FiskDir. Skr. Ser. HavUnders., *15*: 259–265.

INTRASPECIFIC STRUCTURE AND VARIABILITY IN RELATION TO FISHERIES MANAGEMENT

By

GEORGY V. NIKOLSKY

Institute of Animal Evolutionary Morphology and Ecology,
USSR Academy of Sciences, Moscow

INTRODUCTION

Cod is nothing but cod, a fish species, *Gadus morhua* L. This species is caught nowadays with trawls in the north Atlantic and on the Newfoundland banks, in the Barents Sea as well as in the northern Pacific, near the coasts of northern Asia and northern America. This fish is also caught with long lines and hooks in the Norwegian fjords and the White Sea and is known to have been fished by pomors in the last century and by middle age vikings. Cod was fished by the stone age man who populated the Norwegian coast, the Russian Murman and the Pacific coastal areas thousands of years ago.

It is yet uncertain when cod originated as a species, but as far as a number of other species of the same boreal faunistic complex, mostly fresh water fishes, are concerned, they are known to have originated in the mid tertiary period. Most zoologists nowadays regard species as an objective reality, as a form of existence of the living matter. Animal species is not a conventional concept, it is not "what a good taxonomist considers a species", but an actually existing multitude of specimens which possess some specific-qualitative properties characteristic for the given species and relatively stable in time and space. It means that a species which once originated exists a more or less long period of time (so far as the specific environment exists) retaining its specific properties.

As regards freshwater fishes, perch, pike, pike-perch, catfish and some others, they are known to have undoubtedly existed since pliocene time and possibly earlier. At approximately the same time most species representative of the boreal sea fauna complex, cod, oceanic herring, plaice and flounders, etc. were formed (NIKOLSKY 1968). However, the

Contribution given in honour of Gunnar Rollefsen at his 70th birthday.

stability of the species over thousands, and possibly, millions of years is ensured by the intraspecific variability, by its elasticity, so to say.

Stenobiotic species adapted to live under relatively stable, abiotic and biotic life conditions reveal a lower variability, lower elasticity. Usually, their intraspecific structure is simpler. An example of this type of stenobiotic fishes with a very low variability could be supplied by most of the species populating coral reefs, e.g. Pomacentridae. These species are extremely low-variable, occupying as a rule, a very limited distribution area and being adapted to very stable life conditions. They perish when these conditions change beyond the limit of this fish's very low specific adaptability.

Eurybiotic species, such as Arctic chars and cod, possess a much wider range of adaptability, a considerable intraspecific variability and a more complex intraspecific structure. Thus, every species represents an open self-regulating system in a permanent interaction with the environment which incessantly keeps adapting to the changing conditions. This system possesses at the same time certain morphological, physiological and ecological characters distinctive for the species as a system.

INTRASPECIFIC VARIABILITY

For fishery biologists, endeavouring to develop a scientific basis for fish resource exploitation, the knowledge of the elasticity and the structure of the given species-system of economic importance is quite essential. Principal mechanisms operating in the populations provide changes in number and biomass due to respective environmental changes, first and foremost in the food supply rate which is manifested in growth changes. As is known, the increase in growth rate is related to a faster achievement of maturation age and an increase in fecundity. A faster growth is related to reduction of mortality rate, for, as a rule, bigger fish fall prey to predators on a larger scale than the smaller ones. Principle mechanisms of population self-regulation in connection with food supply changes have been rather well studied (Nikolsky 1950, 1962 and 1969, Rollefsen 1954, Schaefer 1956 and others) and a detailed account is uncalled for here.

However, the process in question is often found not to be as direct as in the above scheme, being considerably affected by a number of factors, and, in particular, by mutual interactions of fish in different number of year-classes. A numerous year-class may handicap the growth rate of both preceding and following generations. The problem calls for further investigation for it is of a great theoretical and practical interest, first and foremost, in forecasting of the mature stock recruitment. A review of the data on the problem was reported by Polyakov (1962).

Changes in spawning periodicity appear to be an essential form of self-regulation. In fact, in years when the stock of White Sea herring is numerous a part of the females may leave out a spawning period. Due to food supply insufficiency they fail to fatten during a single feeding period (CHEPRAKOVA 1966). This phenomenon is also observed in some freshwater species, e.g. in whitefish (RESHETNIKOV 1967). It should be noted that many species inhabiting the northern part of the distribution area reproduce every other year, southern populations reproducing annually. Besides whitefish, this has been found in bream and some other species (KOSHELEV 1966). It is interesting that in some species in the southern part of the distribution area, e.g. in bream, portioning in spawning is observed, i.e. the reproduction rate speeds up.

An essential, though yet poorly investigated, mechanism of self-regulation is change in the variability of specimens in the population. Food supply increase is, as a rule, related to a reduction in the year-class size variability. This has been most clearly demonstrated in Baltic herring larvae (ANOKHINA 1969). Strong year-classes are distinguished by a wider variability range that weaken year-classes. The food supply is determined not only by the numbers of fish in an age group, but by the development of its food resources, and equally important, the coincidence of the food plankton period with fry development. This regularity, though manifested in a more complicated way, is noted for cod fry (NIKOLSKY, BELYANINA, PONOMARENKO and SYSOEVA 1968). In the case of cod fry, the variability of characters is largely dependent on the size of the concentrations formed due to the dispersal over one or the other branch of the Atlantic current. Besides, in recent years, due to a low level of reproduction no feedback between the total number of cod fry and the food supply has been observed. This relationship was, however, revealed in specifically rich generation years, e.g. 1963.

The relationship between character variability and the quantity of cod fry is better demonstrated in coastal forms. In such stocks, as a rule, numerous populations prove to be most variable. An increase in variability makes it possible for the population to cope with more diversified environmental conditions. It has been most explicitly demonstrated for characters related to feeding and diet diversity. It is noteworthy, as was revealed in Murman coastal cod, that the diversity of characters in it slightly reduces with age in connection with a higher food supply level in fish at the age 1+ and 2+ as compared with specimens at the age of 0+.

One of the most essential specific characters which secure the existence of a species as a relatively stable unit, is the intraspecific structure. To a certain extent, all the intraspecific forms can be subdivided into four groups.

1. Geographical forms or subspecies, e.g. Atlantic cod and Pacific cod. The formation of subspecies enables the species to fill in a greater distribution area.

2. Ecological forms or infraspecies, e.g. fjord and migratory cod forms. The existence of various ecological forms enables filling in diversified habitats within the distribution area.

3. Seasonal forms, e.g. spring and autumn forms in salmon, autumn and spring spawning herring forms. This means of variability ensures filling in the same biotope to a greater extent in different seasons of the year.

4. Temporary forms, the forms which originate in the same biotope under changed life conditions in a population of any species. Such temporary forms are most markedly observed in numerous freshwater species, e.g. roach in the course of transition to the life in a reservoir newly formed at the river. In mammals such temporary subspecies are found in some fossil forms from the quarternary period, e.g. in Baltic region elk. The adaptive value of temporary subspecies lies in the capability of filling in the same biotope under changed conditions.

The diversity of the four intraspecific forms may be quite different ranging from a clear cut distinguishability to a gradual transition of one form to the other, clinal variability being in evidence. It should be mentioned in this connection that I do not find justifiable the fact that in the latest edition of the zoological nomenclature code taxonomic values are solely attributed to geographical categories, subspecies, the remaining intraspecific forms, being left out. Ecological and seasonal forms, however, often prove to be distinguishable to a greater extent than subspecies.

In many cases the appearance of ecological and seasonal forms is of a parallel character. The phenomenon faced is reminiscent of Vavilov's law of homologous rows (Nikolsky 1969). Possibly, as was suggested by Berg (1948) it is expedient to attribute the same specimens to such similar forms in different species, e.g. deep-water forms, infraspecies profundicola, lacustrine forms, infraspecies lacustris, etc. I believe that this scheme should be employed in zoological nomenclature code, subspecific individual names being retained.

IMPORTANCE FOR FISHERIES MANAGEMENT

For fishery biologists, the existence of intraspecific group forms within a species is extremely essential. When exploiting a certain population, dynamics of its number and distribution area should be taken into consideration. For example, the Arcto-Norwegian cod stock, being a unified self-recruiting form distributed over a great area, calls for a definite

exploitation scheme. If, as in the case of the northwestern Atlantic cod, some local forms are found, rational fishery should be arranged on a different basis than in the case of the Arcto-Norwegian stock. It is interesting to note that morphological indices in different age groups of the same form do not differ greatly in local forms of western Atlantic cod. In the Arctic cod, however, the distinctions in the morphology of different age groups within a form may be quite pronounced. This appears to be accounted for by highly variable life conditions in different age groups (POPOVA 1968). In numerous species there occur both large migratory forms and small coastal ones distinguished by a slower growth as well as an earlier maturation onset. The degree of isolation in these forms may range widely in some cases as in north Caspian roach. A coastal, smaller form may result from reproduction by a semi-migratory fast-growing one, and, evidently, vice versa. In other cases these forms may be isolated, one not reproducing the other.

In red salmon, *Oncorhynchus nerka* (Walb.), the migratory form reproduces in lakes a land-locked form, the so-called residual. In turn from this land-locked form a migratory form can be reproduced under certain conditions (KROKHIN 1967).

It should be noted that in the course of the dwarf red salmon development some caryotypic changes occur, a great number of polyploid specimens appearing. This is of particular interest if polyploidy is related to an increased morphological variability. It is noteworthy that in migratory red salmon the caryotype is peculiarly stable (CHERNENKO 1968). The relationships between seasonal forms prove to be likewise diversified. If, e.g. in autumn- and spring spawning Baltic herring, a partial transition of one form to the other is evidently possible, in chum salmon this appears to be out of the question. It is natural that a fishery biologist aims at elucidating the relationships between the intraspecific forms, in particular, the possibility and conditions under which specimens of one form appear from the specimens of another form, i.e. whether one form can be reproduced by another and to what extent.

Thus, investigation of the theoretical aspects of the problem of species, further elucidation of the concept of species as a self-regulating system appears to be extremely essential for the solution of a number of fishery problems, and, first and foremost, for developing the basis of a rational exploitation of commercial species.*

* Dr. Rollefsen's paper on cod and cod fishery which he kindly sent me bears the following dedication: "To Dr. Nikolsky who also struggles with these mysteries". I believe that joint efforts of scientists the world over will eventually do away with numerous mysteries that still have currency in fishery biology and help to organize rational fishery in international waters, a work which Dr. Rollefsen has been contributing greatly to.

CONCLUSIONS

Every animal species is relatively stable in time and space. This relative stability is provided by adaptive intraspecific variability which makes it possible for the species to exist under certain changes of its biotic and abiotic environment. Species is an open self-regulating system. Eurybiont species usually possess a more complex intraspecific structure and a wider range of self-regulation mechanisms than stenobiont species adapted to more stable conditions.

The knowledge of specific structure as well as its regulatory parameters is essential for rational exploitation of commercial species populations and the ensurement of their reproduction. The most essential system of regulatory mechanisms manifests itself in food supply and reproduction rate variability. Disturbances in this regulatory system affect recruitment and bring about a lack in resources of the given commercial species, i.e. overfishing in the biological sense.

An essential regulatory mechanism which secures the existence of the species is an adaptive morphological variability of its specimens. Every year-class is somewhat distinguishable from adjacent year-classes due to the specificity of its living conditions. At the same time adjacent year-classes specifically in the species with a long life cycle mutually interact, affecting the growth rate, fecundity and other year-class characters.

In specific structure the relationships between intraspecific forms is its essential property. To meet the requirements of fisheries, not only the information of the size and properties of the different species forms are essential, but also the possibilities of reproduction of one of the forms by another, i.e. the character of their relationships.

The knowledge of the peculiarities of commercial species regulatory mechanisms and their structure are prerequisite for developing productive fishery.

SUMMARY

The paper presented deals with the problem of intraspecific structure and variability in fishes. Four forms of intraspecific groups are noted. The necessity to study the intraspecific structure and variability for fishery management is emphasized.

REFERENCES

ANOKHINA, L. E. 1969. *Regularities of fecundity of fishes after the example of Baltic herring.* Nauka, Moscow and Leningrad. 295 pp. [In Russ.].

BERG, L. S. 1948. *Freshwater fishes of the Soviet Union and adjacent countries. 1.* USSR Academy of Sciences Press, Moscow and Leningrad. 466 pp. [In Russ.].

CHEPRAKOVA, YU. I. 1966. Biological characteristics of small herring from Kandalaksha Bay and peculiarities of its propagation. Pp. 57–74 in *Regularities of population dynamics of fishes of the White Sea and its basin.* Nauka, Moscow and Leningrad. [In Russ.].

CHERNENKO, E. V. 1968. Cariotypes of the residual and anadromus sockeye (*Oncorhynchus nerka* (Walb.)) from Lake Daljnee of Kamchatka. *Vop. Ikhtiol., 8* (5): 834–846.

KOSHELEV, B. V. 1966. Some properties of sex cycles in fishes with ovocyte synchronous and asynchronous growth in water bodies of different latitudes. Pp. 79–92 in *Regularities of population dynamics of fishes of the White Sea and its basin.* Nauka, Moscow and Leningrad. [In Russ.].

KROKHIN, E. M. 1967. A contribution of the study of *Oncorhynchus nerka* (Walb.) in Lake Daljnee (Kamchatka). *Vop. Ikhtiol., 7* (3): 433–445. [In Russ.].

NIKOLSKY, G. V. 1950. On biological basis of the rate of exploitation and means of managing the abundance of fish stocks. *Zool. Zh., 29* (1): 16–26. [In Russ.].

— 1962. On some adaptations to the regulation of population density in fish species with different types of stock structure. Pp. 265–282 in *Exploration of natural animal populations.* Oxford.

— 1968. On relative stability of species and some problems of taxonomy. *Zool. Zh., 47* (6): 860–874. [In Russ.].

— 1969. *Theory of fish population dynamics.* Oliver & Boyd, Edinburgh.

— 1969. On parallel interspecific variability of fishes. *Vop. Ikhtiol., 9* (1): 7–13. [In Russ.].

NIKOLSKY, G. V., BELYANINA, T. N., PONOMARENKO, I. J. and SYSOEVA, T. K. 1968. Some data on variability of characters and food composition of cod fry in the Barents Sea. Pp. 18–25 in *Materials on ecology of the North Atlantic cod.* Nauka, Moscow and Leningrad. [In Russ.].

POLIAKOV, G. D. 1962. Adaptable interrelationship between the variability of fish populations and feeding conditions. *Trudȳ. Inst. Morf. Zhivot., 42*: 1–62. [In Russ.].

POPOVA, O. A. 1968. Morphological index of different populations of cod in relation to feeding. Pp. 26–29 in *Materials on ecology of the North Atlantic cod.* Nauka, Moscow and Leningrad. [In Russ.].

RESHETNIKOV, YU. S. 1967. Periodicity of reproduction in whitefish. *Vop. Ikhtiol., 7* (6): 1019–1032. [In Russ.].

ROLLEFSEN, G. 1954. Observations on the cod and cod fisheries of Lofoten. *Rapp. P.-v. Réun. Cons. perm. int. Explor. Mer, 136*: 40–47.

SCHAEFER, M. B. 1956. The scientific basis for a conservation programme. Pp. 14–55 in *Papers presented at the international technical conference of conservation of the living resources of the sea.* United Nations, New York.

Received 18 June 1969

Printed 10 November 1969