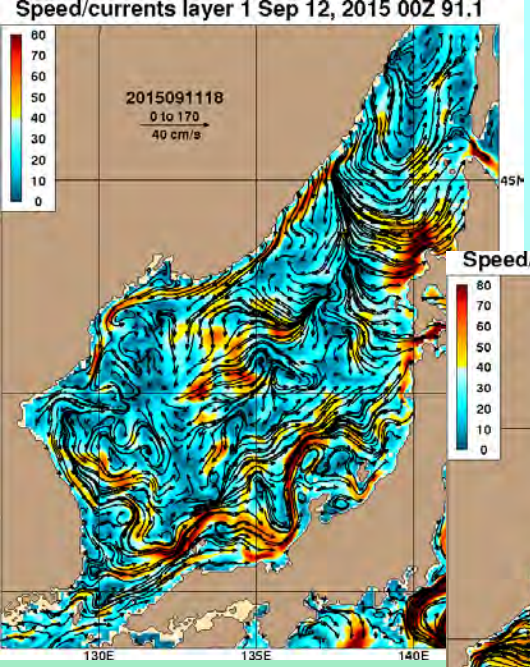


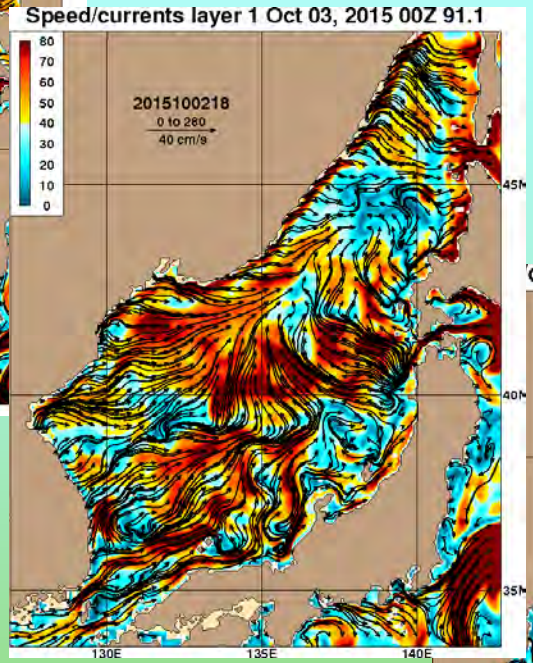
Break of the Primorye Cold Current stream under wind-driven on-shore surge of warm water (October 18, 2013)

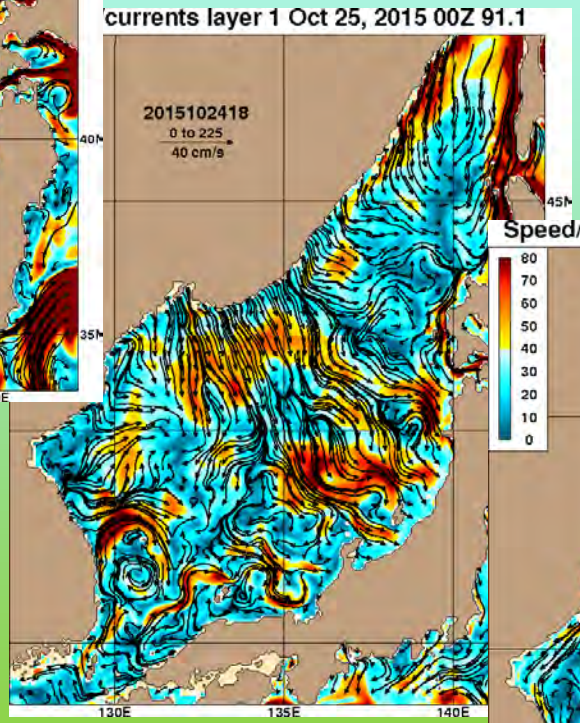
Compensatory influx of cold water in the process of wind-driven upwelling (October 4, 2015)

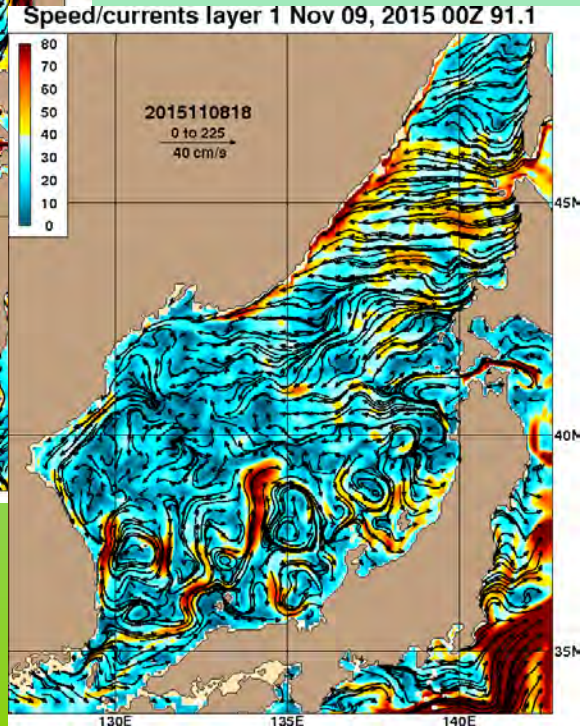


Typical currents at the surface of the Japan Sea in fall season (by satellite data)



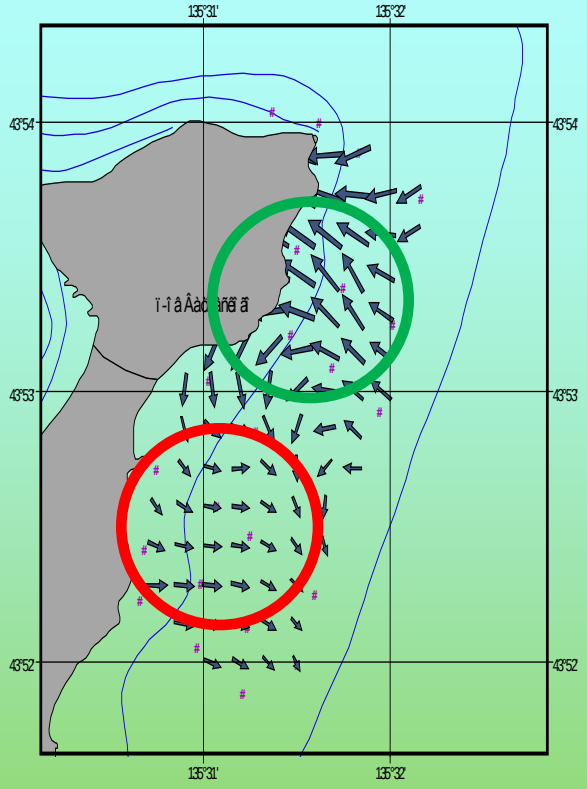


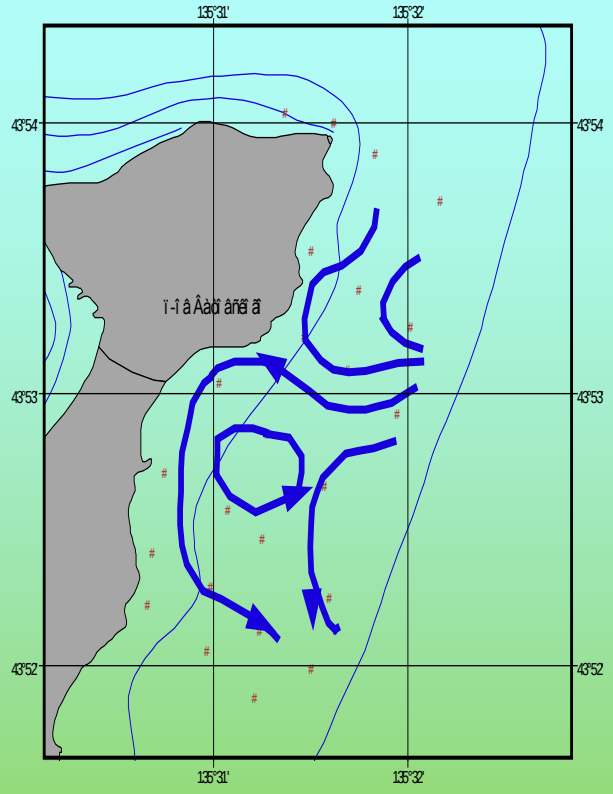




Surface currents determined by satellite data in September, October and November, 2015

Currents at Cape Vatovsky on the sea surface and at the bottom





Stimulated parental thalli of Laminaria with zoospores should be arranged in the area of restoration taking into account the water circulation. For example, the on-shore current prevailing at Cape Vatovsky is favorable for the zoospores settling in the coastal zone (green circle), but the off-shore current southward from this cape is not favorable – so restoration of Laminaria in the southern area could be unsuccessful, or parental thalli should be arranged there with heightened density (red circle)

Species and forms of Laminaria dwelling at Primorye coast

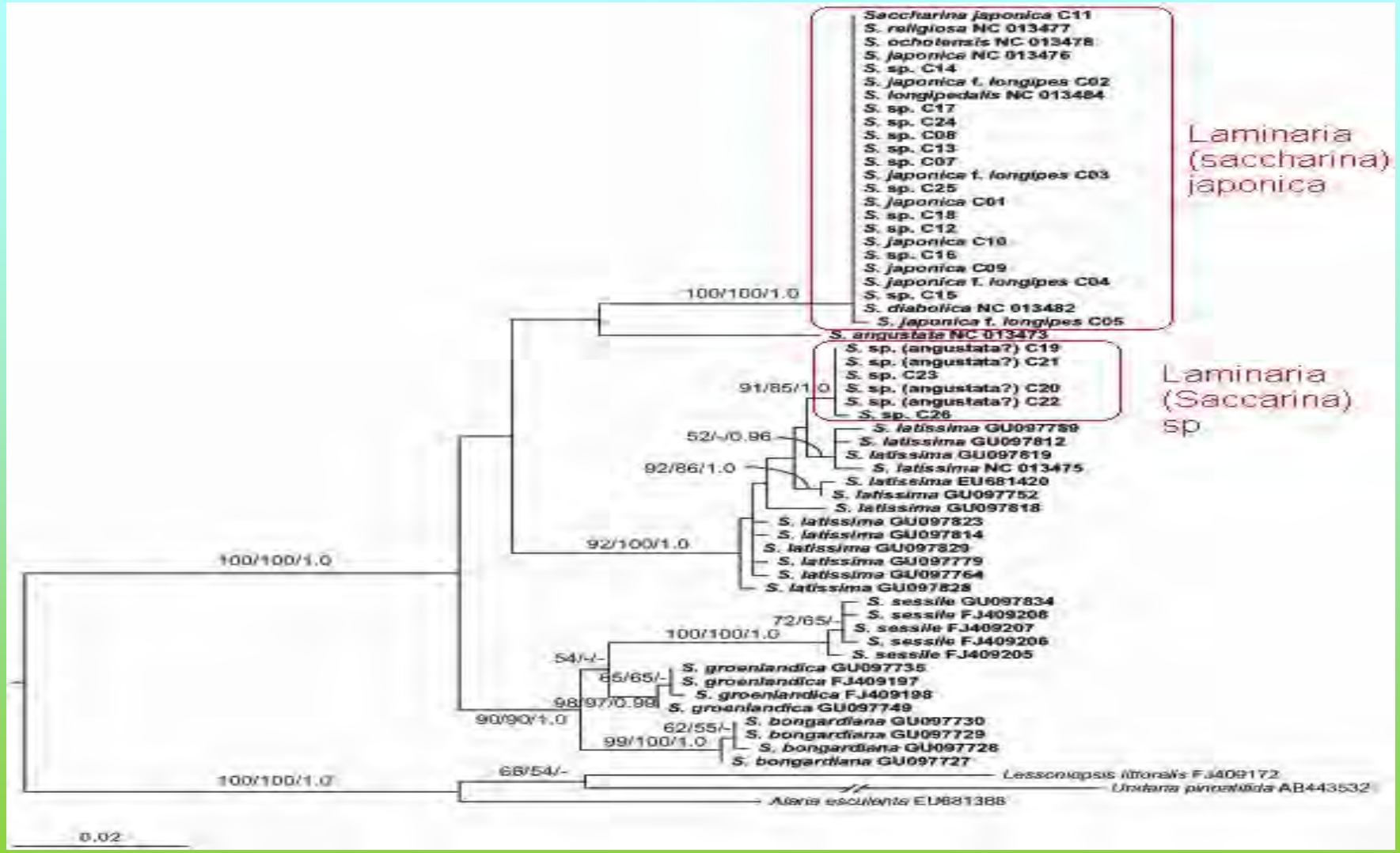
Common Laminaria

Deep-water Laminaria

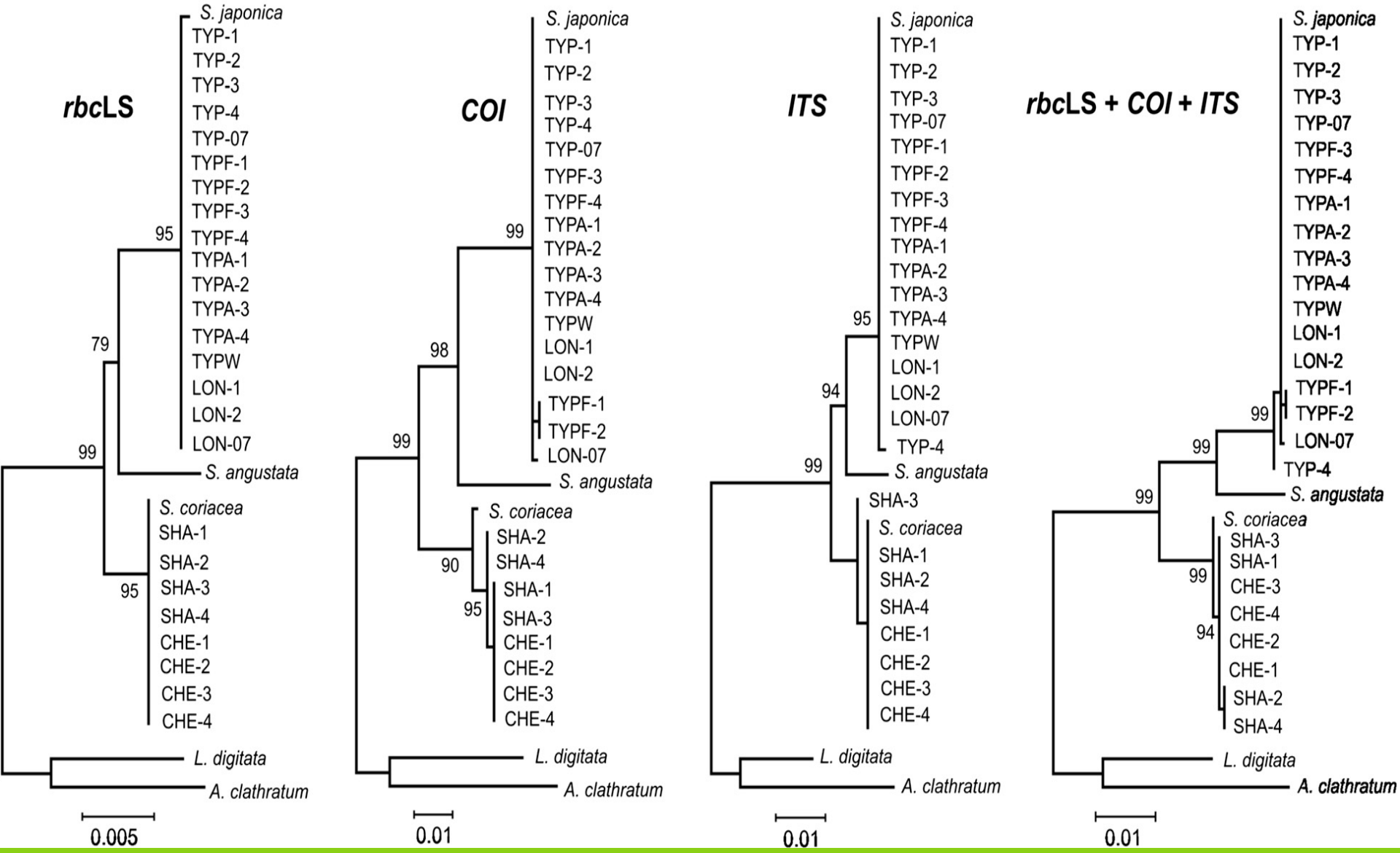
Surf Laminaria

Narrow Laminaria (L.angustata)

Phylogenetic tree of Laminaria



Phylogenetic trees for *rbc* LS, *COI* , *ITS* and united successions (total length 4286) for morphological forms of *Saccharina japonica*



Phenotypic forms of *Laminaria japonica (Saccharina japonica)*

Common Laminaria

(Saccharina japonica (Areschoug) Lane, Mayes, Druehl et Saunders)

Deep-water

(Saccharina japonica f. longipes)

Conclusions

- New biotechnology for recovering of Laminaria thickets at Primorye coast is developed, as the way for its stock heightening for commercial use.

- This technology could be realized directly in vicinity of the Laminaria processing factories that provides them by raw materials and allows to decrease transport expenses.


Thanks!