Le thon rouge en Méditerranée. Biologie et Aquaculture. Sète 9-12 Mai 1978
Actes de colloques du C.N.E.X.O., 8 : Page 209 à 213.

FEASIBILITY STUDY OF RESTOCKING TUNA SPECIES USING HATCHERY PRODUCED SEED

by

Motoo INOUE

R E S U M E

—Les facteurs biologiques et écologiques en faveur d'un élevage des thonidés en vue d'un repeuplement des océans sont passés en revue. Dans un tel but, la recherche devra se porter sur les points suivants, qui ont déjà fait l'objet d'une première expérimentation :
- reproduction contrôlée de géniteurs maintenus en captivité.
- élevage des larves jusqu'au stade juvénile et production en masse de leurs nourritures.
- conditionnement des juvéniles en vue d'un élevage en milieu naturel.—

A B S T R A C T

—The biologic and ecologic factors enabling the rearing of tuna species in the purpose of restocking oceans are presented. Such effort will require to carry out research on the following points which have been already investigated to some extend :
- controled reproduction from mature fishes kept in captivity.
- rearing of larva up to the juvenil stage and mass production of their foods.
- conditioning juveniles for rearing in natural environment.—

KEY WORDS : Tuna, restocking, conditioning, juveniles.

MOTS CLES : Thon, repeuplement, conditionnement, juvéniles.

Recently great attention is being paid to fisheries research concerning skipjack and tuna populations since they inhabit high sea fishing grounds not affected by the 200 mile fishing limits. Researchers believe this is the next important species for restocking after their great success with restocking salmon. However, until now there has been very little work done on techniques for hatechery production of young tuna.

A feasibility study of the artificial propagation of tuna has been carried out by INOUE et al. since 1965 (INOUE et al; 1966, 1969, 1970a, 1972b, 1973 a,b, 1974 a,b).

The suitability of tuna for mass seed production and restocking is based on the following ecological conditions.

1. Great fecundity - tuna spawn a great many eggs which can be hatched out quickly.
2. Rapid growth - they reach suitable restocking size in a short time.
3. Fast swimming - small tuna easily escape from predators.
4. Schooling behaviour - adult fish can be caught using purse seine etc.
5. Special behaviour patterns - skipjack, yellowfin tuna and bigeye tuna tend to remain under floating objects and albacore tuna and bigeye tuna have special feeding habits preferring to feed on deep-sea fishes for which there is no food competition from other species.

These special characteristics were described by INOUE in detail (1970 a, 1973 a, 1977 a,b). The author has studied several points in order to begin artificial propagation. These are experiments in growing Chlorella acclimated to sea water, and mass culture of copepoda and Diaphanosoma sp. These microorganisms are very important for early juvenile stages of tuna and skipjack. The ecological behaviour of skipjack and tuna has also been studied especially their tendency to remain under floating objects (INOUE et al. 1967, 1968 a,b,c, 1969, 1970 a,b, 1971, 1972 a,b, 1973 a,b).

Discussions have also been held with researchers from Soviet Union concerning tuna propagation at the Japan - Soviet Aquaculture Symposium from 1972 to 1974. All the participants are in agreement that the tuna population is an equally important resource as the Salmon population in the North Pacific and artificial propagation should be developed by international cooperation among countries around the Pacific Ocean. Recently, France, Italy and Canada have started to study artificial propagation of tuna. I am looking forward to hearing the latest information concerning these studies at this symposium.

In this paper, I will concentrate on three important points for tuna propagation.

1. Artificial fertilization and indoor culture of larvae

Recent results of such experiments in Japan are shown in table 1. Fundamental experiments with newly hatched larvae have been carried out since 1970 by a research group including the Far Sea Fisheries Research Laboratory of the Fisheries Agency ; Tokai University, Kinki University, Owase and Nagasaki Prefectural Fisheries Experimental Stations. Our university has the first tuna hatchery facility established by the Fisheries Agency, and experiments continued till 1973. After 1974, these esperiments were continued on a wider scale. The results up till 1973 are summarized in "Report on experiments on the development of culturing techniques (April 1970 - March 1973)" published by the Fishery Agency, 1973.

Concerning fertilization of bluefin tuna and albacore tuna there is no information in Japan due to the difficulty in obtaining mature parents. Recently OKIYAMA (1974 and YODA (1976) pointed out that there is a possibility of finding spawning grounds of bluefin tuna in the Japan sea, this means it may be possible to catch fish containing mature eggs and carry out experiments for their fertilization in the near future. As for albacore, I think it will be necessary to keep adults in an oceanarium until they reach maturity in order to obtain eggs from them. For tuna in general it has proved very difficult to carry out experiments in artificial fertilization due to the difficulty in obtaining mature adults near the coast of Japan to overcome this difficulty, it would be necessary to establish the system of induced maturation and spawning of adults kept in a large oceanarium.

2. Indoor culture technology for juveniles with special regard to achieving high survival rates

INOUE, AOKI et al. (1977 c) have carried out experiments with the following results.

(A) Frigate mackerel larvae reared in a 1 ton tank, with (1) 6 000 Lux illumination, (2) 3 000 Lux illumination and (3) natural sun light, fed on Chlorella ellipsoidea, initial density 500 x 10^4 cells/ml, rotifer, Brachionus plicatillis, after the third day 1.8-2.9 inds/ml and Tigriopus japonicus, had a higher survival rate in the 6-10 days after hatching in the case of (1) 10-20 %, (2) 5-10 % than a survival rate of (3) (Fig. 1).

(B) Outdoor experiment in a 17 ton tank with frigate mackerel larvae having a body length of 10-15 mm (15 days old). At this size clear schooling behaviour was seen ; cannibalism occurred after they reached a size of 15-20 mm. The body length of these fish after 19 days reached 26.1 mm and after 43 days 148 mm (Fig. 2).

(C) Based on the results of the preceding experiments, it is clear that mass culture indoors requires the use of artificial illumination at night at a strength of about 6 000 Lux until the juveniles reach a size of 15 cm, after 45 days of culture.

In the future it will be necessary to establish high techniques of culture to ensure a high survival rate, especially in the early larval stages up to 10 mm size. Artificial diets or mass culture of micro-organisms to be used as feed after Brachionus, Altemia and Tigriopus, are needed. The supply of suitable feed is a basic requirement.

3. Studies concerning the conditioning of tuna

A trial has been carried out by the author to try to condition tuna in order to make their culture similar to that of livestock, using bluefin, skipjack, bonito, frigate mackerel, little tunny, etc (1967, 1972 b). In 1976, the same trials have been carried out with Seriola and Caranx and in their case conditioning was by hand feeding, followed by making a noise underwater at time of feeding.

The results were

1. Seriola purpuracens is very easy to acclimate to human activity but S. aureovittata and Caranx delicatissimus are very difficult train.
2. C. delicatissimus and Naucratus indicus show a strong schooling behaviour and S. purpuracens and S. aureovittata tend to mix with each other easily.
3. S. purpuracens needs 0-3 days to become acclimatized to hand feeding and conditioning by sound. Small S. aureovittata need 3 days, Caranx 4-6 days, and large S. aureovittata 32 days.
4. When conditioned S. aureovittata are put out into the open sea, they continue to respond to hand feedings for 1-20 days. S. purpuracens for 41-47 days, and Naucratus only 1 day. Caranx stayed in the net cage for 2 days after it had been opened to release them. A similar experiment took place in a natural bay. S. purpuracens showed homing behaviour, but not frigate mackerel.

In the future, similar experiments should be conducted in lagoons in the South Pacific on a large scale. In such a way it may be possible to succeed in developing a system for culturing tuna in a ranching style.

BIBLIOGRAPHY

Far Seas Fisheries Research Laboratory (1973) : report on experiments on the development of tuna culturing techniques (April, 1970 - March, 1973). F.S.F.R.L. S Series 8. 1 - 165 (in japanese with an english summary).

INOUE, M. -1966c- A design for increasing tuna production in the Pacific. Tokai Univ. Newspaper, 100th Anniv. KOUEN, 133-137 (in japanese).

INOUE, M., AMANO R., IWASAKI Y. and AOKI M. - 1967 - Ecology of various tunas under captivity. I. Preliminary rearing experiments. Fac. Oceanogr., Tokai Univ., 2 : 197-209 (in japanese with an english summary).

INOUE M., AMANO R., IWASAKI Y. and YAMAUTI Y. - 1968a - Studies on environments alluring skipjack and other tunas. II. On the driftwood accompanied by skipjack and tunas. Bull. Jap. Soc. sci. Fish., 34 (4) : 283-287.

INOUE M., AMANO R., IWASAKI Y. and YAMAUTI M. - 1968b - Ditto III. Tagging experiments on the experimental driftwoods as part of ecological study of tunas. Ibid., 34 (4) : 288-294.

INOUE M., AOKI M. and TANAKA Y. - 1968c - Acclimatization of Chlorella to sea water. Ibid., 34 (5) : 378-384 (in japanese with an english summary).

INOUE M. and AOKI M. - 1969 - Reproduction of Copepoda, Tisbe furcata cultured with sea water acclimatized Chlorella as a basic diet. Ibid., 35 (9) : 862-867. (in japanese with an english summary).

INOUE M. - 1970a - Possibility of tuna cultivation and progagation. Bull Jap. Soc. Fish Oceanogr., 16 : 51-64 (in japanese).

INOUE M., IWASAKI Y., AMANO R., AOKI M. and YAMAUTI M. - 1970b - Ecology of various tunas under captivity. II. Behaviour of tuna shown against light and darkness. Jour. Coll. mar. sci. Technol., Tokai Univ., 4 : 53-58 (in japanese with an english summary.

INOUE M. and AOKI M. - 1971 - Reproduction of Diaphanosoma sp. (Cladocera) cultured with sea water acclimatized Chlorella as basic diet with different chlorinities. Ibid. 5 : 1-8.

INOUE M. - 1971b - Possibility of artificially culturing tunas. Bull. Jap. fish. Oceanogr., 16 : 51-64 (translated into english by Div. Foreign Fish. NOAA) 1-31.

INOUE M., AOKI M. and ABE T. - 1972a - Acclimatization of a high-temperature strain of Chlorella (Chlorella NAGASHIMA) to sea water and to high-temperature. Jour. Coll. mar. sci. Technol., Tokai Univ., 6 : 89-94. (in japanese with an english summary).

INOUE M., IWASAKI Y., AOKI M., MIYASHITA A. and YATOMI H. - 1972b - Studies on culture and domestication of tuna, billfish and other large-sized oceanic fish. I. On culture and domestication of Thunnus thynnus, Katsuwonas pelamis, Sarda orientalis, Auxis tapeinosoma, Euthynnus affinis, Histiophorus orientalis and Coryphaena hippurus in a fish preserve and a portable pool at Mera, 1970-1971. Ibid., 6 : 69-78 (in japanese with an english summary).

INOUE M. - 1973a - Possibility of artificial culture of the pacific tunas review of the studies. J. Fac. Mar. Sci. Technol., Tokai Univ., NO 7, 297-312 (in japanese with an english summary).

INOUE M. - 1973b - Recent trends in artificial propagation of tunas, propagation of marine resources of the Pacific Ocean. Pap. Ist. Japan-USSR Joint Symp. Aquacul. Pac. Ocean (Dec. 1972, Tokyo-Shimizu), pp. 57-66. Tokai Univ. (in japanese with an english summary).

INOUE M., IWASAKI Y., AOKI M., TUTUMI K. and NAGAOKA - 1974a - Some notes on the artificial fertilization and rearing of larvae in frigate mackerel and yellowfin tuna, cultured with seawater-acclimatized Chlorella as a basic diet. J. Fac. Mar. Sci. Technol., Tokai Univ., No. 8, 27-36 (in japanese with an english summary).

INOUE M., TUTUMI K., NAGAOKA H. and NAGATA T. - 1974b - Some notes on the artificial fertilization and rearing of larvae in the skipjack tuna. Ibid. No. 8, 37-42 (in japanese with an english summary).

INOUE M. - 1977a - Ecological study on tunas in the Pacific Ocean and their artificial propagation. Proc. 2nd Soviet-Japan Joint Symp. Aquaculture, Nov. 1973, Moscow 30-38 (in japanese with an english summary).

INOUE M. - 1977b - Tuna spawning survey in the tropical sea made by R.V. Tokaidaigaku Maru II and R.V. Bosei Maru. Proc. 3rd Japan-Soviet Joint Symp. Aquaculture, Nov. 1974, 174-180 (in japanese with an english summary.

INOUE M., AOKI M., KUMAMURA K., ZINE S. and MIYASHITA A. - 1977c - Survival and growth of larvae of frigate mackerel, Auxis rochei, cultured with seawater-acclimatized chlorella as basic diet. Resumes of papers at the spring, 1977 Congress of Jap. Soc. Sci. Fish., 302 (in japanese).

INOUE M., YATOMI H., MATIDA H. and HATTORI T. - 1977d - Some notes on the pasturage of Seriola purpurascens, Caranx delicatissimus and other fishes in a manmade froating fish reef uses net cage. Ibid., 315 (in japanese).

OKIYAMA M. - 1974 - Occurrence of the post larvae of bluefin tuna Thunnus thynnus, in the Japan sea. Bull. Jap. Sea. Reg. Fish. Res. Lab. (25) 89-97 (in japanese with an english summary).

YORITA T. - 1976 - On the bluefin tuna of the Japan sea coast of Hokkaido, J. Hok. Fish. Exp. st., Hokusuishi Geppo, (33) 3, 2-11 (in japanese).