Timing of spawning of wild chum salmon *Oncorhynchus keta* in a non-enhanced river and their seaward migration in northern Honshu, Japan

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**Background**
Information on the ecology of wild chum salmon is needed for their sustainable management in Japan, as it enables the development and application of effective conservation measures. However, comparative information on the early ocean ecology of wild chum salmon that originate from non-enhanced rivers is limited in northern Honshu, Japan.

**Objectives**
In order to better understand the early ocean ecology of wild chum salmon, we investigated the timing of spawning of wild chum salmon in a non-enhanced river, and their sea entry.

**Materials and methods**

**Counts of reds and growth prediction**
Chum salmon spawning reds were counted visually once every 10 days from early October to early January in the Funato River where hatchery fry have never been stocked (Fig. 1). A digital thermometer was inserted to 10–15 cm depth in the mount of observed spawning reds to evaluate the ambient temperature of naturally spawned eggs.

The surface water temperature and intergravel temperature of the observed spawning reds were similar on each surveyed day (Fig. 2). Thus, timing of their emergence was predicted based on the accumulated thermal units of the Funato River (Fig. 3).

**Field sampling**
Chum salmon fry were collected from one to three times a month from February to June using a seine net (2-m-wide 1-m-deep mouth, and a central bag with a 1-mm mesh) at Fujitsuka Beach (Fig. 1). 50 m hauls at approximately 0.4–0.8 m depth were performed two to three times by two persons wading backwards along the beach during the daytime.

**Simple discrimination of wild and hatchery chum salmon fry**
Kaji and Tainai rivers are located within 10 km of Fujitsuka Beach, with unmarked hatchery chum salmon with fork length > 48 mm being stocked in these rivers each year (Fig. 1). The hatchery chum fry were stocked by late March in the two rivers.

Most chum salmon fry collected at Fujitsuka Beach were 42 mm fork length or less (Fig. 5). Thus, we assumed that most specimens collected at Fujitsuka Beach were wild fish originating from the Funato River, and not hatchery fish.

**Results**

**Timing of spawning and growth predictions based on intergravel temperature.**

**Occurrence of chum fry and the relationship between the occurrence and environmental factors**

**Conclusion**
- Wild chum salmon fry were detected at Fujitsuka Beach from March to May when the SST was 7.4–17.5°C (Fig. 4, 6). The GLM predicted a 30.2%–62.5% probability of wild chum salmon fry being detected even when the SST was 15°C (Fig. 6).
- The period during which fry were detected at Fujitsuka Beach years largely corresponded to the predicted timing of emergence (Fig. 3, 4). The timing of sea entry of wild chum fry could be predicted from the timing of natural spawning and the accumulated thermal units (Fig. 3).

**Fig. 1** Map showing the study area where chum salmon fry were collected in the surf zone of Fujitsuka Beach, and the study site where the spawning reds of chum salmon were observed in the Funato River, Japan. Number in parentheses represents the number of hatchery reared fry that were stocked.

**Fig. 2** Changes to the surface water temperature (solid lines) at the Funato River (Fig. 3). Intergravel temperature of spawning reds observed on each survey day is shown as horizontal jittered open circles to prevent overlap.

**Fig. 3** Accumulated thermal units (ATU) of the Funato River from mid-October (solid line) and mid-December (dashed line) onwards in 2015–2018. Double headed arrows indicate the emergence period of wild chum salmon, which was predicted from the ATU.

**Fig. 4** Relationship between the probability of presence of chum salmon fry and sea surface temperature and salinity at Fujitsuka Beach, Niigata Prefecture. The plots show observed values. Predicted values generated from a generalized linear model with binomial distribution are expressed as solid, dashed, and dotted lines when salinity was 10, 20, and 30, respectively.

**Fig. 5** Scatterplot of fork length of chum salmon fry collected at Fujitsuka Beach, Niigata Prefecture, in 2013–2018. Specimens with fork length 42 mm or less was considered as wild fish in this study.