NPAFC
Doc. 147
Rev. ____

MARINE MORTALITY OF CHUM SALMON (*ONCORHYNCHUS KETA*) CAUSED BY THE PARASITIC FLAGELLATE *ICHTHYOBODO NECATOR*

by

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Submitted to the
NORTH PACIFIC ANADROMOUS FISH COMMISSION
by the
JAPAN NATIONAL SECTION

October 1995

This paper may be cited in the following manner:
Urawa, S. 1995. Marine mortality of chum salmon (*Oncorhynchus keta*) caused by the parasitic flagellate *Ichthyobodo necator*. (NPAFC Doc. 147) 7 pages. Research Division, Hokkaido Salmon Hatchery, Fisheries Agency of Japan, Toyohira-ku, Sapporo 062, Japan.

MARINE MORTALITY OF CHUM SALMON (*ONCORHYNCHUS KETA*) CAUSED BY THE PARASITIC FLAGELLATE *ICHTHYOBODO NECATOR*

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ABSTRACT

The potential impact of the ectoparasitic protozoan *Ichthyobodo necator* on marine survival of juvenile chum salmon (*Oncorhynchus keta*) was evaluated by laboratory and field surveys. The infection experiments indicated that the parasite infections caused severe epidermal destruction and drastically reduced the seawater tolerance of juvenile chum salmon due to osmoregulatory breakdown. A control experiment was conducted at Yoichi Hatchery along the Yoichi River in western Hokkaido, where the parasite infections annually occurred, resulting in the reduced seawater adaptability of juvenile chum salmon. A formalin bath (250 ppm for 1 h) eliminated the attaching parasites and recovered the seawater adaptability of salmon juveniles before release from the hatchery. The number of adult salmon returns significantly increased in the Yoichi River after the control of parasites. These results suggest that *Ichthyobodo* infections become a factor causing high mortality of juvenile chum salmon in natural waters, especially when they enter the ocean.

INTRODUCTION

It is important for the management of fish population to understand their survival mechanism. The early ocean life of anadromous salmonids may be a critical period in their life history, but the possible causes of mortality are poorly understood. Many factors affect the early marine survival of salmonids, such as predation, food limitation, density-dependence, ocean conditions, and physiological conditions (Pearcy 1992). Diseases also may be a factor that affects survival of salmonids in the ocean. Although various pathogens cause disease conditions among hatchery-reared salmonids, their impact in natural water are poorly understood.

The purpose of the present study is to evaluate the potential impact of the parasitic protozoan *Ichthyobodo necator* on marine survival of juvenile chum salmon (*Oncorhynchus keta*) by laboratory and field surveys.

PARASITE

Ichthyobodo necator is a parasitic flagellate infecting the skin and gills of wild and hatchery-reared salmonids and many other fish species (Robertson 1985). This small single cell parasite is originally a freshwater species, but can reproduce in the marine environment as a result of its adaptation to anadromous hosts (Urawa and Kusakari 1990). The parasite is commonly distributed in the Northern Hemisphere, and occurs in 30-40% of salmon hatcheries in northern Japan (Urawa 1992a). The mortality of *Ichthyobodo*-infected fish is usually low in fresh water, although high mortality occasionally occurs when infections are combined with environmental stress such as high

rearing density or poor water quality (Urawa 1995).

LABORATORY SURVEY

A transmission experiment was conducted in the laboratory to estimate the influence of parasite infections on survival of juvenile chum salmon in fresh water and seawater (Urawa 1993). The parasite density increased 2 weeks after infection, reached a peak at week 6, and then decreased gradually by week 10 (Fig. 1). Parasites attached to the epidermal cells, and caused sloughing of the entire epidermis above the basal layer when the parasite density increased between 4 and 6 weeks after infection (Urawa 1992b). The cumulative mortality in fresh water for 10 weeks was 12% in infected group, and 2% in the controls. Biweekly seawater challenge tests (salinity 33‰ for 48 h) indicated that 60-70% of infected fish died in seawater between weeks 4 and 6 (Fig. 1). When high mortalities were recorded in infected fish between weeks 4 and 6, the serum chloride concentrations of infected fish were significantly lower in fresh water and higher in seawater than those of the controls. In the controls, serum chloride concentration gradually reached seawater adaptive levels of about 130 meq/l within 48 hours after seawater transfer. In infected fish, however, it suddenly increased to 180 meq/l within 3 hours after seawater transfer and continued at much higher levels over the next 4 days (Fig. 2). This initial sharp rise in serum chloride levels was followed by death in many infected fish, indicating acute dehydration that occurred in seawater due to an osmoregulatory disorder of injured skin. These results suggest that the parasite has a high potential to cause mass mortalities in juvenile salmon soon after their ocean entry.

FIELD SURVEY

To verify the hypothesis that *Ichthyobodo* infections induce high marine mortality of juvenile chum salmon, a control experiment was conducted in the spring of 1987 at Yoichi Hatchery along the Yoichi River in western Hokkaido, where the parasite infections annually occurred, resulting in low survivals of chum salmon (Urawa 1992c). This hatchery is located 4 km upstream from the estuary of the Yoichi River, and juvenile salmon enter the sea soon after release from the hatchery. Biweekly observations indicated that the parasite density on hatchery-reared chum salmon increased in the fry stage, and the seawater survival rate of juveniles reduced to 70% (Fig. 3). A formalin bath (250 ppm for 1 h) eliminated the attaching parasites and recovered the seawater adaptability of juveniles within 4 weeks post-treatment (Fig. 4). Thus, approximately 9 million juvenile chum salmon were released by the middle of April 1987 after the complete treatment.

Although the number of juvenile chum salmon released from the hatchery increased gradually year by year, adult returns had been very scanty (less than 4000 fish) until 1988 (Fig. 5). However, adult returns significantly increased in the Yoichi River in 1989-91, the returning years of the 1987 salmon juveniles treated with formalin bath. These increased salmon returns are largely a consequence of the improved early marine survival of juvenile salmon due to the control of *Ichthyobodo* infections.

CONCLUSIONS

The present study has demonstrated that the protozoan parasite *Ichthyobodo necator* becomes a factor causing high mortality among juvenile chum salmon in natural water, especially when they enter the coastal ocean. The parasite is common in hatchery-reared salmonids as well as in wild fishes. Consequently, the control of parasite infections is essential to improve the marine survival of infected fish.

Natural mortality of anadromous salmonids may be also caused by other pathogenic organisms

including bacteria (e.g. *Renibacterium salmoninarum* and *Flavobacterium branchiophila*), protozoans (e. g. *Ceratomyxa shasta* and *Chilodonella piscicola*), and metazoan parasites (e. g. *Nanophyetus salmincola*). Further studies are requested to understand the influence of these pathogens on the survival of anadromous salmonids in the ocean. The present methods that combine laboratory infection experiments with field population survey may be effective for evaluating the possible impact of pathogens.

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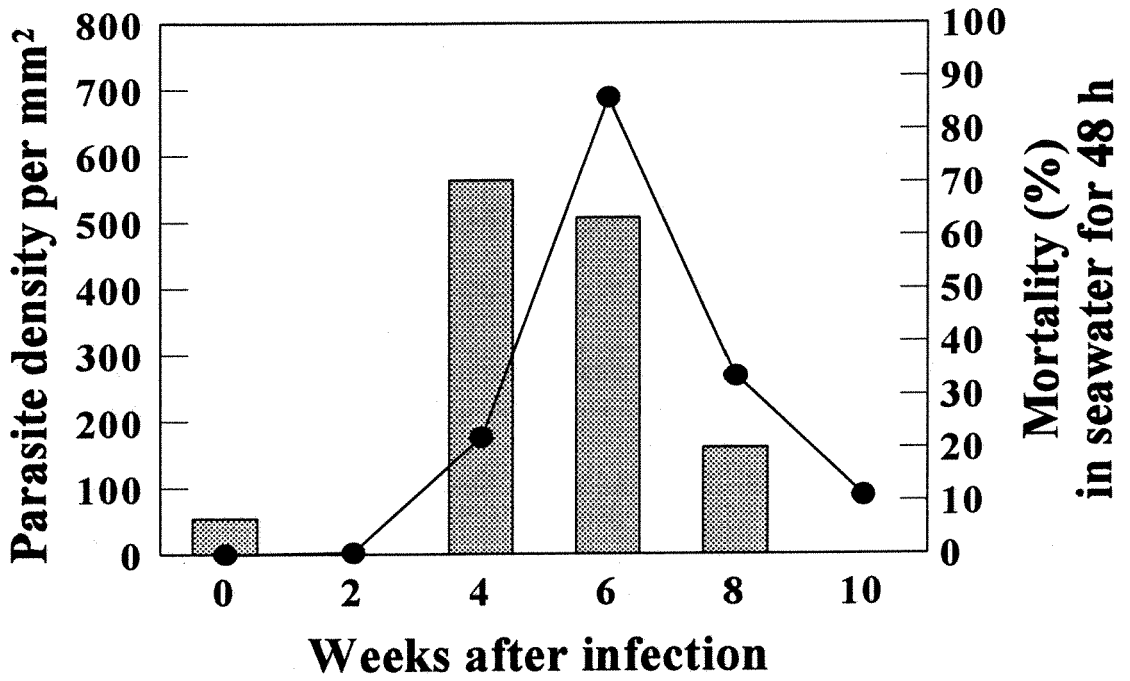

Figure 1. Biweekly changes in the density of *Ichthyobodo necator* on the skin of juvenile chum salmon in fresh water (closed circles) and the mortality of juveniles transferred in seawater (salinity 33‰) within 48 hours (solid columns).

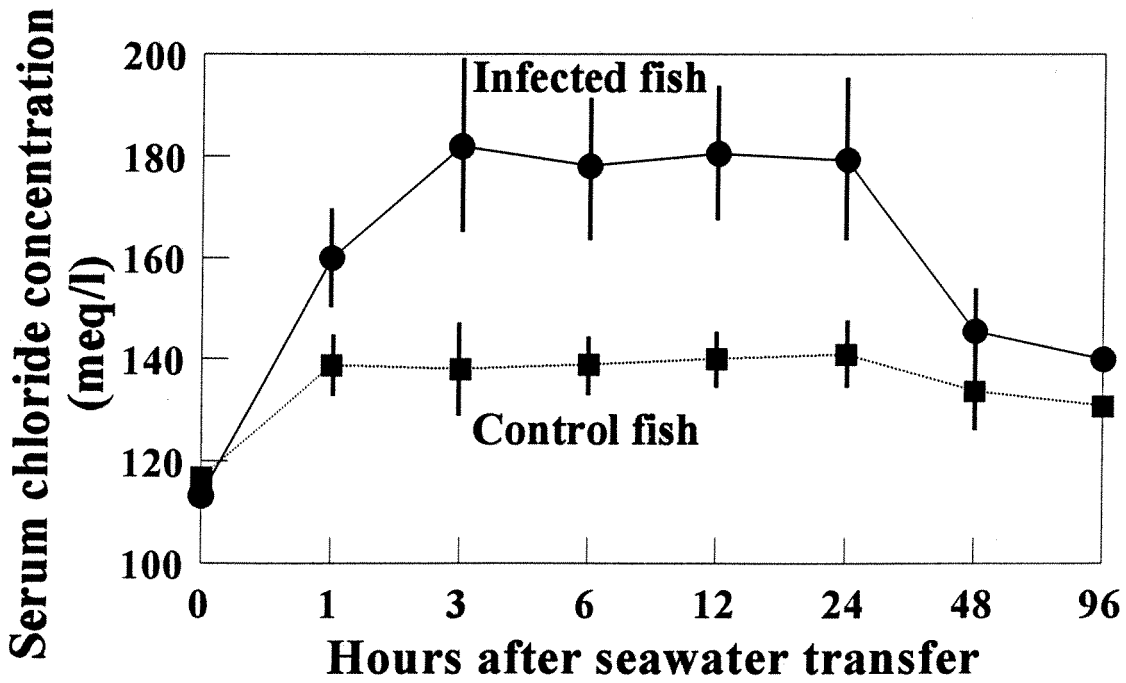

Figure 2. Changes in the serum chloride concentration of *Ichthyobodo*-infected and control chum salmon juveniles held in fresh water following exposure to seawater at week 6. Bars indicate SD.

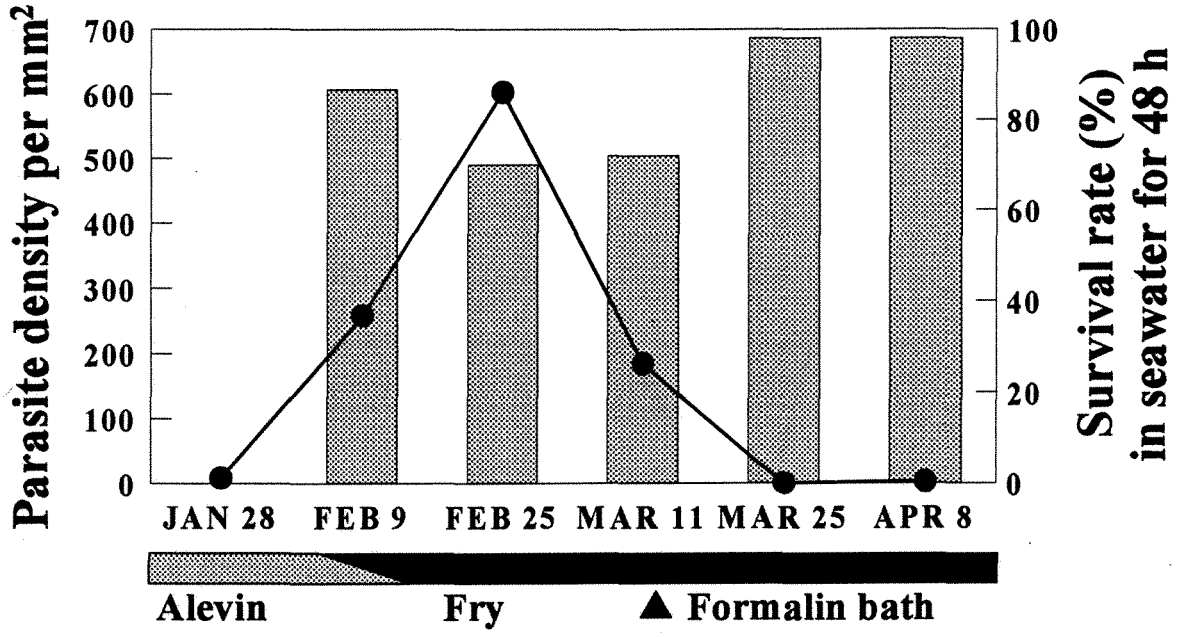

Figure 3. Seasonal changes in the mean density of *Ichthyobodo necator* (solid circles) and seawater survival (salinity 33‰ for 48 h; shaded columns) in juvenile chum salmon reared in the Yoichi Hatchery in 1987. Shaded and solid bars under the abscissa indicate the alevin and fry stages of salmon, respectively. Arrow denotes the date when a formalin bath (250 ppm for 1 h) was conducted.

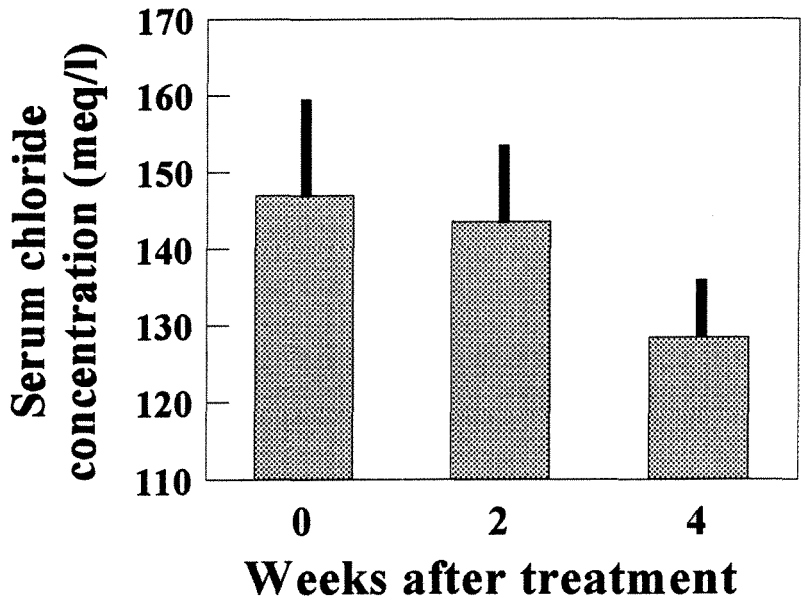

Figure 4. Changes in the serum chloride concentration of juvenile chum salmon held in seawater (salinity 33‰) for 48 h after a treatment with formalin bath.

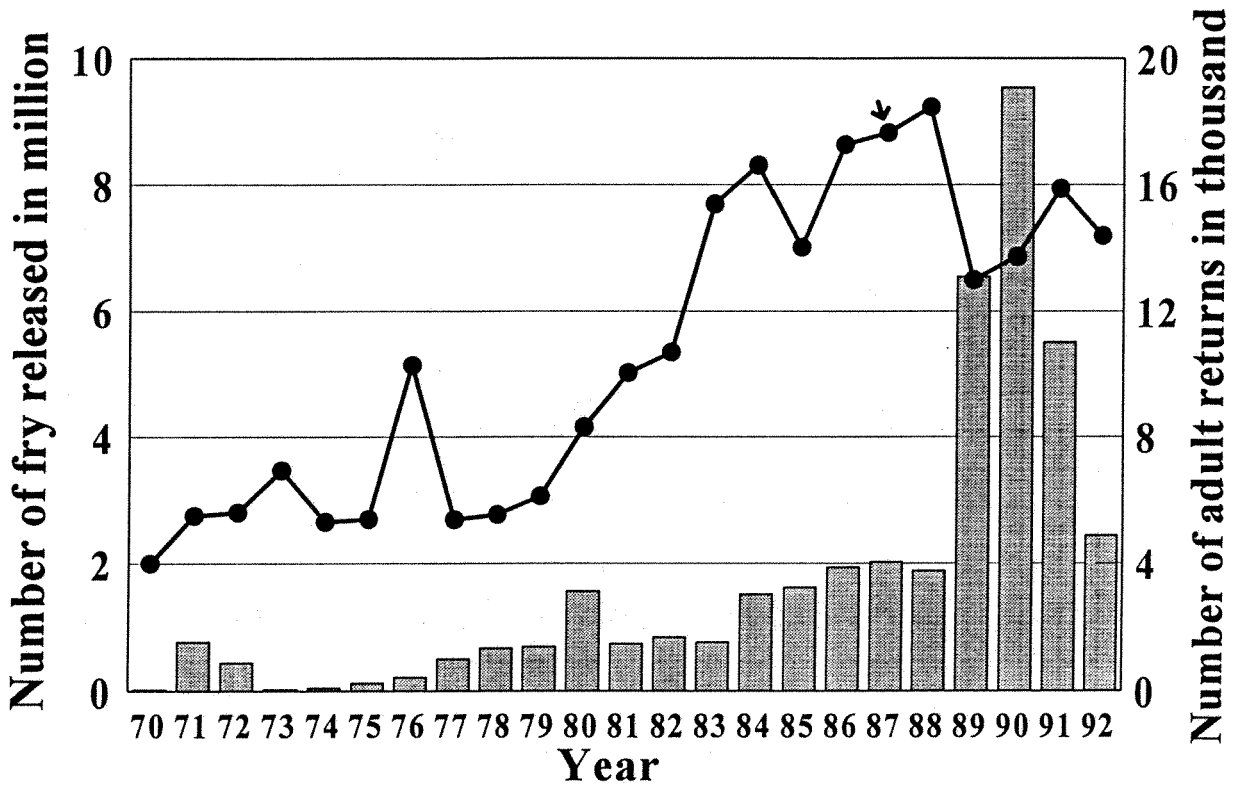

Figure 5. Annual Changes in the number of juvenile chum salmon released (open circles) and adult returns (shaded columns) in the Yoichi River between 1970 and 1992. Arrow indicates juvenile chum salmon treated with formalin bath before release in 1987.