3rd International Conference on Fish Telemetry
World Trade Convention Centre
Halifax, Nova Scotia, Canada
July 16 (Thursday), 2015

Large and small scale Pacific salmon homing behavior using the PIT tag system

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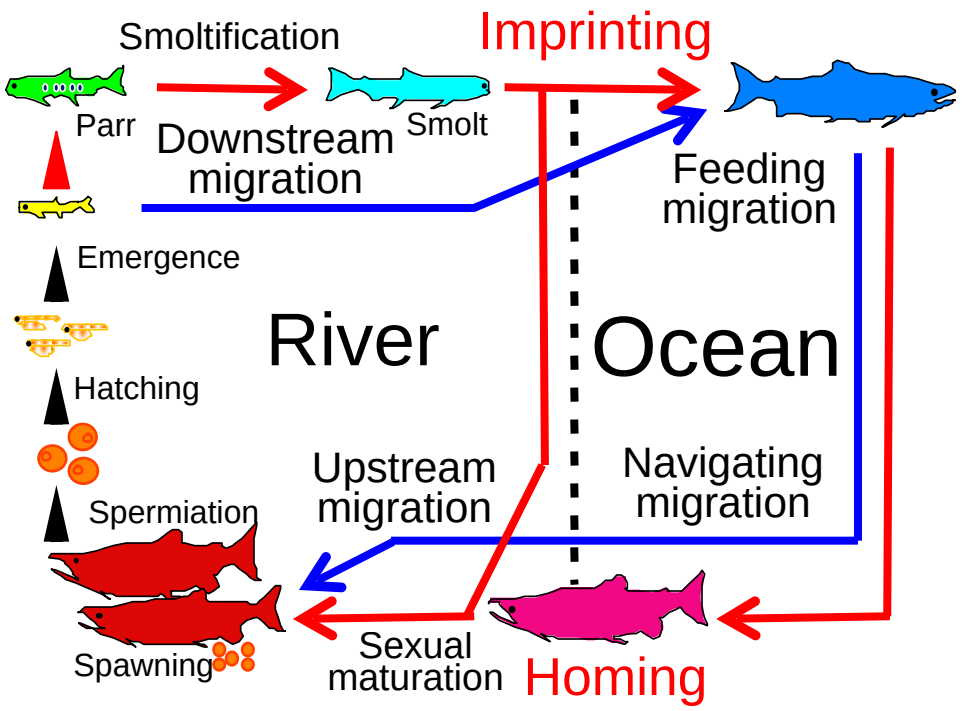
1. Life cycle, propagation system, and changes in stocks of chum and masu salmon in Japan.
2. Large scale masu salmon homing behavior in the Shimoakka Hatchery.
3. Small scale chum salmon homing behavior in the Sapporo Salmon Museum.
4. Future prospects for fish telemetry.

Photo by Yuji Seo

Life cycle of chum and masu salmon in Japan

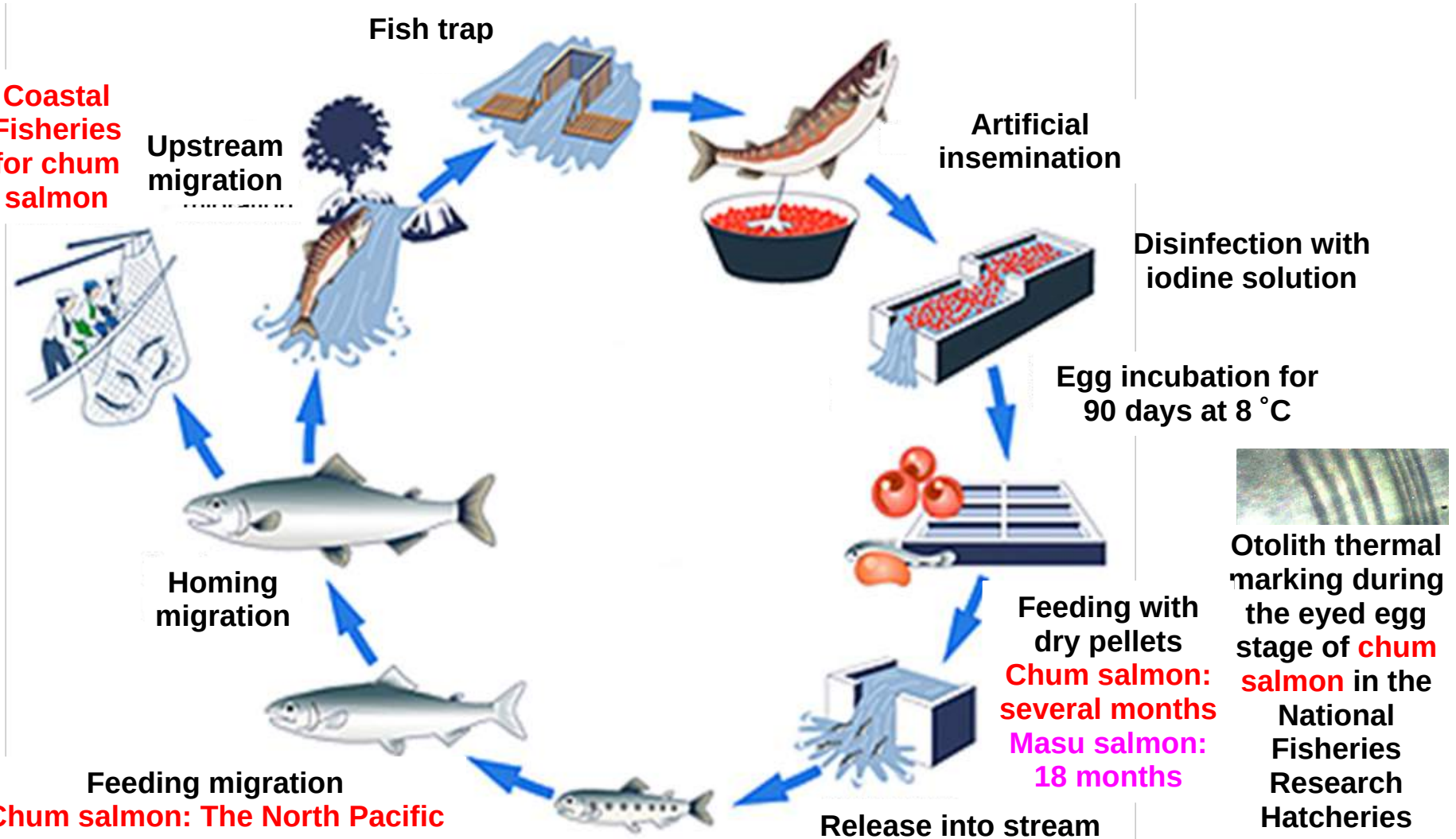

Chum salmon (*O. keta*)


Masu salmon (*O. masou*)



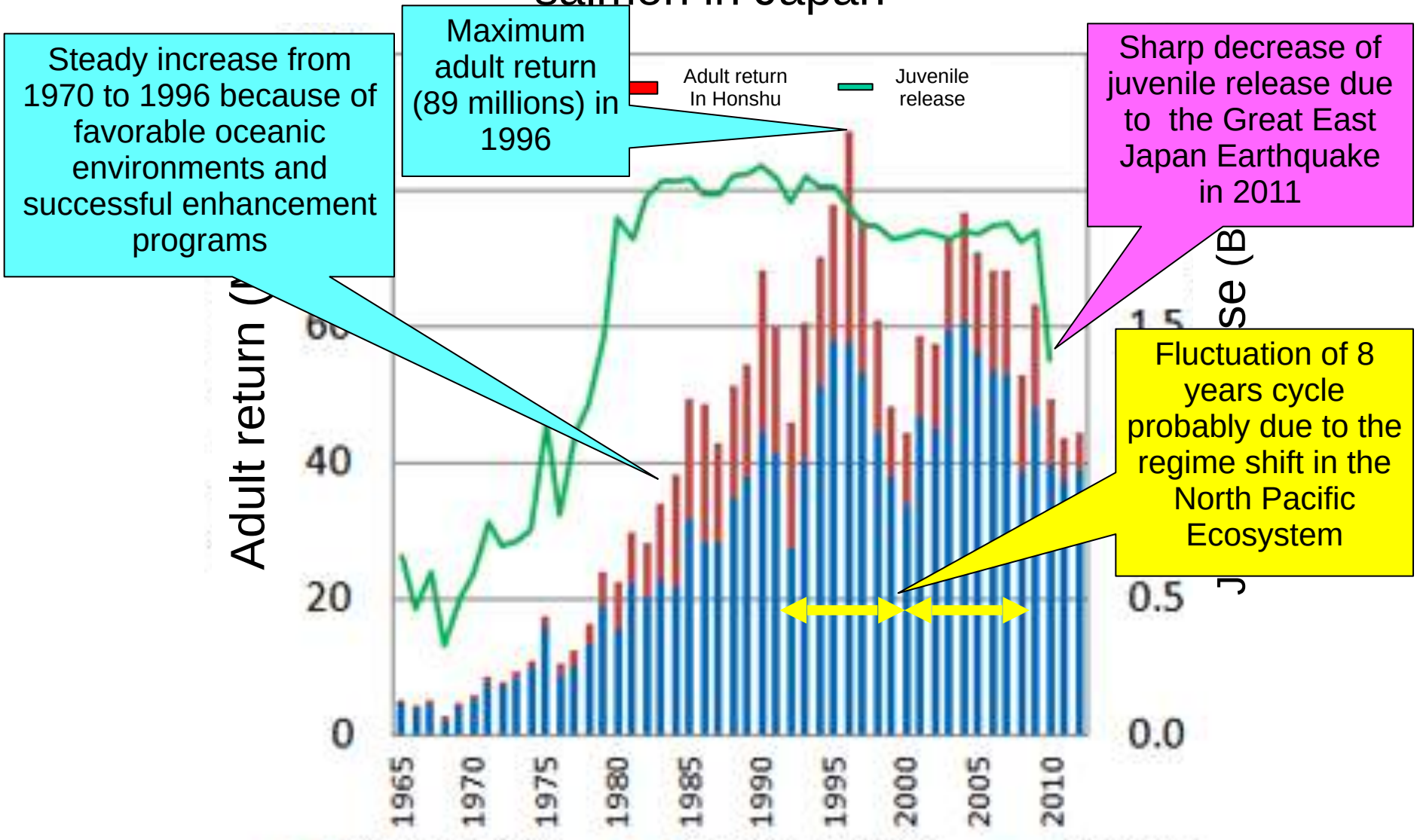
- Cold water freshwater species.
- Migrate to ocean to feed.
- Not possible to fertilize eggs in seawater.
- Acquire imprinting and homing ability.
- In Japan, using salmon imprinting and homing ability, chum and masu salmon are propagated and are very important fisheries resources.

Chum and masu salmon propagation system in Japan



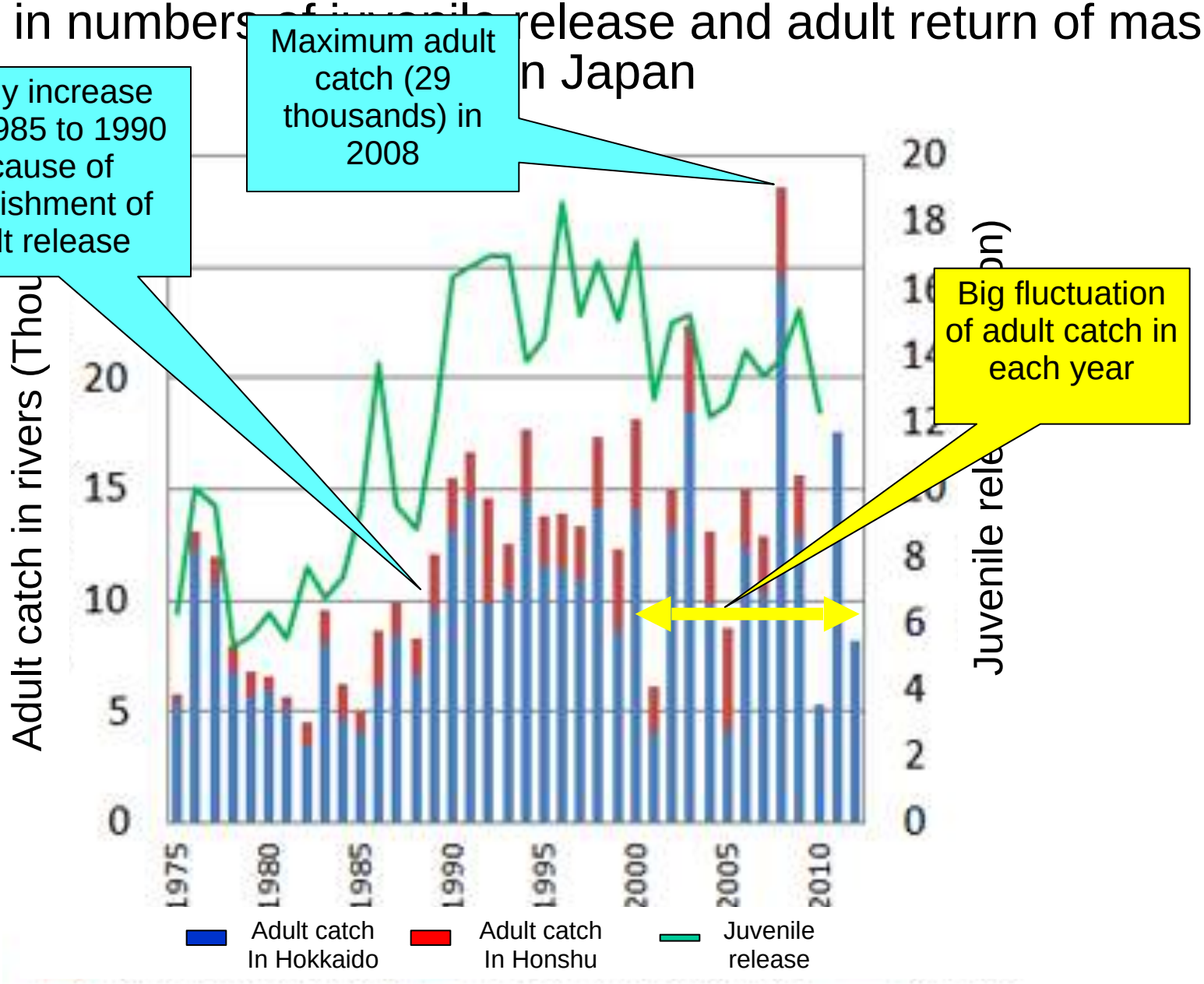
Otolith thermal marking during the eyed egg stage of chum salmon in the National Fisheries Research Hatcheries

Changes in numbers of juvenile release and adult return of chum salmon in Japan



Hokkaido National Fisheries Research Institute
http://salmon.fra.affrc.go.jp/zousyoku/ok_relret.htm

Changes in numbers of juvenile release and adult return of masu in Japan



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Support for reconstruction and revitalization after the Great East Japan Earthquake by Japan Science and Technology Agency (JST)
Creation of Innovation Technology for Marine Products Industry
Production of high homing rate of Pacific salmon in East Japan

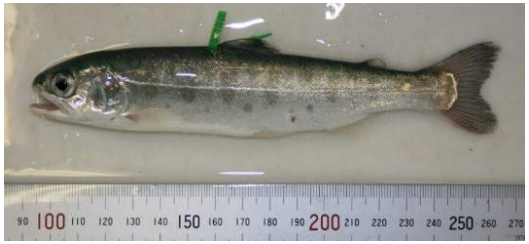

Dr. Hisaya Nii


Dr. Kazu Hayashida

2013

1. April 15-19: 1,500 masu salmon smolt were tagged with PIT tag and ribbon tag.
2. May 1-6: Masu salmon smolt were fed with ω3 (rich in DHA) contained pellets.
3. May 10 (New moon): Release of masu salmon smolt from the Shimoakka Hatchery to the Akka River.

2014 and 2015
The similar tagging was carried out between the middle and late March.



PIT tag: Biomark, Boise, USA.
Length: 12.5 mm
Weight: 0.1 g

The tagging was carried out by experts in the Hokkaido Aquaculture Promotion Corporation.

Two PIT tag detection antennas (3×1.2 m) were set up at entrance of the Shimoakka Hatchery with remote detection system.

Improvement of olfactory imprinting capability of masu salmon smolt

- We have succeeded in artificial imprinting to a single amino acid before and during smoltification in one-year-old sockeye salmon.
- Juvenile salmon can imprint to their natal stream odors during downstream migration that is deeply involved with smoltification
- Imprinting is believed to correlate with changes in the brain-pituitary-thyroid axis hormone of Pacific salmon.
- We are now carrying out the experiments to improve olfactory imprinting capability of juvenile Pacific salmon by the oral administration of bioactive substances:

Docosahexaenoic acid (DHA)

- ✓ Increase the number of dendrites
- ✓ Development of axon
- ✓ Maintaining healthy condition of brain functions

N-methyl-D-aspartate (NMDA)

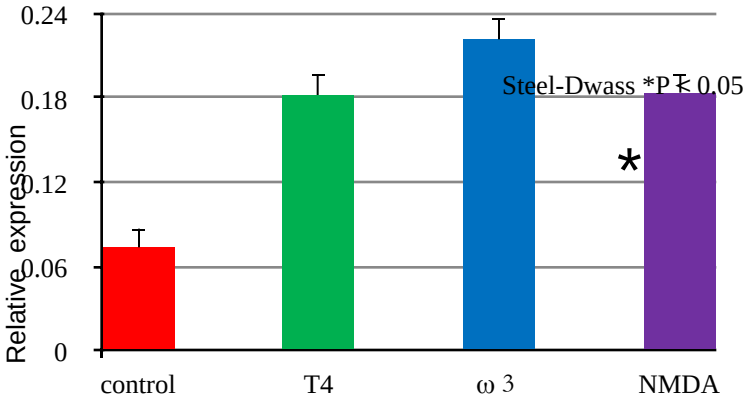
- ✓ Development of the neural network
- ✓ Learning and memory in the mouse brain
- ✓ Forming and recalling the imprinting memory in the chick brain

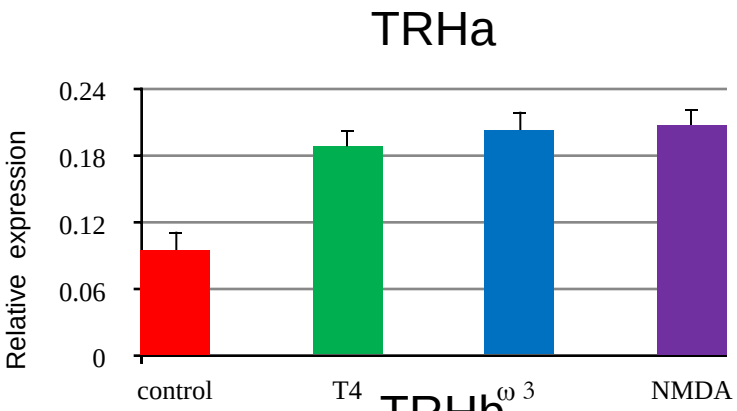
Thyroid hormone (T_3 & T_4)

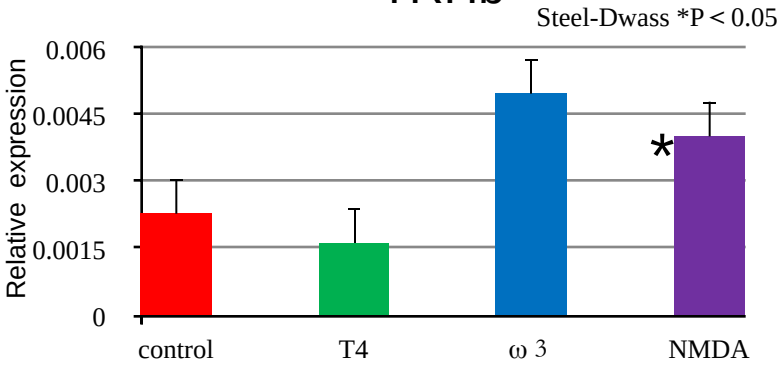
- ✓ Potentiates brain development in vertebrates
- ✓ Metamorphosis in frog
- ✓ Imprinting and learning in the bird brain

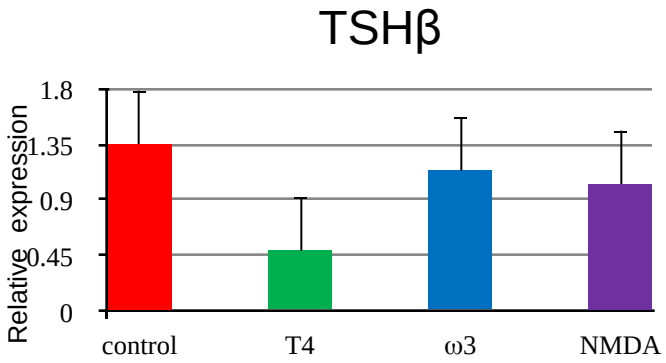
Effects of bioactive substances (T4, ω3, and NMDA) on the Brain-Pituitary-Thyroid axis of masu salmon smolt

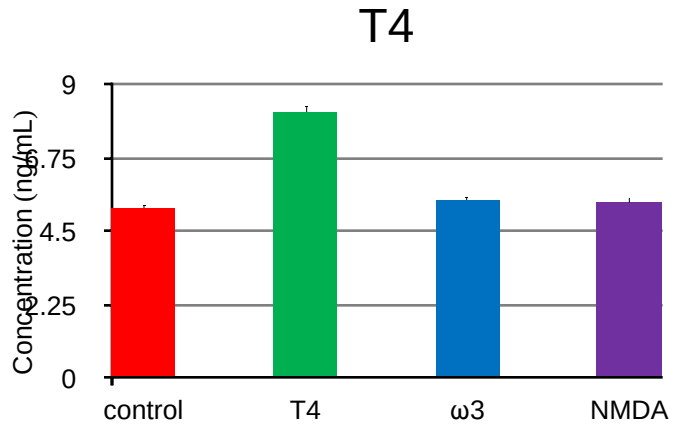
Naoki Katayama











Ueda, Fish Sci, 81:219-228 (2015)

Homing rate of adult masu salmon in the Shimoakka Hatchery

Release timing	1996	1997	1998	1999	2000	2001	2002	2003	2004
0+ Autumn	*0.002*	*0.004*	*0.007*	*0.065*	*0.009*	*0.002*	*0.001*	*0.006*	*0.004*
1+ Spring	*0.118*	*0.032*	*0.020*	*0.065*	*0.016*	*0.010*	*0.001*	*0.021*	*0.039*

Homing of ω3 pellet feeding adult masu salmon in the Shimoakka Hatchery in 2014

Homing rate: 0.333

No	Tagging Date	Tagging number	Releasing date	Homing date
1	*2013/4/16*	*989.001000525060*	*2013/5/10*	*2014/8/10*
2	*2013/4/16*	*989.001000524616*	*2013/5/10*	*2014/9/18*
3	*2013/4/16*	*989.001000526053*	*2013/5/10*	*2014/10/2*
4	*2013/4/16*	*989.001000525377*	*2013/5/10*	*2014/10/6*
5	*2013/4/16*	*989.001000524812*	*2013/5/10*	*2014/10/16*

Detecting of masu salmon feeding ω3 pellet in the Shimoakka Hatchery in 2014

No	Tagging Date	Tagging number	Releasing date	Detecting date
1	*2014/2/18*	*989.001003031340*	*2014/3/31*	*2014/4/1*
2	*2014/2/17*	*989.001003032024*	*2014/3/31*	*2014/4/1*
3	*2014/2/19*	*989.001003031988*	*2014/3/31*	*2014/4/16*
4	*2014/2/19*	*989.001003031411*	*2014/3/31*	*2014/9/10*
5	*2014/2/19*	*989.001003031449*	*2014/3/31*	*2014/9/25*
6	*2014/2/17*	*989.001003030970*	*2014/3/31*	*2014/9/27*
7	*2014/2/18*	*989.001003032075*	*2014/3/31*	*2014/9/29*
8	*2014/2/17*	*989.001003030919*	*2014/3/31*	*2014/10/5*

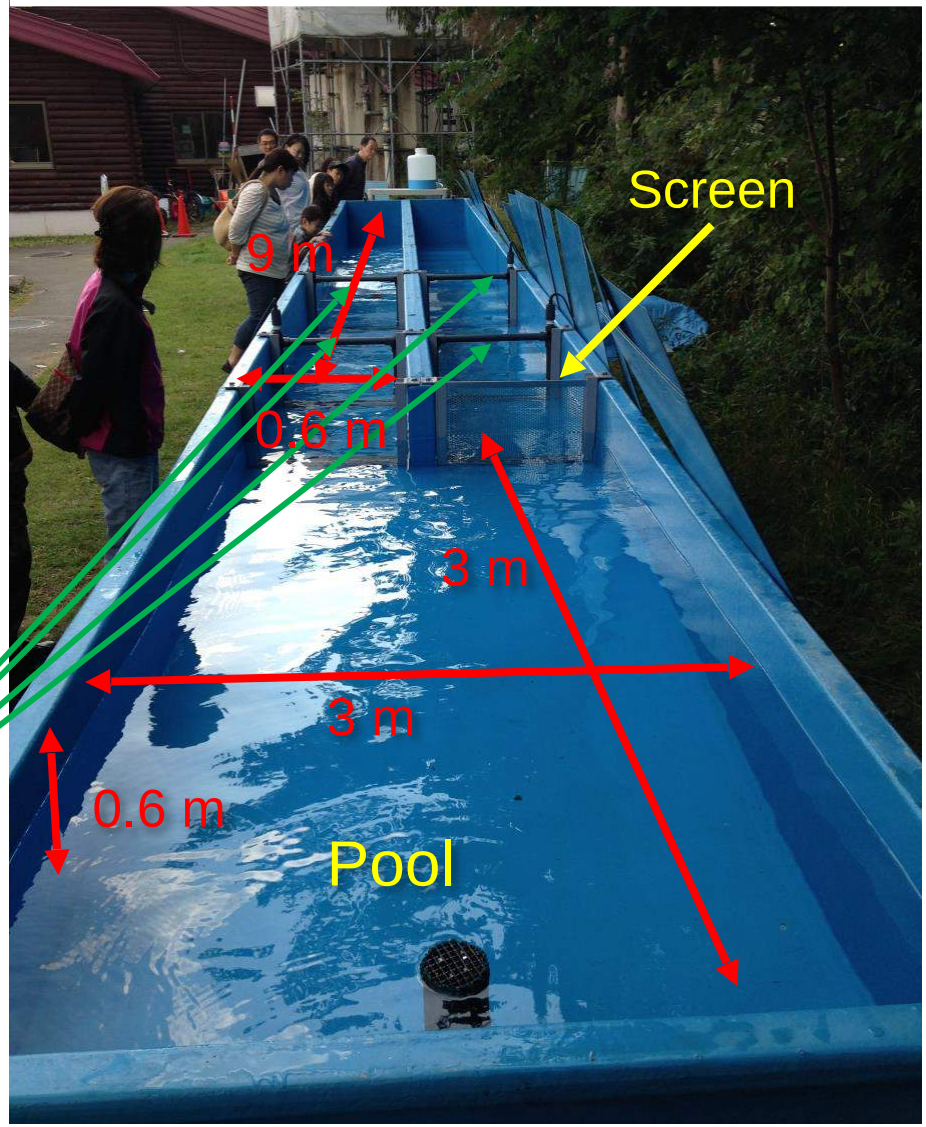
Chum salmon discriminating behavior of artificial stream water in Y-maze of the Sapporo Salmon Museum

Ernest Chen

12.5 mm PIT tag

Matured adult male chum salmon collected at the Chitose Hatchery were moved to the Sapporo Salmon Museum, and PIT tagged (Biomark, Boise, USA).

Artificial stream waters (ASW) were prepared using the same dissolved free amino acids (DFAA) concentration in each stream.

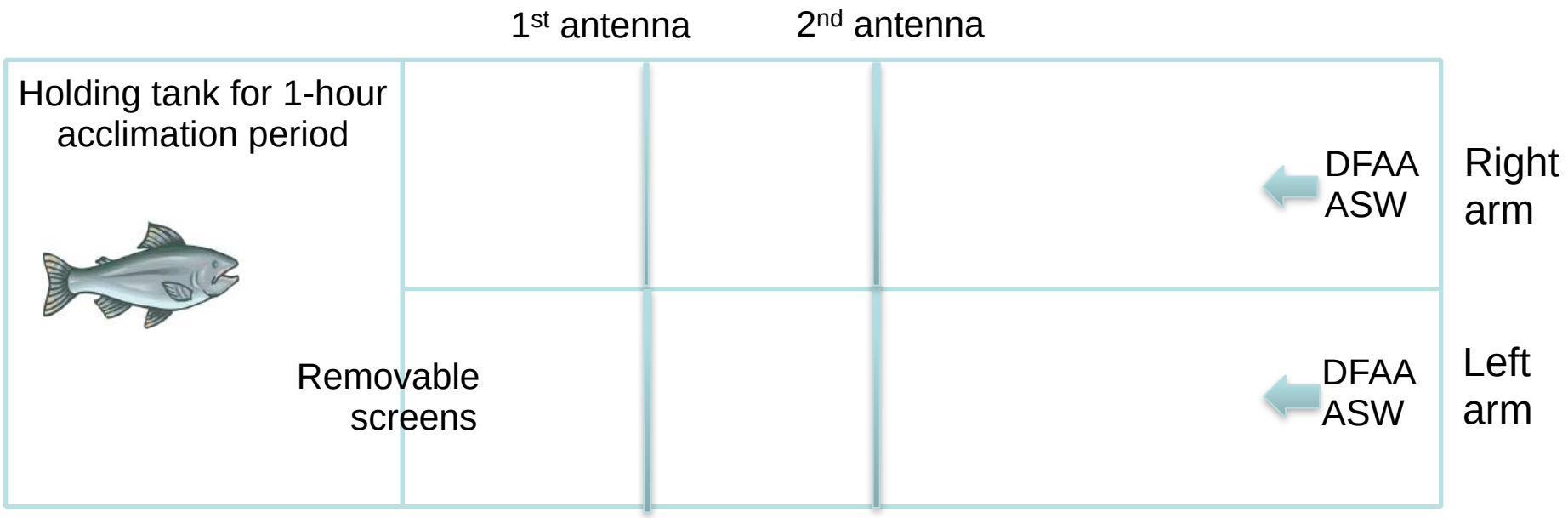


Two PIT tag detection antennas (60 × 60 cm) in each arm

Experimental design of PIT tag system in Y-maze of the Sapporo Salmon Museum

All experiments began with a 1-hour acclimation period in the holding tank

After acclimation, the screens were removed and the fish were allowed to swim freely into each arm for 3 hours at night to prevent light and visual interference

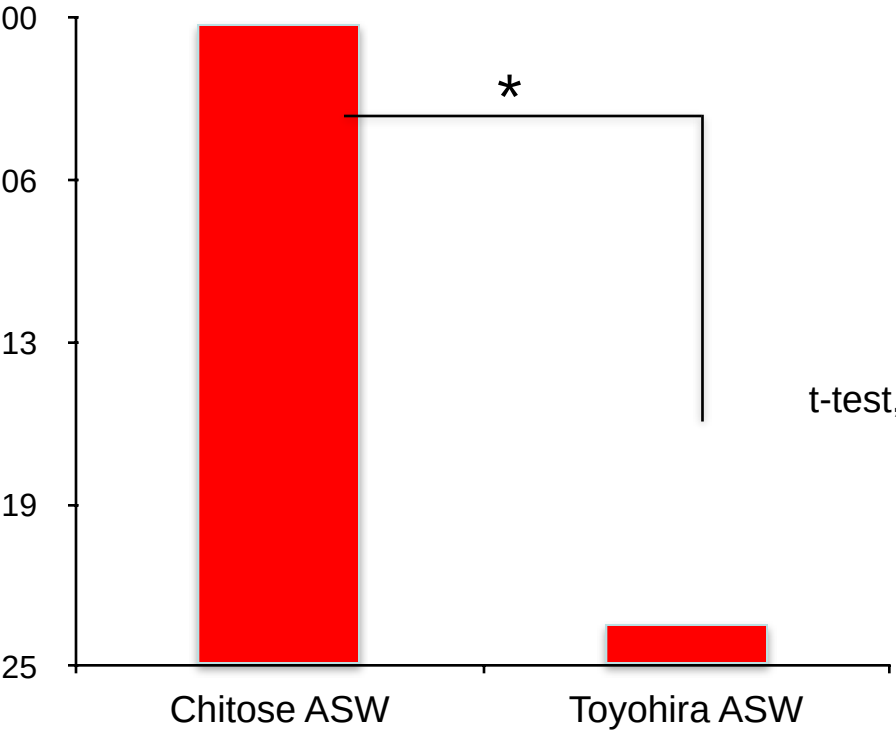


One fish per test run to avoid potential shoaling and dominance behavior

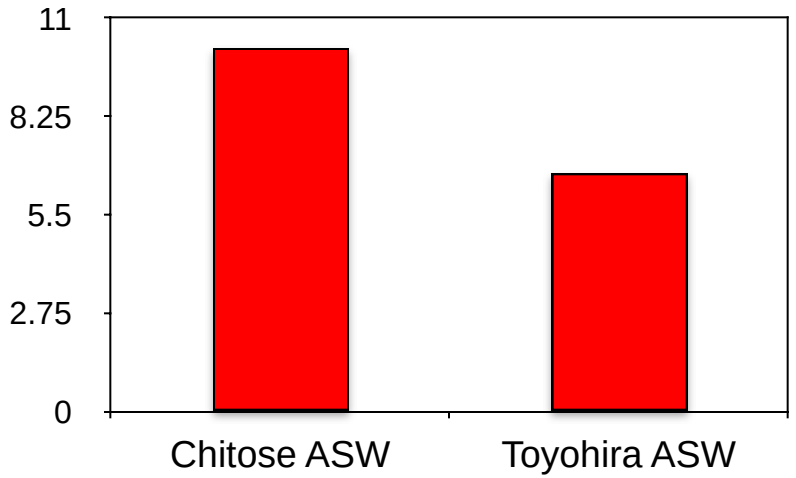
Comparison between Chitose ASW and Toyohira ASW

16 of 20 fish showed upstream movement into either arm (80%)

Average total duration per run

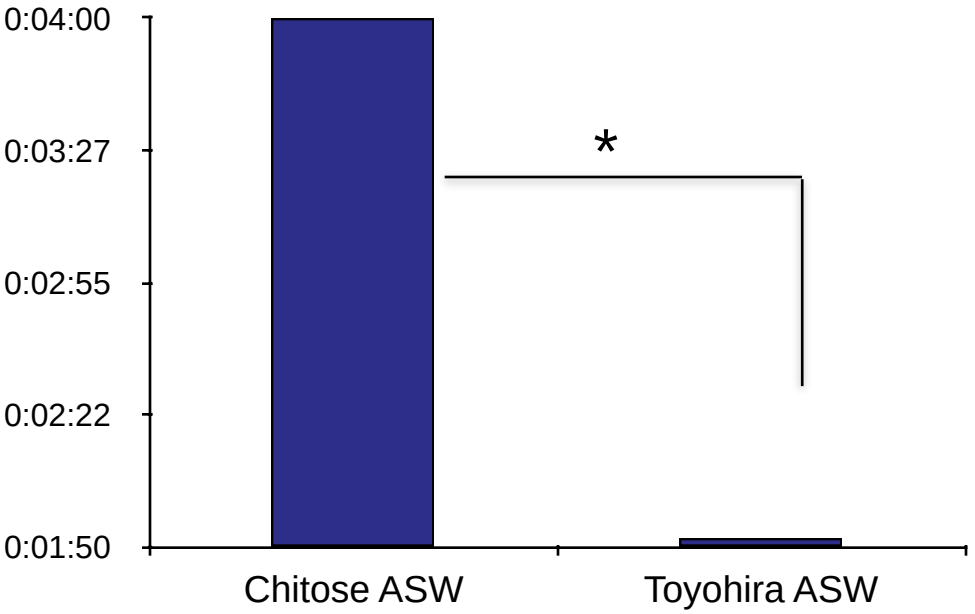


Average number of entries per run



t-test, * $p < 0.05$

Average duration of each entry



Significantly longer total and average duration spent in Chitose ASW arm

Summary

- ✓ Large scale masu salmon homing behavior in the Shimoakka Hatchery indicates that masu salmon fed with ω3 that might improve olfactory imprinting ability showed 3 times higher homing rate than control.
- ✓ Small scale chum salmon homing behavior in the Sapporo Salmon Museum reveals that adult chum salmon that homed to the Chitose River displayed significate preference for Chitose ASW over Toyohira ASW.
- ✓ These results suggest the usefulness of PIT tag system to clarify salmon homing behavior

Future prospects of fish telemetry

- ➢ I have studied Pacific salmon homing behavior for 24 years using several telemetry equipments, ultrasonic and radio tracking systems, electromyogram and electrocardiogram transmitters, micro-data loggers with propeller, pressure and temperature sensor, and PIT tag system.
- ➢ I have revealed several important Pacific salmon homing behavior, but I am still unable to clarify juvenile salmon imprinting behavior.
- ➢ I would like to ask fish telemetry companies to develop tiny sophisticated eco-friendly fish telemetry equipment.

Thank you for your kind attentions

I am happy to answer your questions