TEMPERATURE PROFILES OF LIVE FISH SHIPMENTS BETWEEN NEW CALEDONIA AND THE UNITED KINGDOM



A report prepared by the

Secretariat of the Pacific Community (SPC)

Colette WABNITZ
Fisheries Scientist (Aquarium trade), SPC

Franck MAGRON
Coastal Fisheries Information & Database Manager, SPC

Antoine TEITELBAUM
Aquarium Fish New Caledonia

Derek THOMSON
Tropical Marine Centre, U.K.

SPC Secretariat of the Pacific Community

Australian Aid

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Introduction

A large number of fish traded on the marine aquarium market are shipped from tropical countries (e.g., New Caledonia, Fiji, Marshall Islands, Solomon Islands) to temperate countries (e.g., United States, United Kingdom, Germany), with shipments often experiencing vast differences in outside temperature. To optimize fish health however, animals should be maintained at their temperature optimum at all times during transport (i.e., large fluctuations in temperature are to be avoided).

Transport conditions

Live fish traded for the marine aquarium trade are typically transported in sealed plastic bags containing water and pure oxygen. Fish are packed – one individual per plastic bag – with enough water in the bottom of the bag to cover the fish when the bag is upright. The bags are wide enough to allow each fish to turn around comfortably. Once filled with water, air is removed from the bag and replaced with oxygen. The final step is to seal the bag with a rubber band or mechanical clip. The bags are then placed in an insulated box, typically made out of Styrofoam, itself put in a cardboard shipping box. Boxes will then need to be marked with an International Air Transport Association 'Live Tropical Marine Fish' label. The label specifies that perishable animals are in the box and require special handling (e.g., specific temperature, boxes to be kept upright). This label signals to airport and airline staff that the shipment will need to be kept out of direct sunlight and protected from the elements as much as possible during loading and while in transit, as well as placed in the climate controlled cargo bays of the plane's hold.

Packing is a task that needs to be done with care. The amount of water and oxygen that will be added to each bag for transport will vary depending on the amount of time fish will spend in transit. Final destinations should be reached within 48 hours from the time of the first fish being packed to the last fish being unpacked. This is to comply with the International Air Transport Association's Live Animals Regulations, which specify that fish must be packed to survive unattended for at least 48 hours. While long flight times are possible without compromising the quality of the shipment, they require excellent fish health at the origin and a superior degree of proficiency in packing. In addition, long flight times will require additional water per fish, which increases freight expense and is a competitive disadvantage.

The parameters that are of importance to fish health during transport include temperature, dissolved oxygen, pH, carbon dioxide and ammonia.

Temperature

Fish are cold-blooded; as a result, the metabolic rate of fish will be affected by the temperature of their environment. The metabolic rate of fish has been found to double for an increase in 8°C. An increase in metabolic rate will augment oxygen consumption, ammonia production, and carbon dioxide production. As water warms, it will also hold less oxygen. It is, therefore, particularly important to avoid warming of the transport containers. When shipping from the tropics, small blue ice packs are often placed on top of bags prior to closing off boxes during transport, especially over longer transport periods to avoid potential increases in temperature. In some instances heat packs are used to limit temperature declines. In either instance experience by experts in the industry point to their use being inconclusive, particularly for long transit times.[1]

[1] Note that heat or cold packs were not used in shipments here

Shipment temperature

Shipments can be exposed to important differences in temperature:

1. When being transported to and from the holding facility and the airport;
2. On the tarmac at origin and destination; and
3. During transport on the airplane.

To identify what a temperature profile may look like during transport of tropical marine fish we kindly asked a company situated in New Caledonia to include temperature loggers in its monthly shipments to the United Kingdom. Shipments were sent between the month of February and July 2015, thereby covering winter and summer seasons in both hemispheres.

Loggers and transport conditions

We used Monarch Track-It™ Temperature Data Loggers. These loggers were chosen as they were compact, easy to use, battery powered with the capability of recording up to 64,000 samples of temperature data, cost-effective, and allowed for the data to be downloaded by plugging the logger into a USB port. A copy of the Track-It Software programme was sent to the importer in the UK.

Loggers were programmed to record temperature every 5 minutes. Note that measurements have an accuracy of ±0.5°C for the 0 to 50°C range and a resolution of 0.06°C/ 0.11°F according to specifications. Yet with standard settings, temperature readings have 0.25°C increments. Temperatures were received rounded in °F which creates an additional uncertainty of 0.28°C at max and 0.14°C on average (Table 1).

Table 1 –Rounding error due to software settings

Reading in °C	°C after rounding in °F	Error
19.00	18.89	0.11
19.25	19.44	-0.19
19.50	19.44	0.06
19.75	20.00	-0.25
20.00	20.00	0.00
20.25	20.00	0.25
20.50	20.56	-0.06
20.75	20.56	0.19
21.00	21.11	-0.11
21.25	21.11	0.14
21.50	21.67	-0.17
21.75	21.67	0.08
22.00	22.22	-0.22
22.25	22.22	0.03
22.50	22.78	-0.28
22.75	22.78	-0.03
23.00	22.78	0.22
23.25	23.33	-0.08
23.50	23.33	0.17
23.75	23.89	-0.14
24.00	23.89	0.11
24.25	24.44	-0.19
24.50	24.44	0.06
24.75	25.00	-0.25
25.00	25.00	0.00
25.25	25.00	0.25
25.50	25.56	-0.06
25.75	25.56	0.19
26.00	26.11	-0.11
26.25	26.11	0.14
26.50	26.67	-0.17
26.75	26.67	0.08
27.00	27.22	-0.22
27.25	27.22	0.03
27.50	27.78	-0.28
27.75	27.78	-0.03
28.00	27.78	0.22

Shipments were sent once a month, usually on a Monday. Packing took place early in the morning and one logger was placed in one of the shipment's boxes at around 7AM each time. The flight schedule from Noumea to London Heathrow is as follows:

NOU-AKL	NZ783	12:00PM	4:40PM	(2H40m flight)
AKL-LAX	NZ2	10 :40PM	2 :55PM	(6H layover - 12h15m flight)
LAX-LHR	NZ2	4 :55PM	11:25AM	(2H layover - 10H30m flight)

with a total flight/transit time of 33H25mn. At the receiving end, the boxes need to clear customs and then be transported to the importer's facility, with unpacking taking place around 16H30 local time. Therefore, from origin to destination, boxes were travelling for a total of approximately 43 hours total.

Table 2 - Temperature minima (MIN), maxima (MAX), averages (AVG) and differences (DIF) for each sector for fish shipments travelling between Noumea and London. Note that we started analysing data from 7H35 AM at departure and up to 4H30 PM at arrival, approximately 38H30 later, except for loggers #7 and #9 (see explanation in text).

LOGGER #1				
	AVG	MIN	MAX	DIF
to NOU	25.57	25.00	26.11	1.11
NOU-AKL	25.45	25.00	26.11	1.11
layover	24.90	24.44	25.00	0.56
AKL-LAX	24.28	23.89	25.00	1.11
layover	24.21	23.89	24.44	0.56
LAX-LHR	24.10	23.89	24.44	0.56
from LHR	22.89	21.67	23.89	2.22
		21.67	**26.11**	**4.44**

LOGGER #2				
	AVG	MIN	MAX	DIF
to NOU	25.45	25.00	25.56	0.56
NOU-AKL	25.40	25.00	25.56	0.56
layover	25.00	25.00	25.00	0.00
AKL-LAX	24.68	24.44	25.00	0.56
layover	24.44	24.44	24.44	0.00
LAX-LHR	24.27	23.89	24.44	0.56
from LHR	23.31	22.78	23.89	1.11
		22.78	**25.56**	**2.78**

LOGGER #3				
	AVG	MIN	MAX	DIF
to NOU	25.56	24.44	26.11	1.67
NOU-AKL	25.88	24.44	26.11	1.67
layover	24.73	23.33	25.00	1.67
AKL-LAX	24.52	23.89	25.00	1.11
layover	23.89	23.89	23.89	0.00
LAX-LHR	23.89	23.89	23.89	0.00
from LHR	23.65	23.33	25.56	2.22
		23.33	**26.11**	**2.78**

LOGGER #4				
	AVG	MIN	MAX	DIF
to NOU	25.84	25.56	26.11	0.56
NOU-AKL	25.89	24.44	26.67	2.22
layover	24.32	23.89	25.00	1.11
AKL-LAX	23.31	22.78	24.44	1.67
layover	22.94	22.78	23.33	0.56
LAX-LHR	22.17	21.67	23.33	1.67
from LHR	21.49	21.11	22.78	1.67
		21.11	**26.67**	**5.56**

LOGGER #5				
	AVG	MIN	MAX	DIF
to NOU	22.89	20.56	23.33	2.78
NOU-AKL	22.78	21.11	23.33	2.22
layover	21.93	20.56	22.22	1.67
AKL-LAX	20.74	20.00	22.22	2.22
layover	20.44	20.00	20.56	0.56
LAX-LHR	19.86	19.44	20.56	1.11
from LHR	19.75	18.89	23.89	5.00
		18.89	**23.89**	**5.00**

LOGGER #7				
	AVG	MIN	MAX	DIF
to NOU	25.00	25.00	25.00	0.00
NOU-AKL	24.76	23.89	25.00	1.11
layover	23.32	22.78	23.89	1.11
AKL-LAX	22.82	22.78	23.33	0.56
layover	23.06	22.78	23.33	0.56
LAX-LHR	22.80	22.22	23.33	1.11
from LHR	22.11	21.67	22.78	1.11
		21.67	**25.00**	**3.33**

LOGGER #9				
	AVG	MIN	MAX	DIF
to NOU	24.19	23.89	24.44	0.56
NOU-AKL	23.89	23.89	23.89	0.00
layover	23.18	22.78	23.89	1.11
AKL-LAX	22.78	22.78	22.78	0.00
layover	22.78	22.78	22.78	0.00
LAX-LHR	22.78	22.78	22.78	0.00
from LHR	22.83	22.78	23.89	1.11
		22.78	**24.44**	**1.67**

Findings

A total of 9 loggers were supplied to the exporter. One of these failed to record data and another failed to be recovered. For all data, recorded from the months of February to July, overall temperatures ranged between 19°C and 28°C (Table 2). However, the latter is based on including data for all loggers up to a generally applicable cut-off time communicated to us by the importer as the time at which the boxes were unpacked at their facility. This, therefore, does not represent the actual time at which shipments were received and the higher temperature is influenced by the last two shipments specifically. While temperatures may have been higher at that time it is likely that the actual unpacking time for those shipments was earlier (as exemplified in data for loggers #3 and #5 were data were downloaded prior to the communicated cut-off point). Taking this into account we can assume that temperatures overall ranged between 19°C and 26°C, typically however spanning between 22°C and 26°C (Table 2).

Temperature range was greatest for loggers #1, #4, #5 at 4.4°C, 5.5°C and 5°C respectively (Table 2). For loggers #3 to #9 and particularly for shipments associated with loggers #3, #4 and #5 a significant drop in temperature can be observed on the NOU-AKL flight leg (Figure 2). This may have been due to the heater not being turned on or being faulty on those flights. While such malfunctions or oversights could be a concern on longer flights, it did not negatively impact fish health in the shipments monitored here.

In addition to the temperature control in the cargo hold not always being adequate or turned on, industry experts have highlighted the following issues with shipments:

a. Boxes not on a pallet and directly touching cold surfaces in the cargo hold;
b. Boxes placed next to frozen products and products being cooled with dry ice; and
c. Boxes left exposed outside for extended periods of time before loading or after unloading.

All recorded temperatures for logger #5 were markedly lower than for all other loggers and to determine whether this difference is "real" we would need to verify the difference in recorded temperature by all loggers for a set temperature (i.e., verify there is no drift between loggers' sensor).

Table 3 - Local temperature range at major cities the shipments travel from/through/to.

		Temperature (°C)			
Logger	Date	Noumea	Auckland	Los Angeles	London
#1	18-feb	25-32	14-24	13-24	2-7
#2	4-mar	25-33	19-26	9-22	2-8
#3	6-apr	26-30	16-24	12-19	5-12
#4	27-apr	18-29	18-21	14-28	6-14
#5	11-may	22-29	10-20	14-24	7-16
#7	8-jun	22-30	6-16	16-29	6-16
#9	6-jul	22-25	11-16	18-24	11-22

Given the low temperatures in London in February through May and Auckland in May-July (Table 3), the trends observed indicate that overall Styrofoam boxes are a good insulator from outside temperature variations (Figure 2). Moreover, the seawater fish are shipped in, which has very high heat capacity, acts as a good buffer against possible outside temperature changes. Despite the recorded differences in temperatures at the various transit points and in flight as well as between seasons, there were no noticeable differences in the health on arrival of fish contained in the shipments.

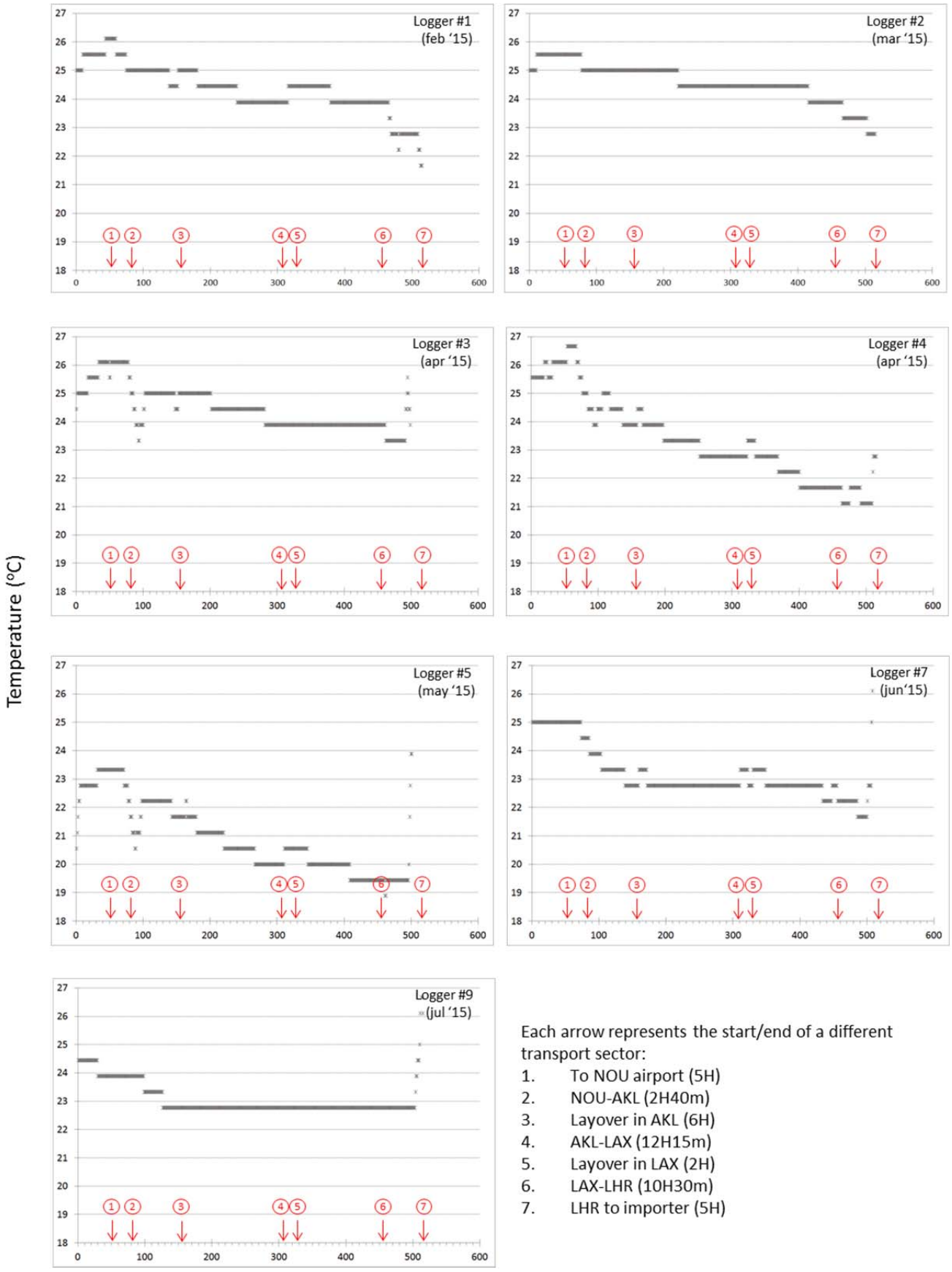

Figure 1 - Temperature profiles of individual loggers

To verify the buffer capacity of seawater against outside temperatures, we ran the following experiment:

- We placed a submersible temperature logger (SeaBird SBE 56) into a bag filled with 3 litres of sea water (logger #1);
- We placed a second logger (logger #2) (SBE 56) of the same type as logger #1 into a Styrofoam box (used to transport fish) and also included a logger of the type used for all shipments between New Caledonia and the U.K. (Check-it logger);
- The last logger (logger #4) (SBE 56) was maintained outside the box.

At 08h12 the bag filled and the logger placed inside it. From 08h23 to 11h26 the Styrofoam box and logger #4 were left on the front-seat of a vehicle parked in the sun. From 11h26 to 13h26 the Styrofoam box and Logger #4 were moved into SPC's office spaces. Lastly from 13h26 to 15h41 the Styrofoam box and Logger #4 were placed into a freezer.

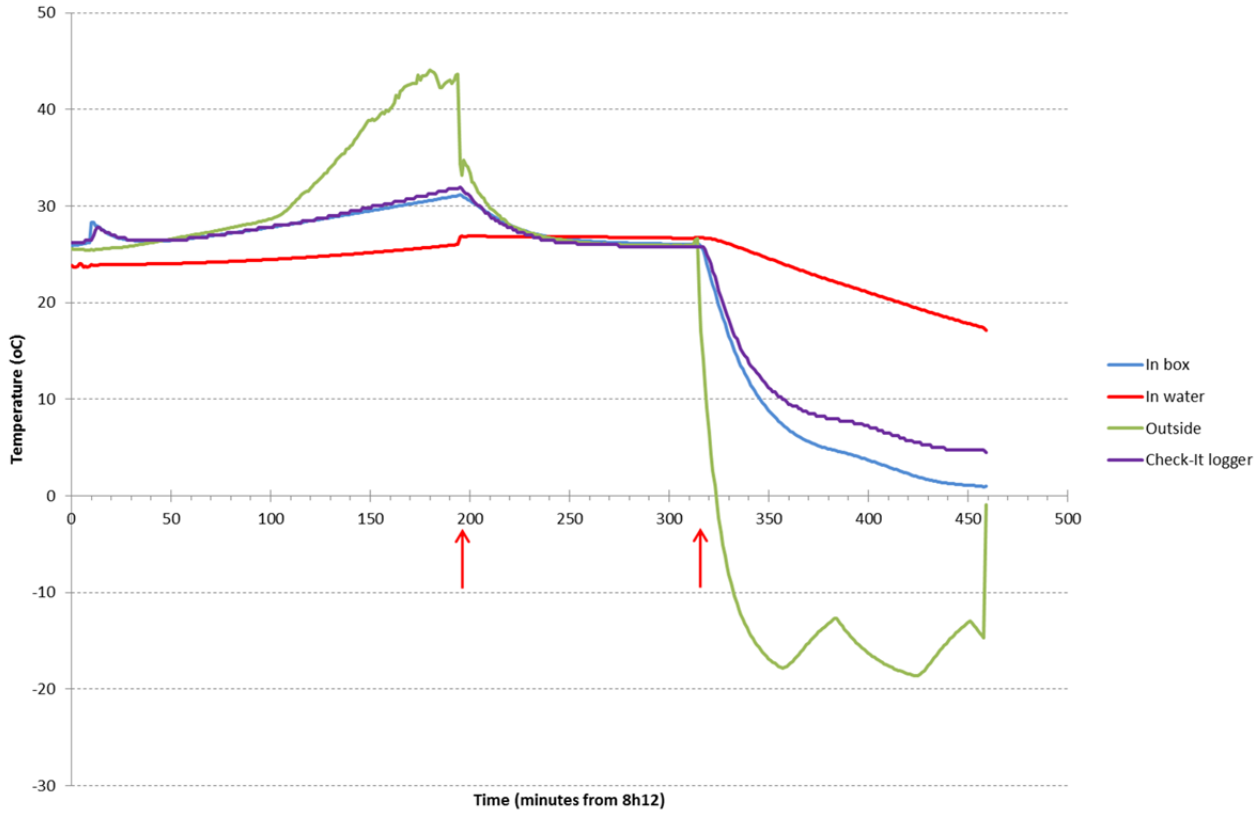

Figure 2 – Temperature curves of 4 loggers: #1 placed inside a plastic bag filled with seawater inside a styrofoam box; #2 placed inside the box; #3 check-it logger also placed inside the box; #4 placed outside. The red arrows indicate when the box and loggers were moved i. to an office space from the car and ii. placed inside the freezer.

The SeaBird and Check-it logger tracked each other well up to the point of transfer into the freezer (Figure 2). The difference in recorded temperature between the check-it and seabird logger once placed in the freezer can be explained by the water filled seabag rolling onto the check-it logger while the box was moved. The results of this experiment clearly confirm that Styrofoam has great insulating properties; and that seawater has remarkable heat capacity (i.e., heats and cools slowly), is a slow conductor of heat and therefore here a great "insulator" from outside temperature differences for the fish (Fig. 2).