Slipper limpet the alien from North America

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General information

Scientific Crepidula fornicata (first described in 1758)

Originally from North American Eastern coast, first observed in Northern Wadden Sea in 1934. It was brought with oysters

Taxonomy Moluscs (Mollusca) > Mollusca > Gastropoda > Neotaenioglossa > Calyptraeidae > Crepidula fornicata

Size & appearance Up to 50 mm in length and up to 25 mm in height (for 4 - 5 year individuals). It has brownish white, beige or yellowish oval shell, with streaks or blotches of red or brown on the outside, and white on the inside. Inside there is a thin shelf (septum) covering half the aperture.

Known introduced range North American Pacific coast, Japan, northern Europe, southern France, Sicily, Uruguay. It’s gradually expanding its range and may be capable of colonizing other temperate and Mediterranean climatic regions.

Growth moderate factors There was only one factor that moderate slipper limpet growth revealed: high winter mortality during freezing winters [2]. Slipper limpets are not affected much by parasites, their reproduction takes place at warm period of year so reproduction output is high enough and predators prefer to eat other mollusks. So with the global warming the environmental conditions are becoming more and more favorable for growth of slipper limpets.

Ecological effects It is believed that slipper limpets compete with oysters and mussels for plankton but this has not been proven. It was observed that oysters don’t suffer from slipper limpets and mussels have problems with dead slipper limpet as well as with alive ones. Thus it is not competition for food but mechanical interference. Potentially competition for food could arise because they eat same food.

In general it’s more correct to consider not only negative effects on recipient ecosystems [1]:

NEGATIVE	POSITIVE
Interference competition with basibionts (mussels)	Reduced predation pressure on basibionts
Trophic competition with associated suspension-feeders	Additional substrate for other epibenthos
Spacial competition for basibionts	Adds heterogeneity to habitat structure

NEGATIVE	POSITIVE
Enhanced siltation in beds of suspension-feeders	Reduces parasite attacks on basibionts
Changes in phytoplankton composition	Increases diversity, biomass and abundance

Research idea

The first task of the research was to find spectra of slipper limpet clusters from observations and the second one is to elaborate mathematical model which is capable to help making conclusions or predictions concerning slipper limpet population and cluster size distribution at a curtain place.

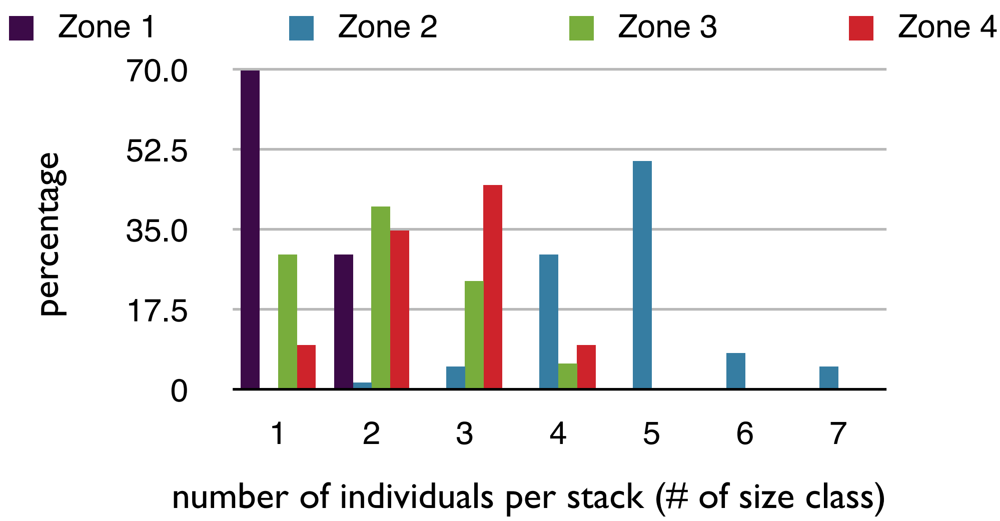
Observations

We used two methods and studied four sites in the Wadden Sea: two in tidal zone (Zone 1 to the north from Alfred Wegener Institute and Zone 2 to the south from Alfred Wegener Institute) and two in deep water (Zone 3 with 4 m depth and rather weak currents and Zone 4 with 16 m depth and relatively strong currents).

zone	Overall density (ind. per sq. m)	Average size (sm)
1	0.5	1.5
2	0.75	1.8

zone	Relative density (%)	Average size (sm)
3	30	2.5
4	10	1.5

Distributions for the zones are given at the following figure, but the precision is not very high due to not very large amount of data.



Mathematical model

Size spectrum evolution has been modeled. The model of slipper limpets population evolution is based on the following assumptions:

1. No more than one slipper limpet per cluster can die per simulation step (one step is equal to one year), no more than one slipper limpet can join to the cluster per simulation step

2. Model variables represent clusters, in the model cluster has two parameters: age in years and size in individuals coupled together, so we can represent it like a matrix (see below). Number of individuals in every age-size group is represented as a real number

3. On every simulation step there are four channels for age-size group to be filled: first is by one year younger group of the same size in the case of no new individual were added to the cluster (let's denote the probability of this as P1), second is by one year younger group of the smaller size in the case when one individual was added to the cluster (P2), third is by same year group with larger size when one individual died (P3) and forth by the group itself when one died and one added (in this case the age has not changed so as size) (P4)

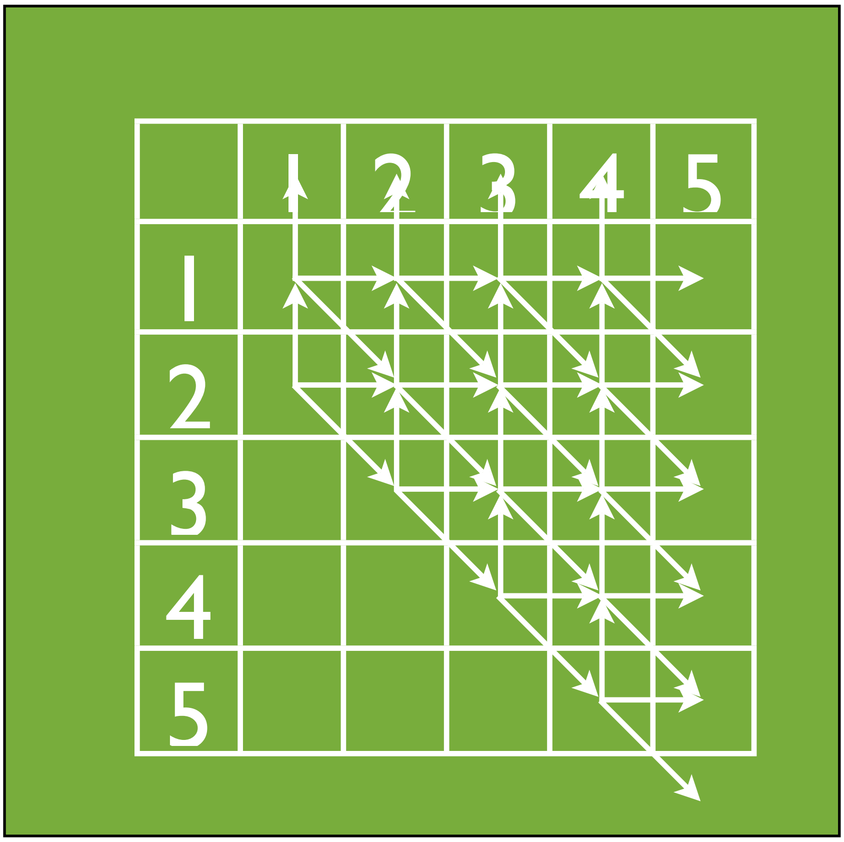


Fig. 1. Size of cluster is by vertical axis, age in years by horizontal one

4. There are two parameters in the model: reference time and reference density of slipper limpets, we can chose first one to be equal to 1.669 years because of used distribution law for death probability $P_{death} = 1 - e^{t/\tau}$, tau equal to 1.669 means that 95% of individu-

als will die in 5 years; second parameter is rather difficult to calculate and it shows how favorable conditions for population growth are:

$$P_{birth} = \frac{1 - e^{\rho/\rho_{ref}}}{1 + e^{\rho/\rho_{ref}}}$$

$$P_1 = (1 - P_{death}) \cdot (1 - P_{birth})$$
$$P_2 = (1 - P_{death}) \cdot P_{birth}$$
$$P_3 = (1 - P_{birth}) \cdot P_{death}$$
$$P_4 = P_{death} \cdot P_{birth}$$

All other probabilities can be calculated using these two:

Model results

During simulation run it was observed that in the case of high reference density (not very good conditions for slipper limpets) the final state after long simulation time is 100% of clusters are clusters of size 1, that means death of population. In the case of good conditions we can see something like spectrum maximum movement. If we take arbitrary spectrum for a certain time from Fig. 2 it can not be easily distinguished from one from Fig. 3, except the case of long time when size 1 prevails. It can be seen on Fig. 2 and Fig. 3, it is not obvious whether population die or not because of not monotonic character of the process.

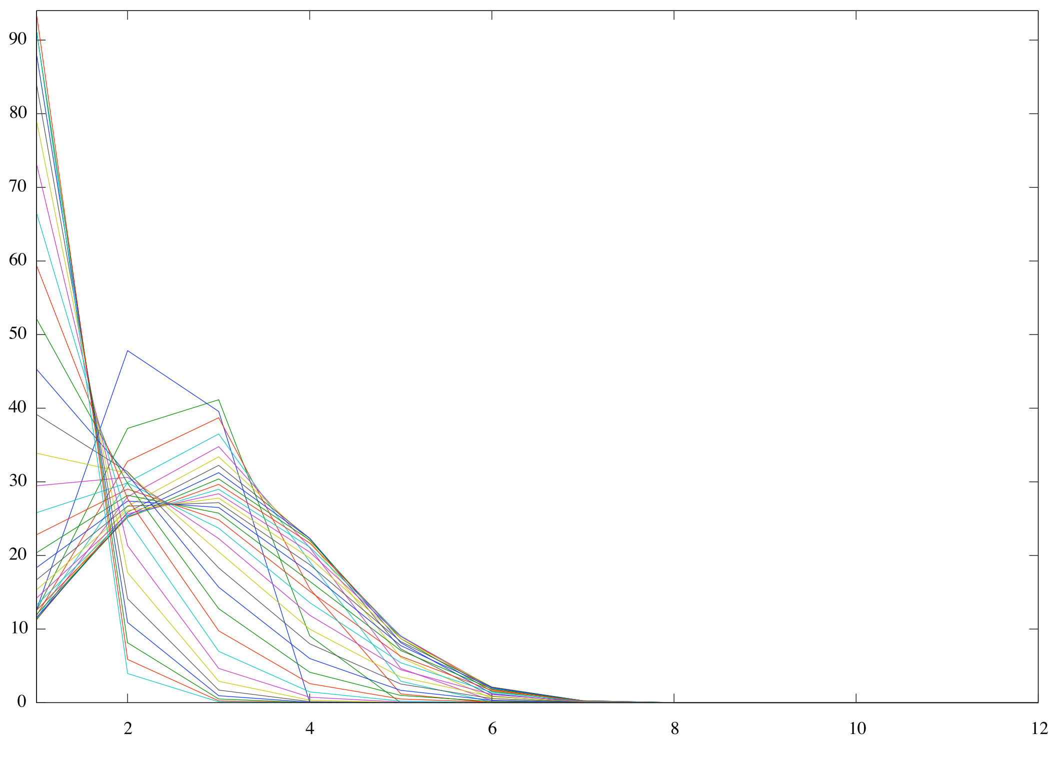


Fig. 2. Spectra for different times with high ρ_{ref}

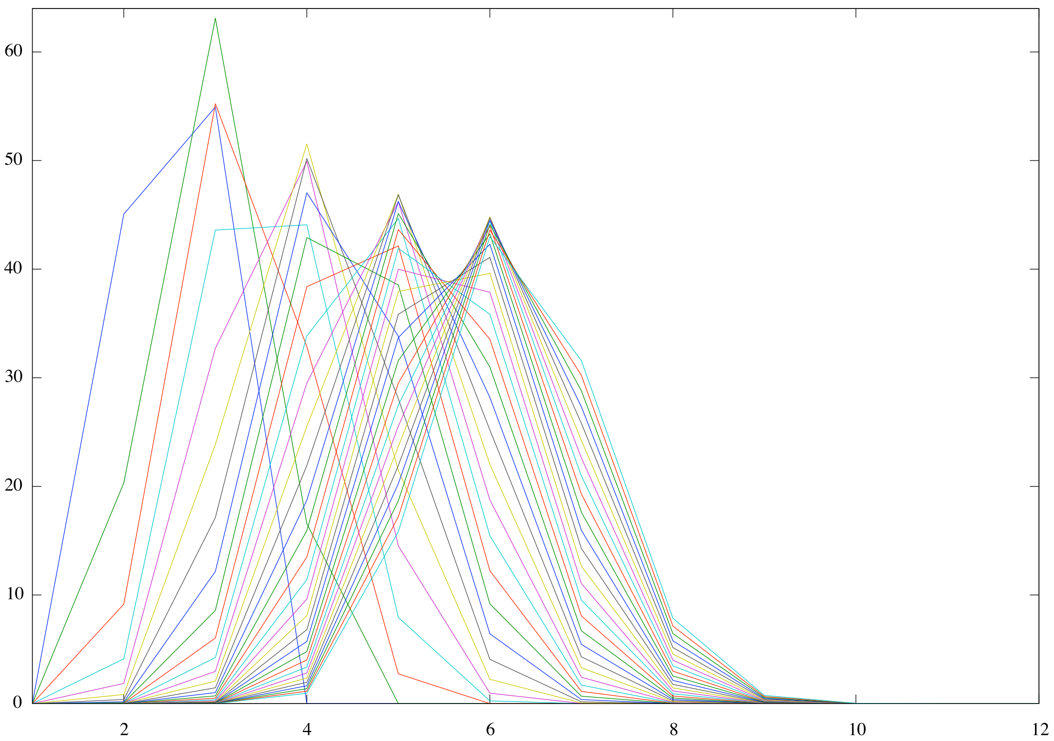


Fig. 3. Spectra for different times with low ρ_{ref}

Conclusions

- If we have a situation when low-number clusters prevail it means that the population is getting to be dead.
- If we see the spectrum maximum shift to the higher-number clusters it means that the conditions are good for population.
- Theoretically, it is possible to determine by spectrum evolution whether conditions are good for slipper limpets or not.

In our case we could conclude that comparing Fig.1 and the very first chart it is possible that population in Zone 1 can die soon but we have not enough data to be absolutely sure about distribution and the model we present should be validated and maybe improved.

Anyway it is worth to continue such investigations for better understanding of the processes in population in for elaborating methods for making ecological predictions.

List of references

[1] D. W. Thieltges, M. Strasser, K. Reise (2006) How bad are invaders in coastal waters? The case of the American slipper limpet Crepidula fornicata in western Europe. Biological Invasions, 8:1673-1680

[2] D. W. Thieltges, M. Strasser, J. E. E. van Beusekom, K. Reise (2004) Too cold to prosper - winter mortality prevents population increase of the introduced American slipper limpet Crepidula fornicata in northern Europe. Journal of Experimental Marine Biology and Ecology, 311 (2004) 375-391

[3] DASIE site, http://www.europe-aliens.org/speciesFactsheet.do?speciesId=268