Adaptive significance of spatial distribution patterns as reflection of life history strategy and density dependence in populations of some pelagic fish, squid and jellyfish species in Russian EEZ of North Pacific

by

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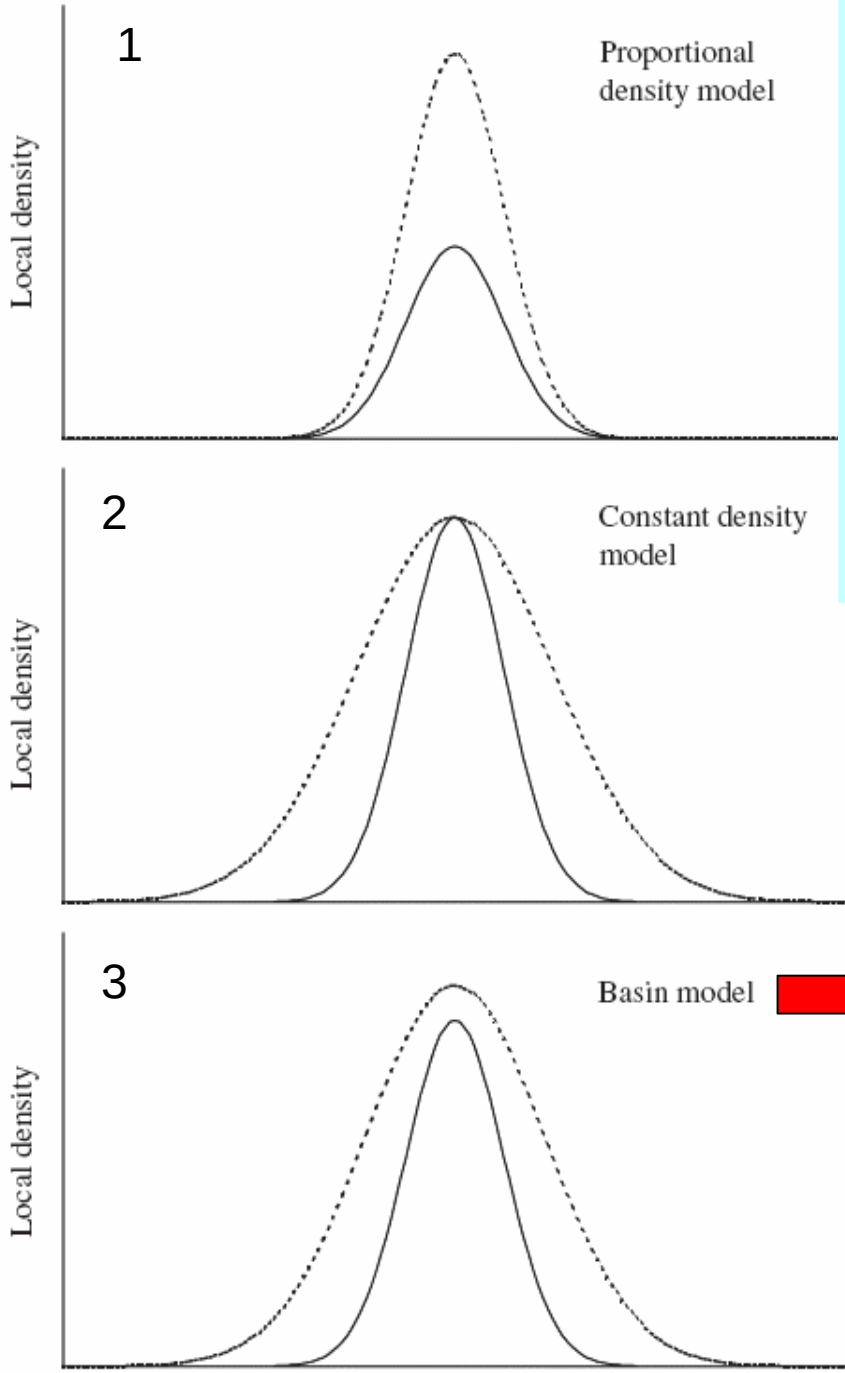


Variety of spatial dynamics in fish populations is often explained by three key models: 1) the proportional density model, 2) the constant density model and 3) the basin model. Each model predicts a distinct pattern of distribution based on how localized density changes with respect to total population abundance. Solid lines and dotted lines represent spatial distribution of local densities under low and high population abundance respectively (Shepherd, Litvak, 2004).

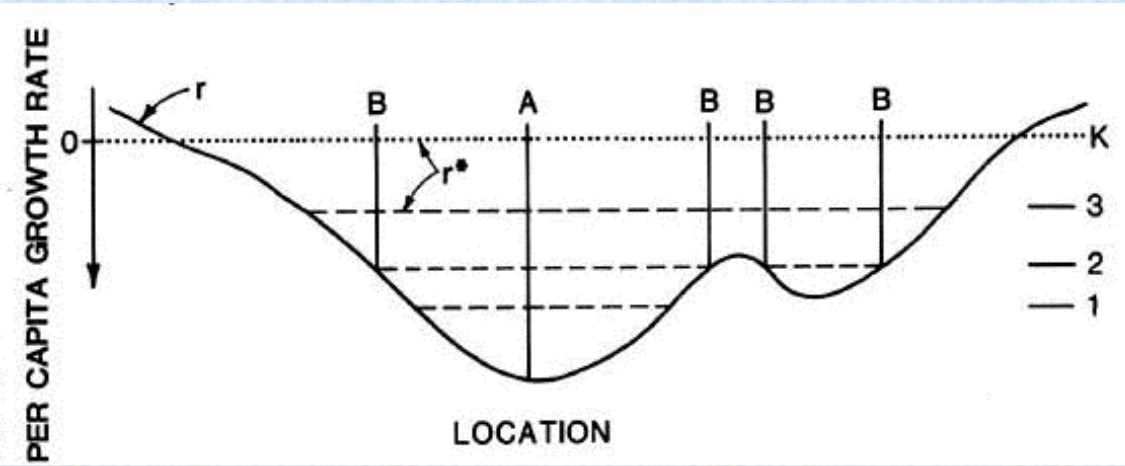


Diagram of the "Basin Model", proposed by MacCall (1990), relating habitat suitability to the intrinsic rate of population growth (r) and to stock size as a function of the local carrying capacity (K) of the habitat.

Objectives

1. Analyze interannual and seasonal dynamics of CPUEs and biological parameters with reference to density dependence in species populations.

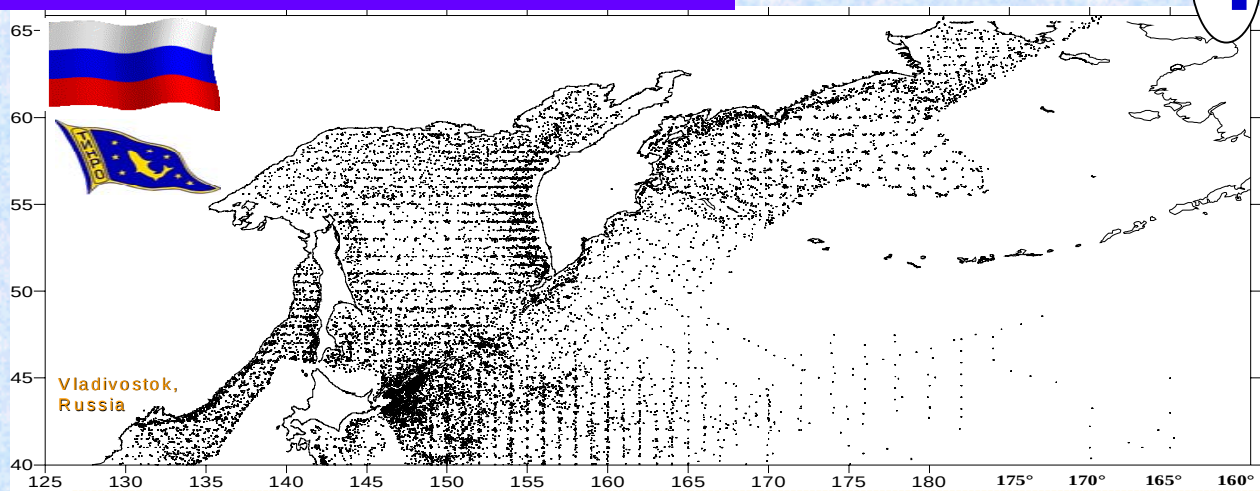
2. Relate spatial patterns of CPUEs and biological data to overall species abundance with reference to optimal foraging theory and density-dependent habitat selection.

3. Explore relationships between species-specific adaptive life history strategy and pattern of species' spatial structure.

4. Test for regional variation in rates of local abundance change with changes in overall population abundance.

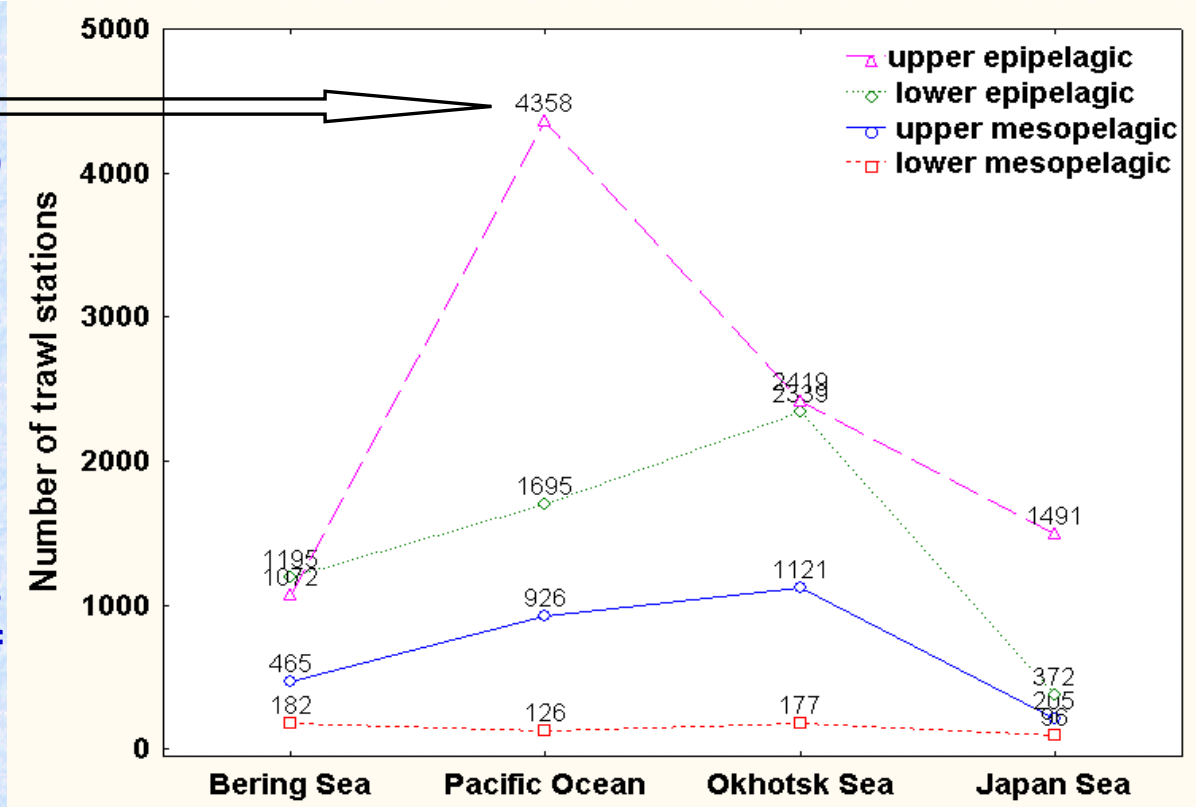
Materials and methods

Stations location for research pelagic trawl surveys by TINRO-Center during 1980-2004 period.



Numbers show number of research surveys' pelagic trawl tows.

Database for approximately 18.000 stations of scientific pelagic trawl surveys by TINRO-Center during 1980-2004 period has been utilized. Database contains technical data, CPUEs and nekton species' biological analysis data. Plankton and oceanographic observations data are available for majority of stations.



Relationship between abundance and area occupied by immature and mature Pacific salmon during summer period

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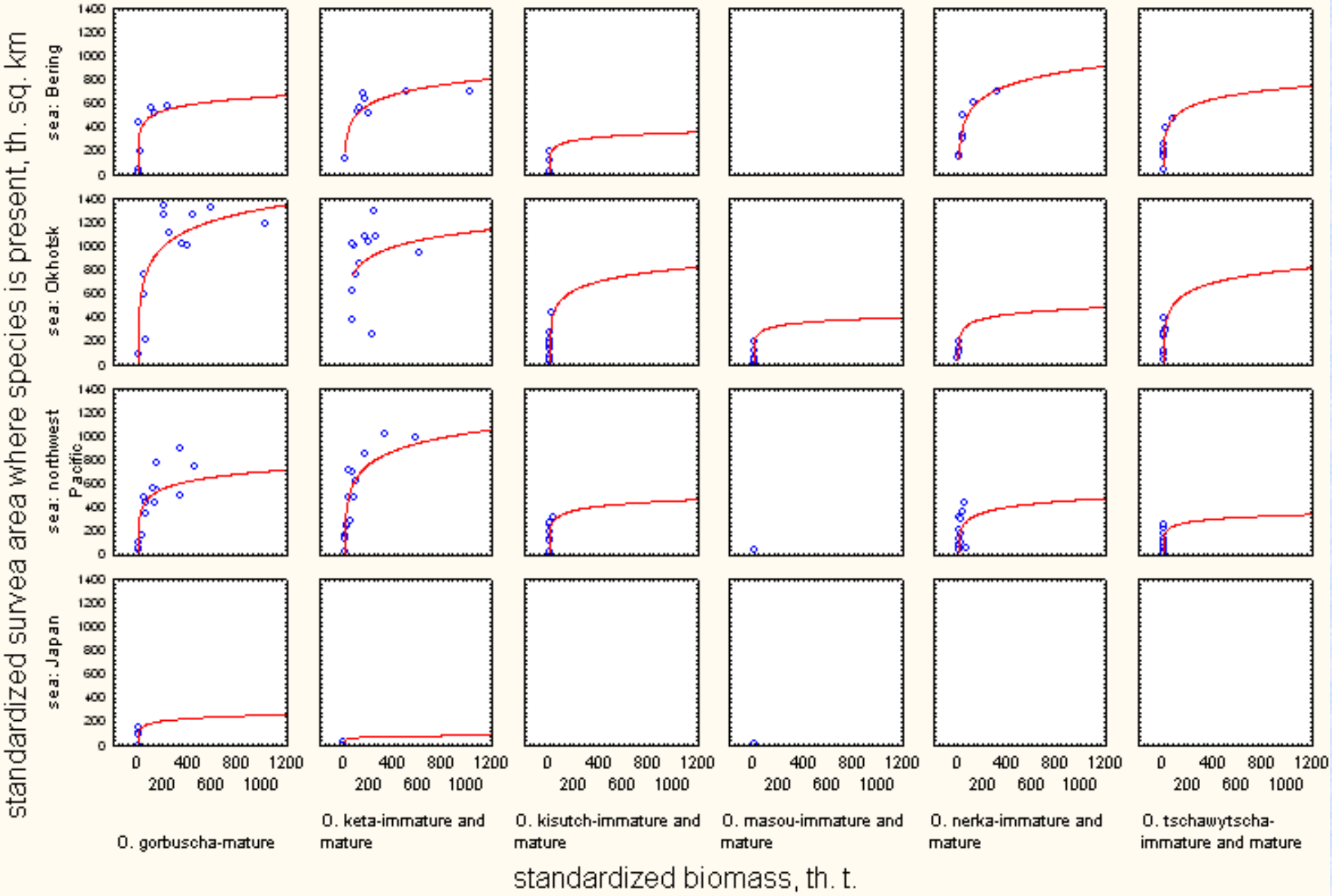
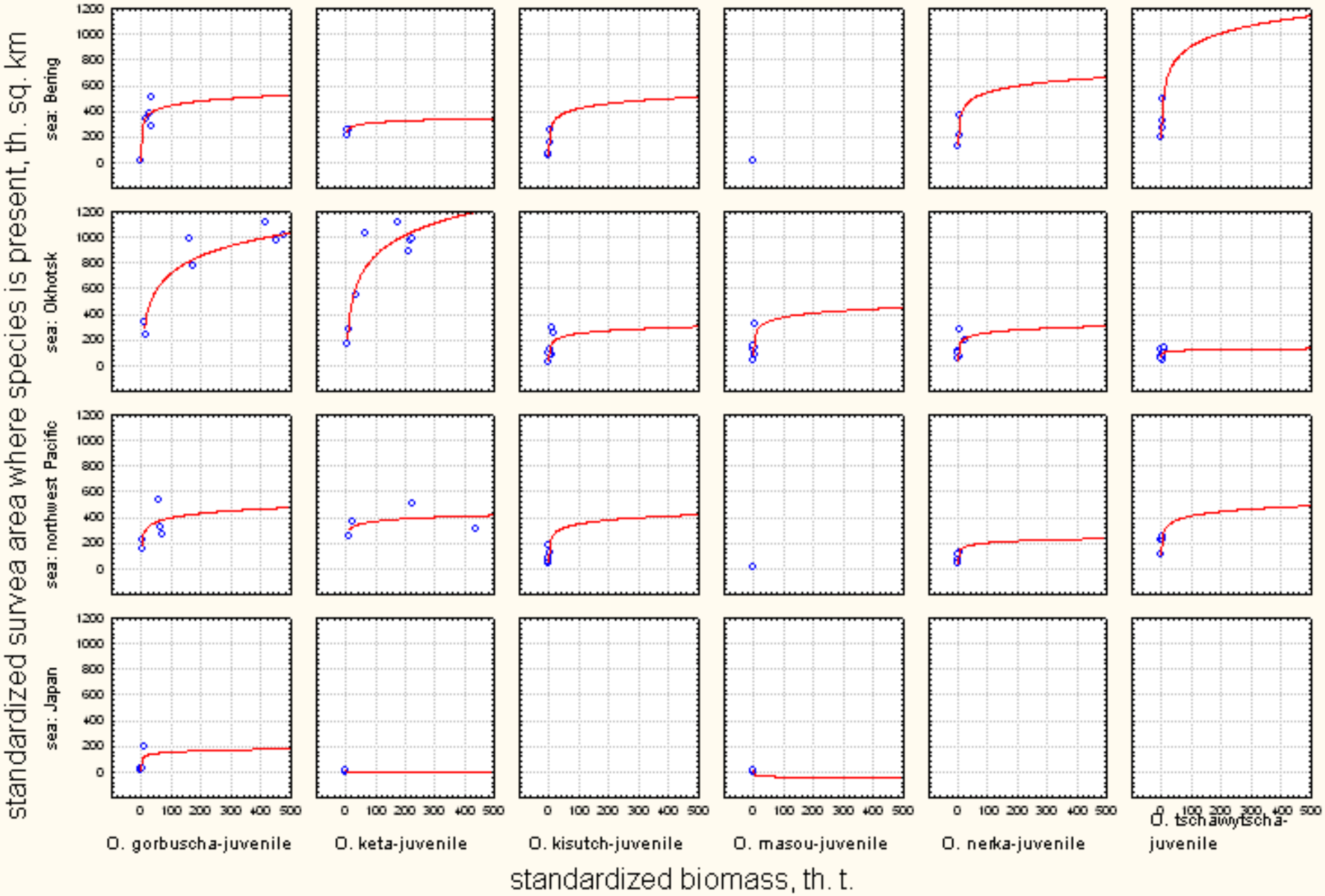
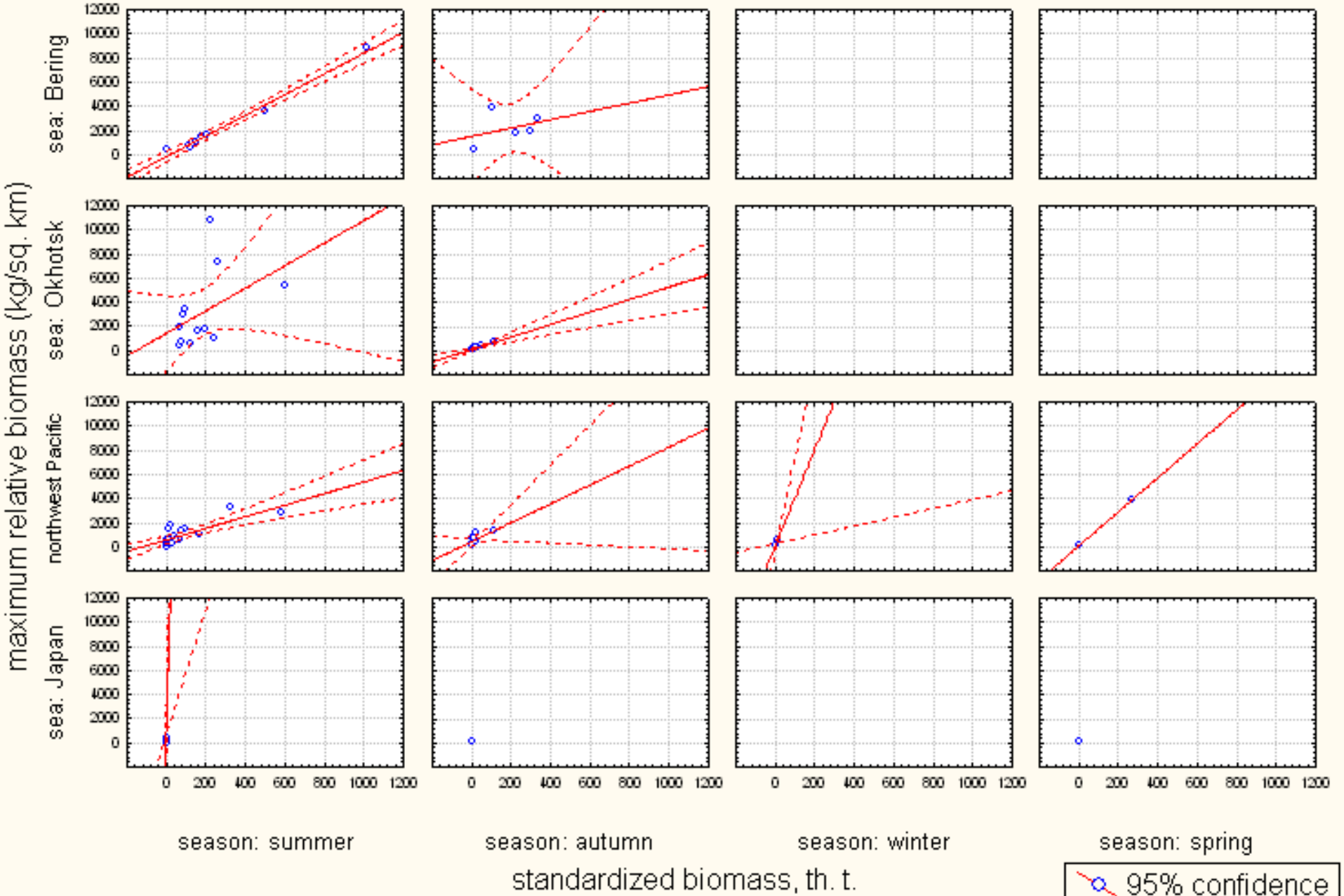
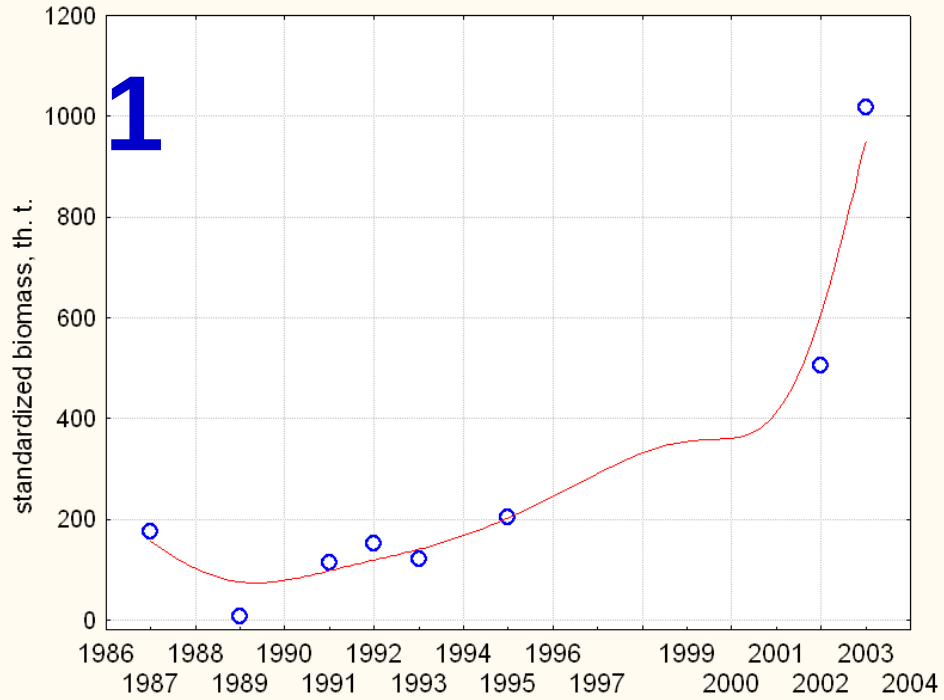


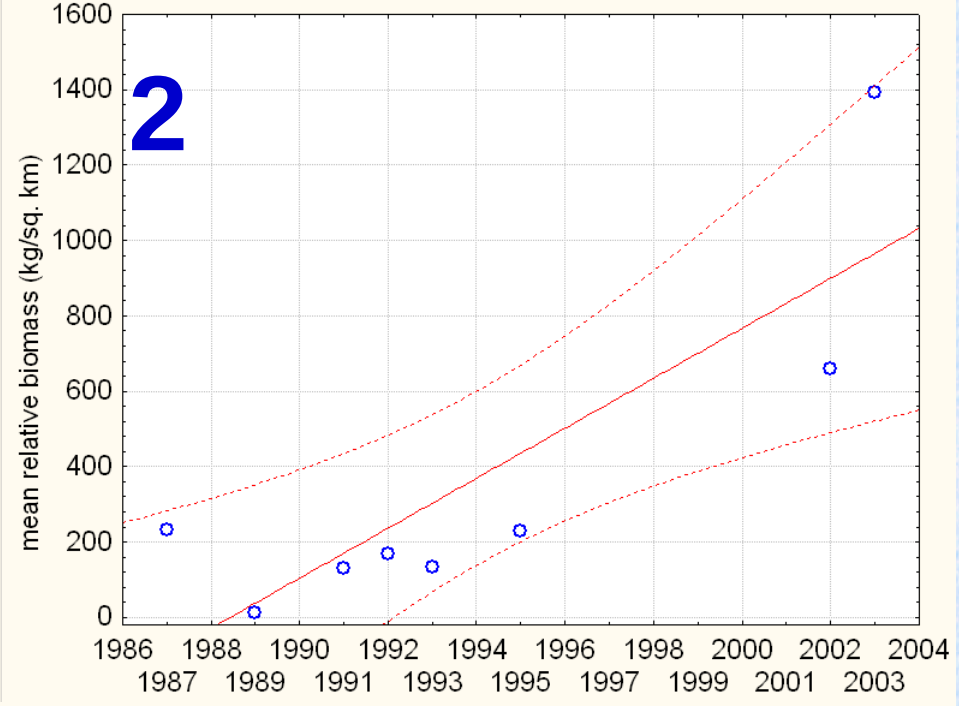
Relationship between abundance and area occupied by juvenile Pacific salmon during autumn period

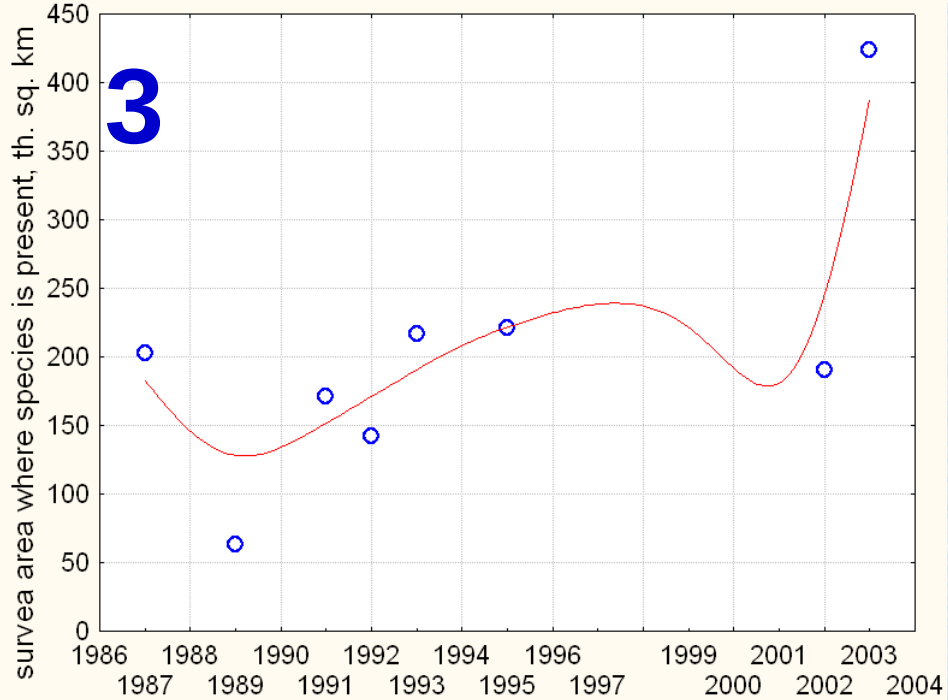


Relationship between abundance and maximum CPUE of immature and mature chum salmon



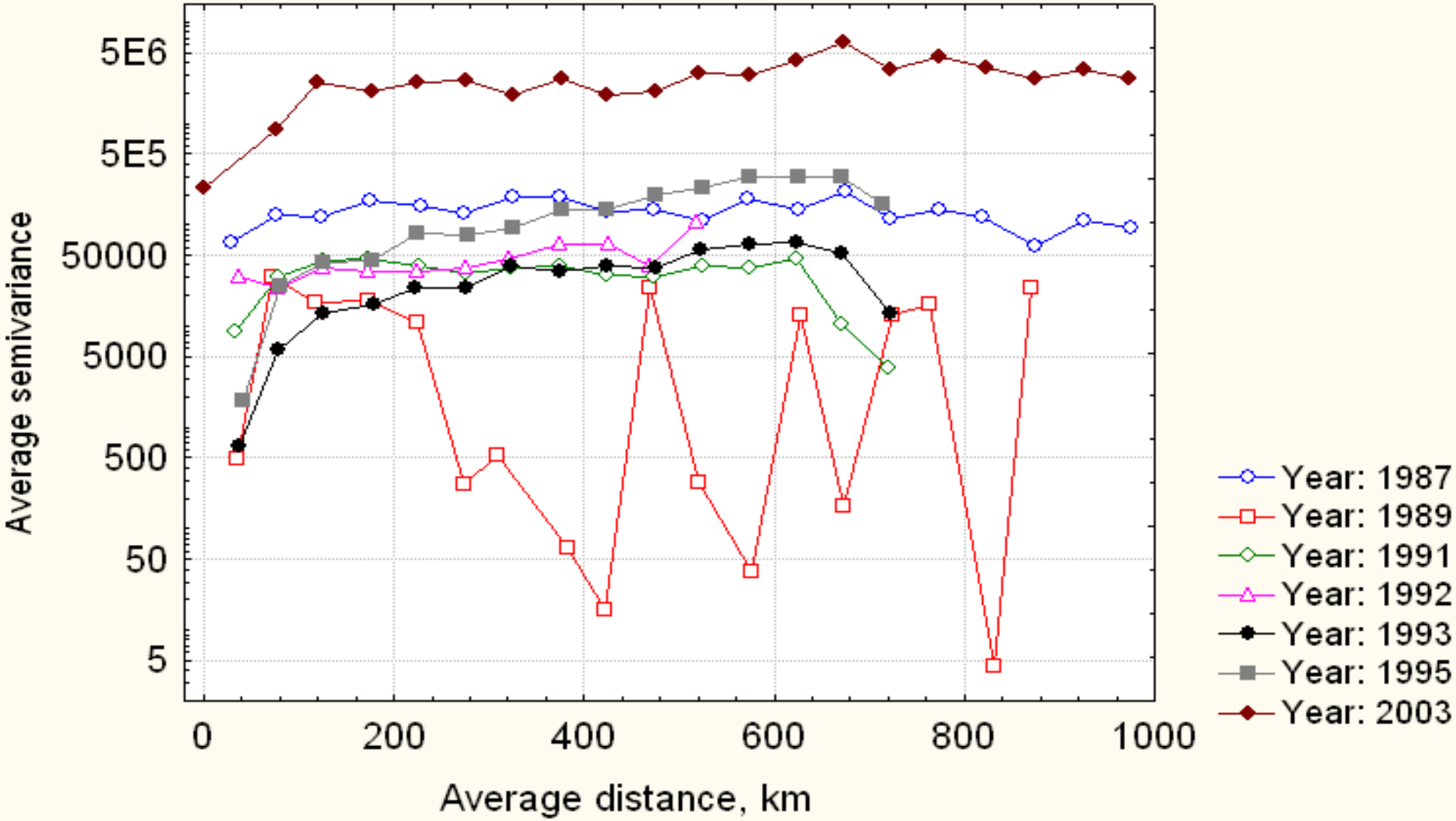




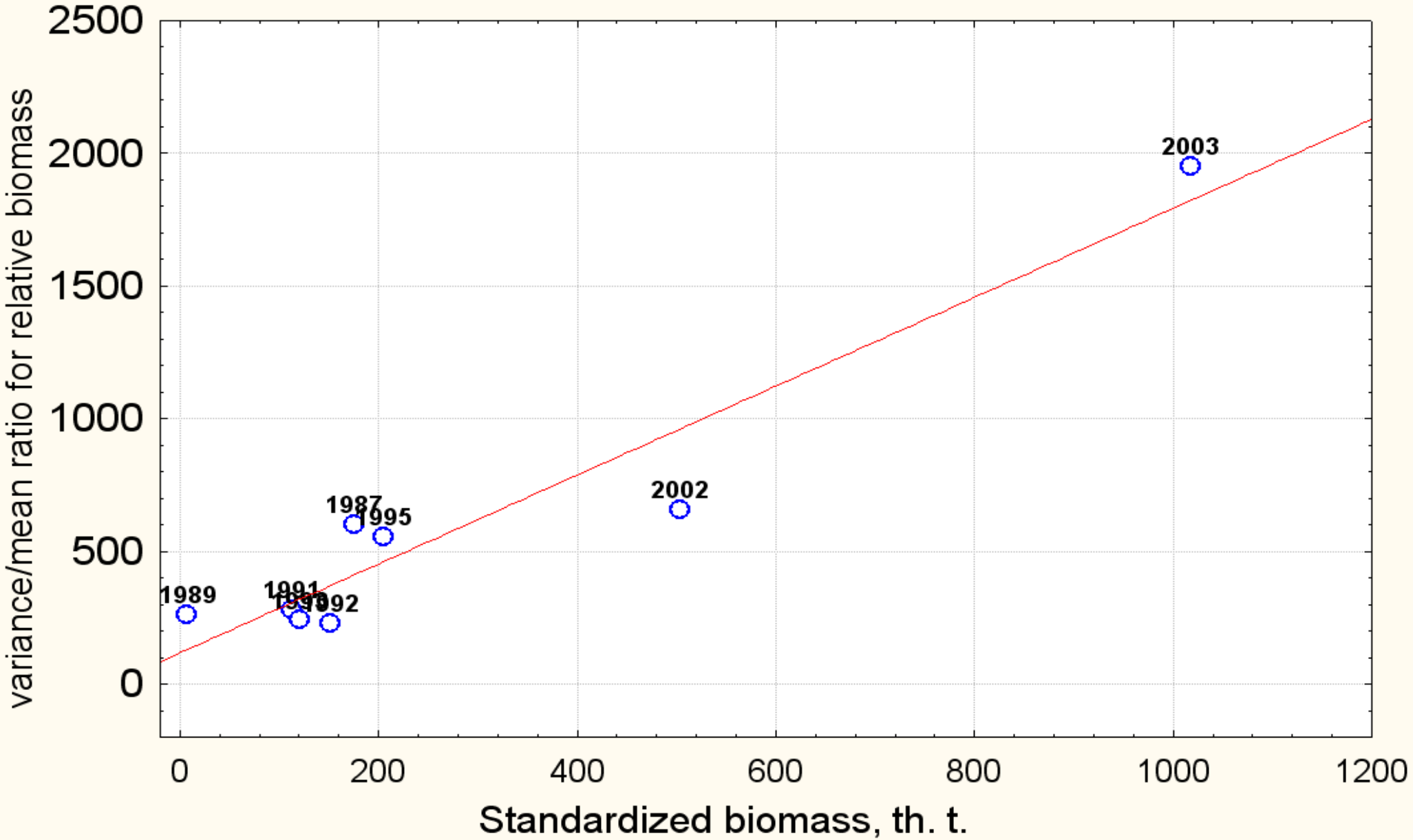


Interannual dynamics of overall abundance (1), average CPUEs (2) and area of species presence (3) in immature and mature chum salmon (Bering Sea, summer)

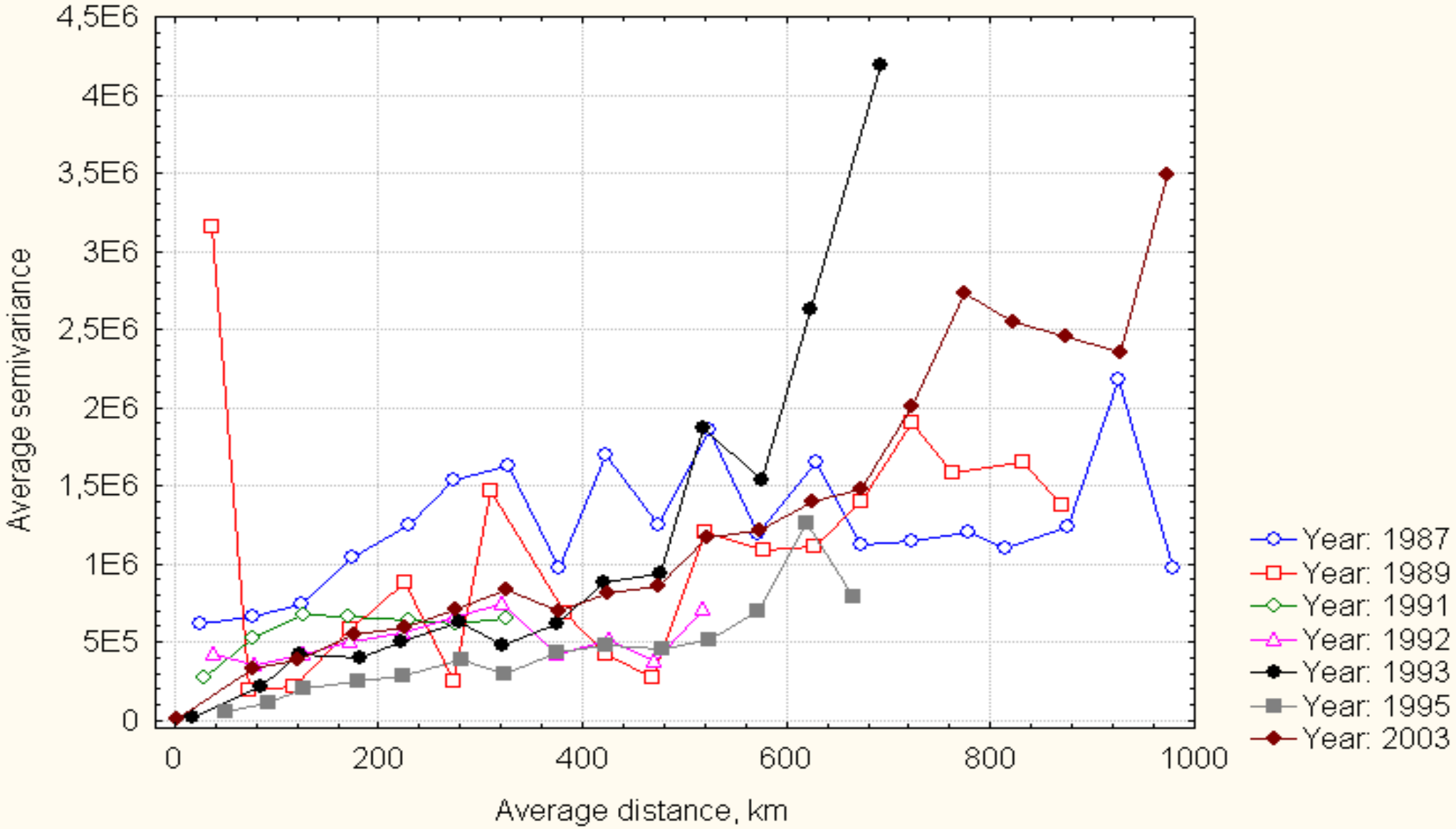
Variogram for immature and mature chum salmon CPUEs (kg/sq. km) in the Bering Sea in summer.
Sill parameter corresponds to axis Y value at the point where variogram curve levels off



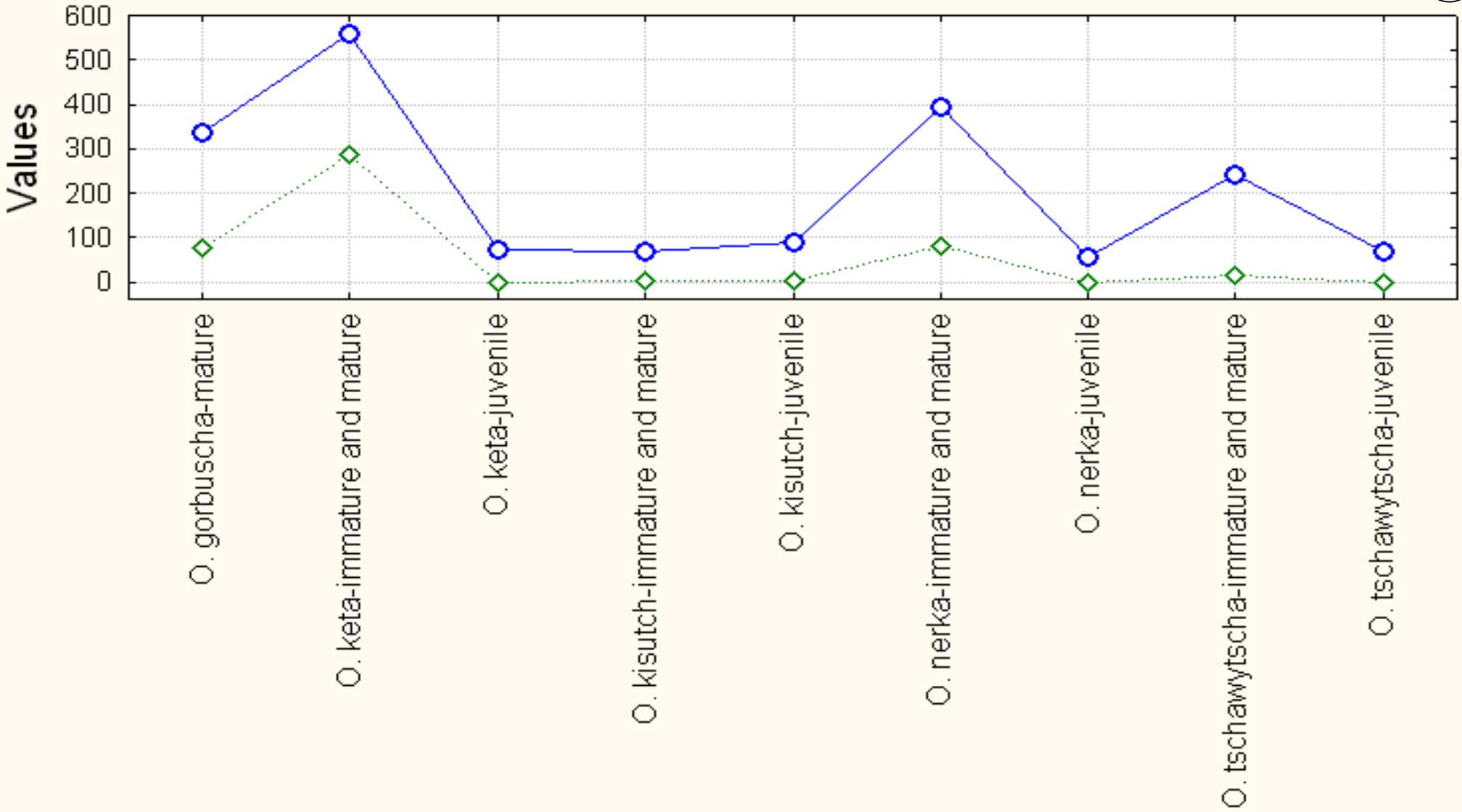
Relationship between abundance and CPUEs variance/mean ratio (immature and mature chum, Bering Sea, summer period)
r=0.956, p<0.001



Variogram for immature and mature chum salmon average body weight (g) in the Bering Sea in summer.
Sill parameter corresponds to axis Y value at the point where variogram curve levels off.



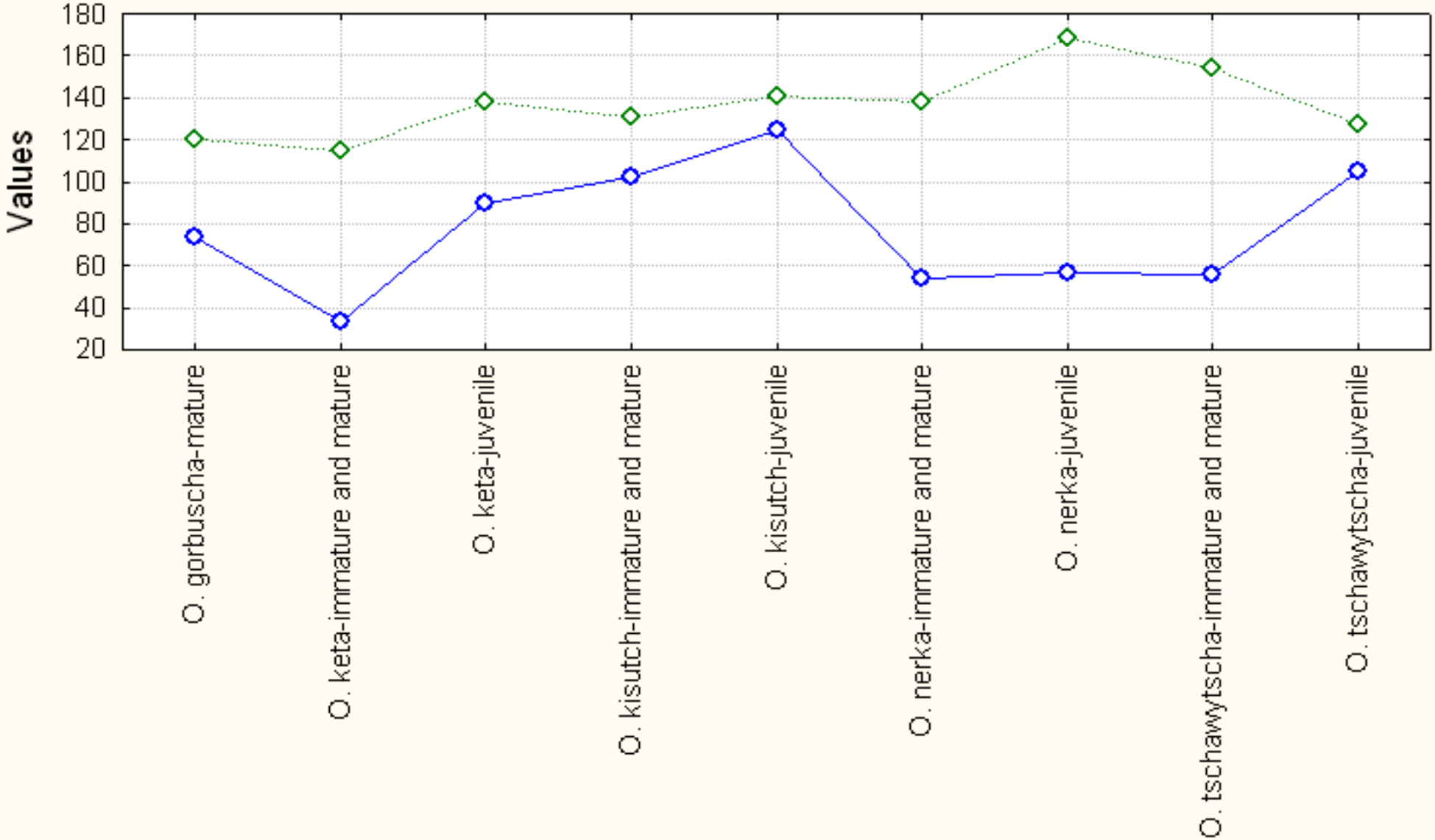
Interspecific differences in average values of standardized survea area where species is present and abundance, th. t. (Bering Sea, summer)



standardized survey area where species is present, th. sq. km

standardized biomass, th. t.

Interspecific differences in coefficient of variation (CV, %) of standardized survey area where species is present and abundance, th. t. (Bering Sea, summer)



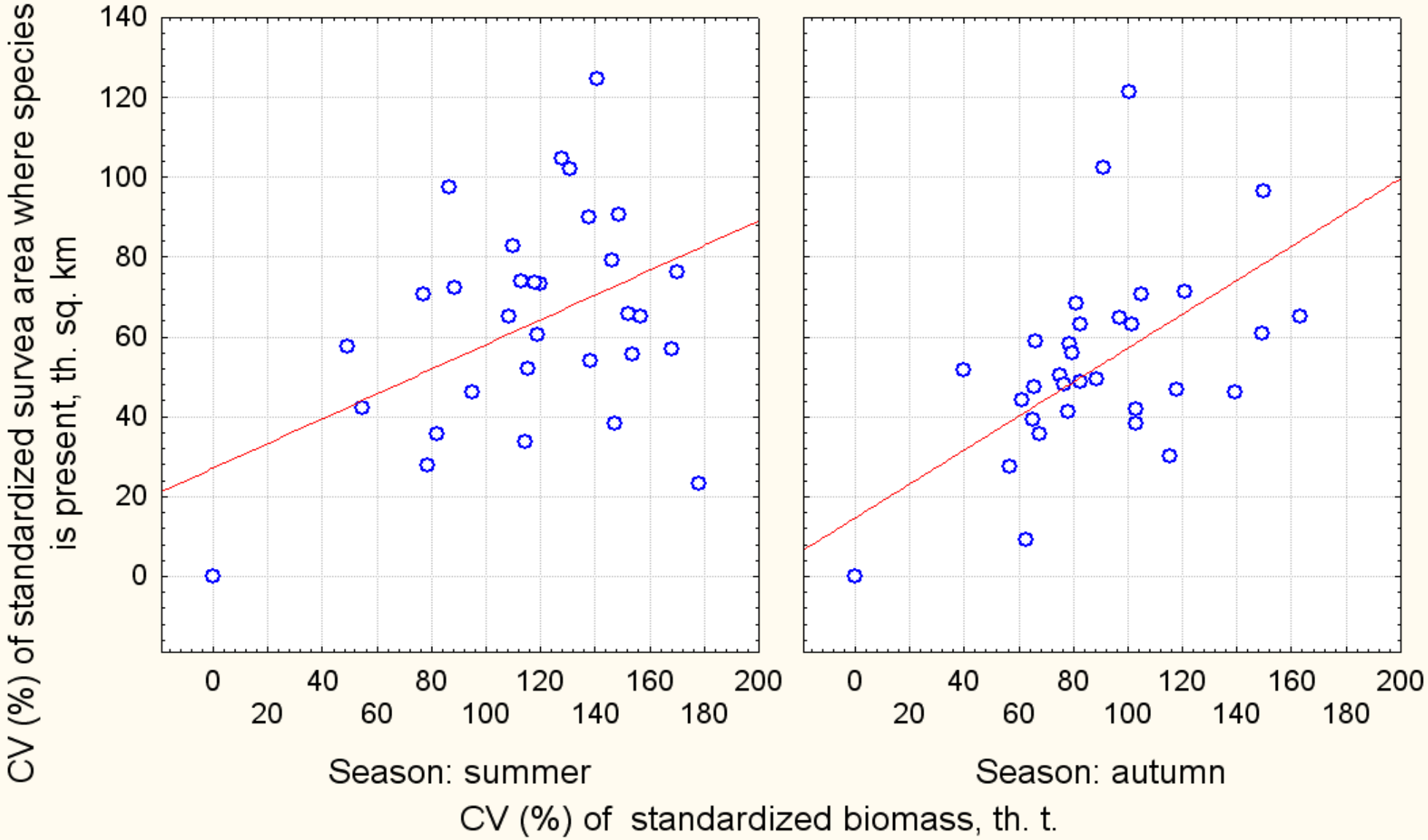
standardized survea area where species is present, th. sq. km

standardized biomass, th. t.

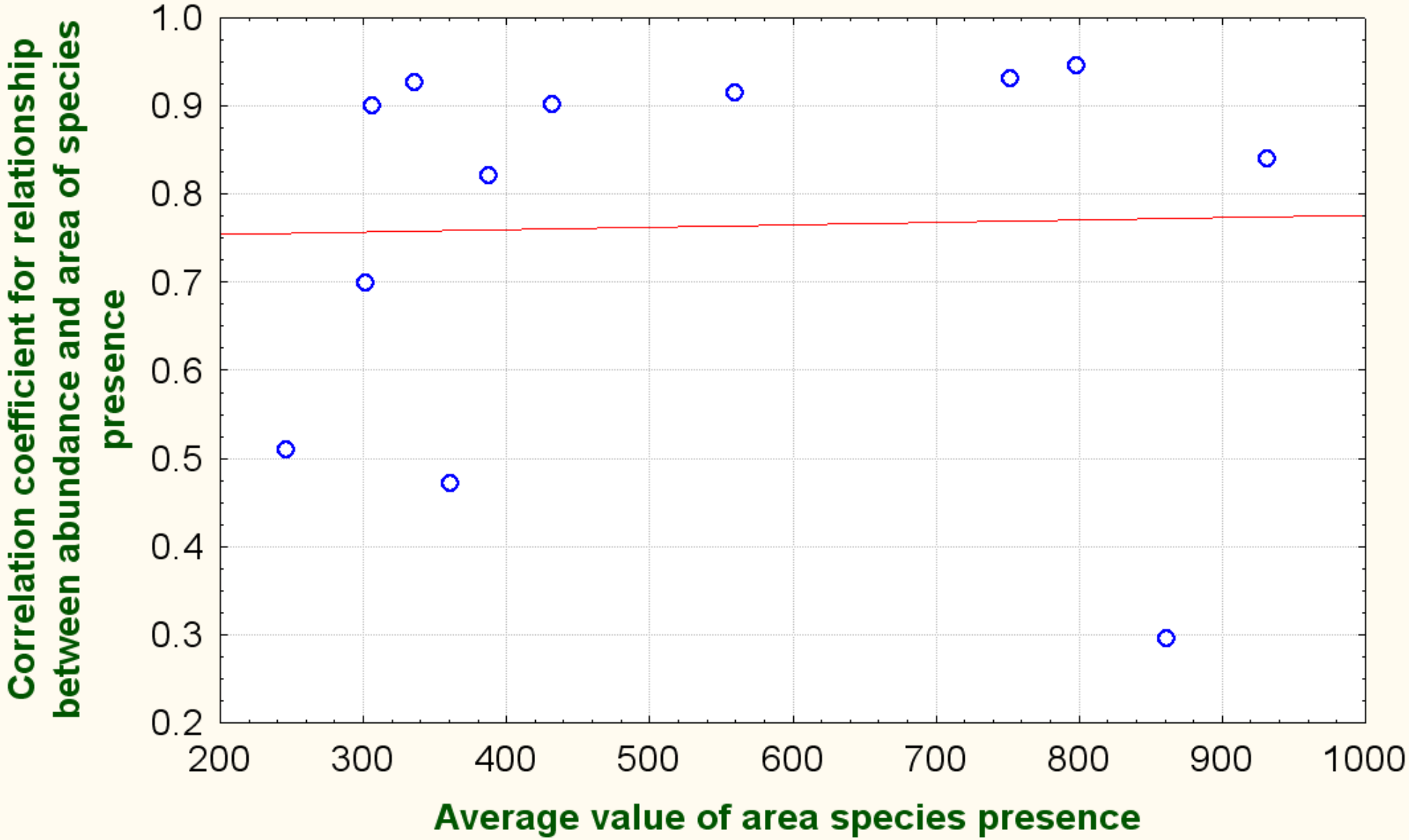
Relationship between coefficients of variation of abundance and area occupied (all Pacific salmon species and regions)

summer - r=0.48, p<0.01

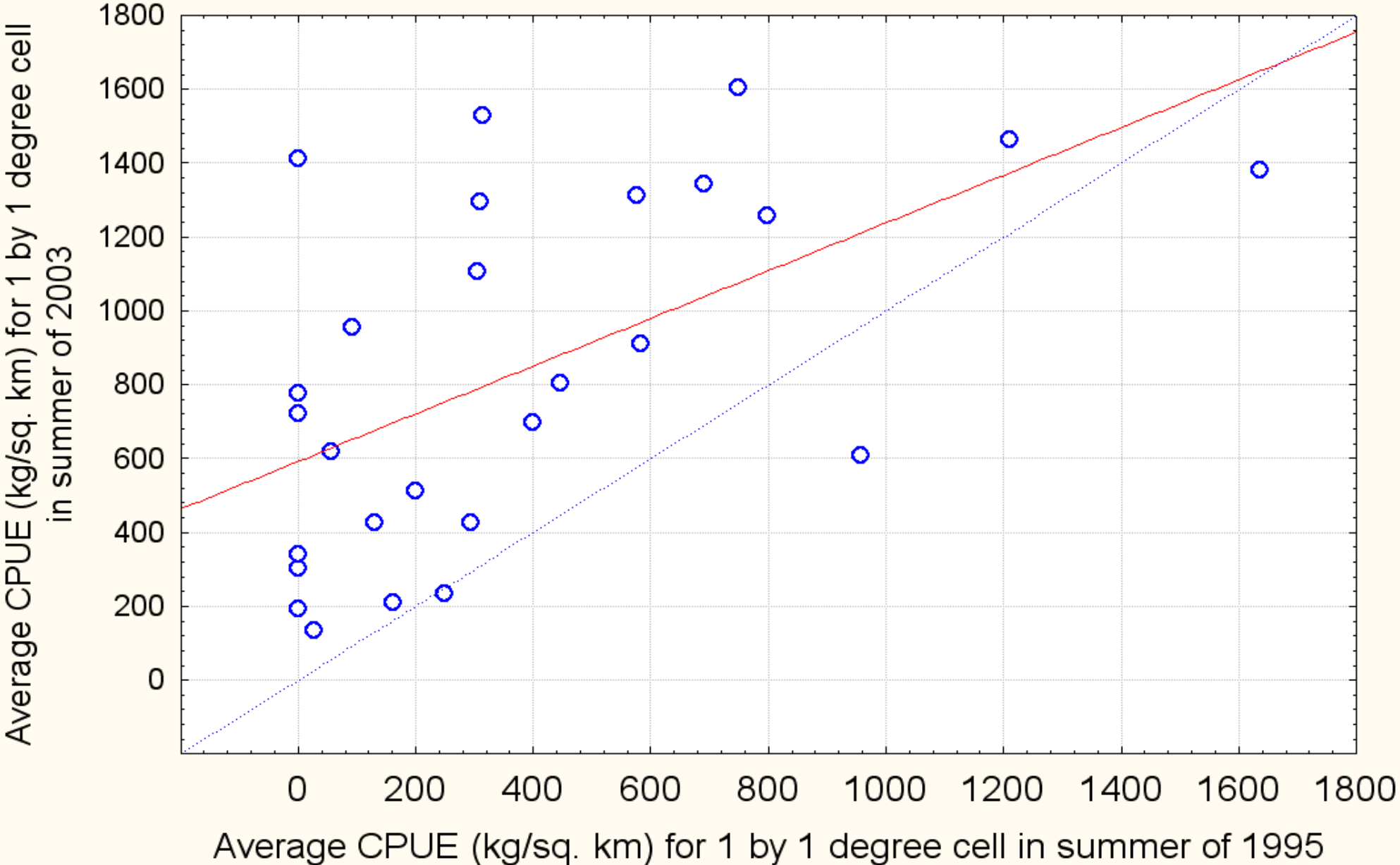
autumn - r=0.63, p<0.001



Relationship between average value of area species presence and correlation coefficient for relationship between abundance and area of species presence. Only chum and pink salmon in Bering and Okhotsk Sea and NW Pacific were analysed. (r=0.03, p=0.92).



Relationship average CPUE (kg/sq. km) for 1 by 1 degree cell in summer of 1995 versus summer of 2003.
r=0.48, p<0.01



Conclusions

1. The described observations provide preliminary reflection of some species adaptive strategy, which appears to be aimed at the decrease of density-dependence and avoidance of excessive competition through the transformation of species spatial structure.
2. Mechanisms of density-dependent habitat selection seem to exhibit species, life-stage, regional and seasonal specificity which yet have to be explored and mechanisms of this selection are to be clarified.
4. As the prey type and distribution and interspecific competition likely to be important determinants of habitat quality for particular species, these variables will be incorporated in the future models of density-dependent habitat selection. Further studies on carrying capacity issue should consider interactions between the effects of density-dependent resources and density-independent factors.
5. Additional caution should be taken while making judgments on spatio-temporal dynamics of carrying capacity and density-dependence due to the great methodological complexity of this problem and controversial interpretation of results.
6. Spatial statistics provides promising results in studying variability of density dependence. However, no single statistic or approach is likely to provide a clear picture of species density-dependent responses to abundance changes. Wide range of adequate techniques and approaches has to be applied and results have to be compared in order to achieve adequate understanding of this controversial issue.