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TECHNICAL REPORT

Long-Term Transportation of Ratfish, *Hydrolagus colliei*, and Tiger Rockfish, *Sebastes nigrocinctus*

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On December 10, 2000, five tiger rockfish, *Sebastes nigrocinctus*, and 10 ratfish, *Hydrolagus colliei*, were transported from Vancouver, Canada, to Lisbon, Portugal, for 51 and 44 hours, respectively. The transport vessels consisted of large circular tanks (1.0-m diameter × 0.6 m high) and filtration was added to the rockfish tank only. Filtration consisted of a combination of cartridge and activated carbon, powered by a 12-V bilge pump placed on the middle of the transport vessel. Water quality parameters (ammonia, temperature, and oxygen saturation) were tested during the transport, and an ammonia detoxifier was added to some of the transport vessels when ammonia concentration reached 0.25 mg/L. Sodium bicarbonate was also added for pH buffering. All animals survived the trip and the subsequent 4 weeks. The water quality monitoring and treatment regimen therefore seemed appropriate for this type of long-term transportation. Zoo Biol 20:435–441, 2001. © 2001 Wiley-Liss, Inc.

Key words: chimaera; husbandry; aquarium; water quality

INTRODUCTION

The transportation of marine fish involves careful planning and logistics, depending on numerous variables, such as species resilience to environmental changes, size of specimens, behavior of specimens, duration of transport, and many others. The design of the transport can be as simple as a plastic bag filled with two thirds water and one third oxygen (a technique commonly used for small tropical fish) or as complex as a large tank containing filtration and water monitoring units, as described by Andrews and Jones [1990], Murru [1990], or Smith [1992] for large sharks.

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Regardless of the animal requirements, long-term transportation (>36 hours) will undoubtedly present an immediate challenge of declining water quality. Typically, during extended periods, a still body of water containing a living marine fish will drop in pH and oxygen and undergo a buildup in ammonia, as a result of animal waste products and respiration. Other environmental variables will also fluctuate during a transport. However, controlling these important parameters will greatly maximize chances of survival.

Because oxygen is essential, a lack of dissolved oxygen in the water will cause the animals to die or will prevent them from adequately coping with their physiological needs. A light trickle of oxygen from a pressurized cylinder usually provides enough oxygen for a moderate density of animals in a transport vessel.

The control of pH in fish transport has been addressed by numerous authors, including McFarland and Norris [1958], Cliff and Thurman [1984], and Smith [1992]. In aquariums, pH has a natural tendency to drop because of buildup of carbon dioxide and accumulation of acids. This tendency is particularly evident during long-term transport and more so if the nature of the transport precludes adequate aeration. Often, transportation by air involves the use of sealed containers and therefore little opportunity for gas exchange between the tank and its surrounding environment. The control of pH can be achieved by the use of buffering chemicals, such as the tribuffer described by McFarland and Norris [1958], or common baking soda, sodium bicarbonate.

Fish create nitrogen-rich waste as ammonia, which is toxic to aquatic life. Biological filtration converts ammonia to nitrite and in turn to nitrate, less toxic nitrogen compounds. However, the activity of such filtration does not occur spontaneously and can take many weeks before a bacteriological community is adequate enough to convert lethal concentrations of ammonia. Ammonia must therefore be eliminated from the water of a transport tank by 1) using detoxifying chemicals, 2) changing water, or 3) using already matured biological filtration. The nature of transportation by air and the necessity of moving the animals in a sealed, leak-proof environment can preclude the two latter options. The use of detoxifying chemicals may constitute the only valid alternative. In summary, pH, oxygen, and ammonia present themselves as water quality characters that deteriorate most quickly with time and that need to be controlled.

The ratfish, *Hydrolagus colliei* [Lay and Bennet, 1839], is a common species in the eastern Pacific Ocean, ranging from Cape Spencer to Alaska, Sebastian Vizcaino Bay, Baja California, northern Gulf of California, and Mexico [Allen and Smith, 1988]. This species is displayed in few public aquariums (e.g., Long Beach Aquarium of the Pacific and Seattle Aquarium), and is considered to be very sensitive to fluctuations in water quality. It grows to a total length of 97 cm, and its long caudal fin, which has very undeveloped upper and lower lobes, forces it to rely heavily on its pectoral fins for maneuvering. It is therefore important to provide an obstacle-free environment during a stressful situation such as a transport, where the specimen may incur great energy expenditure.

The tiger rockfish, *Sebastes nigrocinctus* [Ayres, 1859] is also a common species in the eastern Pacific Ocean, ranging from Cape Resurrection to Kenai Peninsula, Alaska, Point Buchon, and central California [Eschmeyer et al., 1983]. This species grows to a maximum size of 61 cm and is quite popular in public aquariums. It is considered to be more resilient to water parameter fluctuations than the ratfish.

METHODS

On December 10, 2000, 10 ratfish and 5 tiger rockfish were packed in four round 1.0-m diameter × 0.6 m high polyethylene vats (Fig. 1). The animals were packed as described in Table 1. All animals were collected in British Columbia, Canada, and were kept for approximately 4 weeks before transport. The animals were fasted for 1 week before transport.

Once the fish were introduced into the container with water, a wooden lid was screwed to its top. A 0.5-in gasket of foam was placed in between, to ensure that the lid properly sealed the container, preventing all leaks. Oxygen was supplied by a pressurized cylinder, which fed the tank through approximately 4 m of standard air-line and a small wooden airstone placed in the bottom and middle of the tank (Fig. 1). Oxygen flow was kept at a minimum (i.e., very light trickle of minuscule oxygen bubbles from airstone) throughout the transport, below any measurable flow in the pressure regulator's gauge.

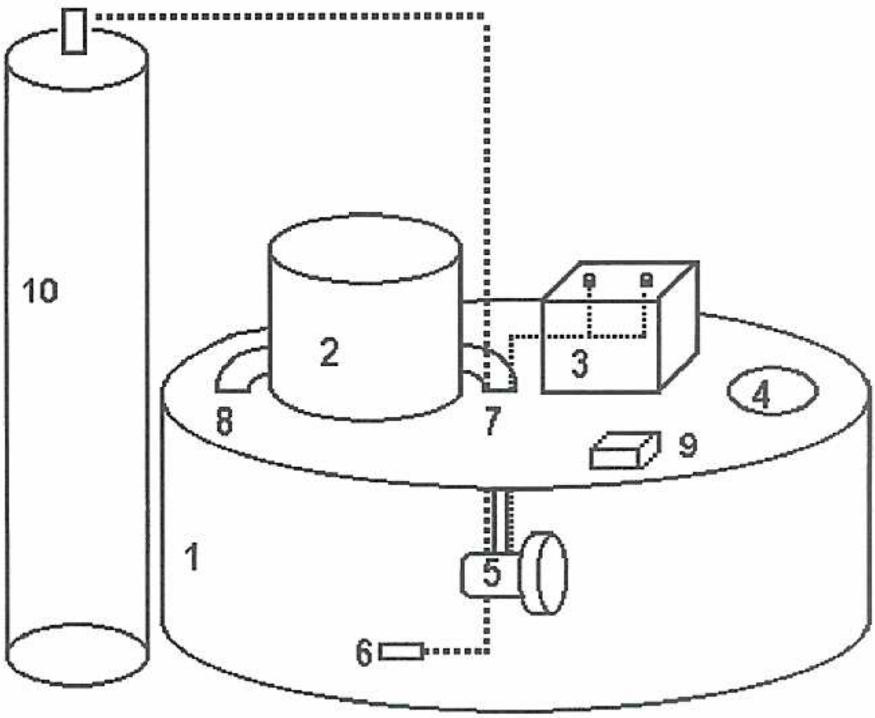

Fig. 1. Transport tank for *Hydrolagus colliei* and *Sebastes nigrocinctus*. 1: Transport tank (1.0-m diameter × 0.6 m high) with 0.5-in-thick plywood lid screwed over 0.5-in gasket. Water level approximately three quarters high (i.e., approximately 300 L of water). 2: Filter unit; contains one cartridge and one mesh bag with activated carbon. 3: 12-V dry-cell sealed battery, wired to bilge pump. 4: Porthole, removable. 5: 12-V powered bilge pump, pushes water up through filter. 6: Airstone, fed by airline connected to pressurized oxygen cylinder. 7: Filter inlet, i.e., PVC elbow mounted through wooden lid. 8: Filter outlet, i.e., PVC elbow mounted through wooden lid, returns water above surface of water inside tank. 9: Small AA 1.5-V battery-powered aeration unit, attached also inside of lid. Airstone was connected to this unit whenever the use of oxygen was not permitted. 10: Pressurized oxygen cylinder, strapped to side of tank.

TABLE 1. Logistics of long-term transportation of *Hydrolagus colliei* and *Sepastes nigrocinctus*

Tank no.	Species	No. and approx. size[a] of animals (cm)	Packing date and time (day-mo-yr, hr:min)	Water temp. (°C)	Water volume (L)
1	*S. nigrocinctus*	5, ~ 20	10-12-00, 03:00	7.0	~300
2	*H. colliei*	3, ~ 50	10-12-00, 10:00	8.0	~300
3	*H. colliei*	3, ~ 40	10-12-00, 10:00	8.0	~300
4	*H. colliei*	4, ~ 35	10-12-00, 10:00	8.0	~300

[a]"Size" refers to total length.

All four tanks were fitted with a round cartridge filter (model CFR-50, Jacuzzi Bros. Division, Little Rock, AR; 0.3-m diameter × 0.4 m high) mounted on the top of each lid. A block of frozen saltwater was placed inside the filter of tanks 2 through 4 (ratfish), which therefore had no cartridge or filtration whatsoever. Tank 1 (rockfish) was also fitted with a 12-V bilge pump (model 10, 2000 GPH, Rule, Gloucester, MA) that was placed on the bottom of the tank and fed water to the filter mounted on the lid through 40 cm of flexible hose. The water circulated through a cartridge and mesh bag filled with activated carbon placed inside the filter. Filtered water returned to the tank by dropping from approximately 15 cm above the surface, near the side of the tank (Fig. 1). The bilge pump was powered by a 12-V dry-cell sealed battery (model 800S, Optima, Aurora, CO) also mounted on top of the tank lid.

Water quality was tested whenever possible, using an oxygen and temperature probe (model Handy MK III, Oxyguard, Birkerød, Denmark) and an ammonia colorimetric test kit for salt and freshwater (model Tetratest, Tetra, Blacksburg, VA).

The fish were then transported: 1) packing of rockfish in Vancouver at 03:00 on December 10, 2000; 2) truck ride to Seattle; 3) packing of ratfish in Seattle at 10:00; 4) flight to Amsterdam at 16:00; 5) landing in Amsterdam at 9:00 on December 11, 2000; 6) truck ride to Brussels at 20:00; 7) flight to Oporto at 03:00 on December 12, 2000; 8) truck ride to Lisbon at 9:00; and 9) unpacking at 14:00. Total transit packed time was 51 hours for the rockfish and 44 for the ratfish.

In Amsterdam (approximately 29 and 22 hours of transport for the rockfish and ratfish, respectively), a 20% water change was performed using some water from the tank where the ratfish were originally kept (i.e., 10%) and some from the Rotterdam Aquarium (i.e., 10%). The Rotterdam Aquarium's water temperature was tested at 14.5°C.

In Brussels (at approximately 35 and 28 hours of transport for the rockfish and ratfish, respectively), ammonia was tested as 0.25 mg/L in tanks 2 and 4 (containing three large ratfish and four small ratfish, respectively). Ten grams of an ammonia quelcher (model Amquel, Kordon, Hayward, CA) was then dissolved in a 1-L plastic bottle with water from the respective tank and then dropped in the same tank. Fifty grams of baking soda (i.e., sodium bicarbonate) was also added to the same tank, using the same dissolution technique. The baking soda was used in combination with the ammonia quelcher because experience from other live fish transports has shown that the use of ammonia quelchers often involves a drop in pH (F. Young, personal communication, 2000; Dynasty Marine, Marathon Key, FL)

The simultaneous use of oxygen and 12 V batteries was not permitted on board the aircraft that would carry the tanks during the flight from Brussels to Lisbon, because of the danger of explosion. Therefore, all filtration and oxygenation was

TABLE 2. Temperature of water in tanks during long-term transportation of *Hydrolagus colliei* and *Sebastes nigrocinctus*

Location, approximate ambient temperature (°C)	Total transport time (hr)[a]	Temperature in tank (°C)			
		1	2	3	4
Seattle airport, 15.0	5 (12)	8.7	9.6	9.6	9.6
Airplane, 10.0	9 (16)	7.6	9.7	8.8	8.8
Airplane, 10.0	14 (21)	7.6	8.6	8.4	8.1
Airplane, 10.0	17 (24)	7.8	8.9	8.8	8.4
Amsterdam, 12.0	22 (29)	10.0	9.7	10.0	9.7
Brussels, 12.0	28 (35)	11.2	10.0	10.2	11.5
Brussels, 15.0	32 (39)	11.9	11.4	11.7	12.0
Lisbon, 15.0	44 (51)	13.0	11.8	12.4	11.5

[a]Transport time refers to ratfish with rockfish total transport time in parentheses.

stopped and small aeration units were attached to the inside of all tank lids. These small aeration units ran on standard 1.5-V AA batteries and supplied atmospheric air to the water.

DISCUSSION

All 15 animals arrived in good condition and remained so during the following 4 weeks. Water quality results are shown in Tables 2–4. Results show that a very light trickle of oxygen—while on, oxygen flow averaged 5 psi·hr–1tank–1—during relatively short periods induced saturations in the water as high as 300%. This did not appear to have any negative effect on the animals.

The addition of the ammonia detoxifier to tanks 2 and 4 successfully decreased its concentration from 0.25 to 0.12 and 0.04 mg/L, respectively. The addition of sodium bicarbonate also provided some buffering because these two tanks had the highest pH of all transport tanks (7.81 and 7.94, respectively) on arrival.

The use of filtration (in the case of the rockfish) and addition of buffering agents successfully maintained the water quality within standards that permitted the survival of the animals. The delicate nature of the ratfish, however, precluded the use of filtration, because the constant negotiation around an object placed in the

TABLE 3. Oxygen saturation in tanks during long-term transportation of *Hydrolagus colliei* and *Sebastes nigrocinctus*

Total transport time (hr)[a]	Oxygen saturation in tank (%)			
	1	2	3	4
2 (O_2 on)	170	98	120	170
5	163	94	123	196
9 (O_2 off)	167	247	387	187
14	103	235	360	172
17	89	165	261	126
22 (O_2 on)	105	122	188	103
28 (O_2 off—aeration on)	182	452	277	152
32	145	431	272	149

[a]Transport time refers to ratfish. For rockfish total transport time add 7 hours.

TABLE 4. pH on arrival and ammonia concentration of water in tanks during long-term transportation of *Hydrolagus colliei* and *Sebastes nigrocinctus*

	Ammonia concentration (mg/L)			
Total transport time (hr)[a]	1	2	3	4
14	—[b]	—	—	0.000
17	0.125[c]	0.000	—	—
21	0.125	—	0.000	—
26	—	—	—	0.125
28[d]	0.125	0.250	0.125	0.250
44[e]	0.400	0.120	0.220	0.040
44 (pH)	7.75	7.81	7.66	7.94

[a]Transport time refers to ratfish. For rockfish total transport time, add 7 hours.
[b]Not tested.
[c]"0.125" indicates color of sample between colors corresponding to "0" and "0.25" mg/L.
[d]10g of "Amquel" and 50g of sodium bicarbonate added to tanks 2 and 4.
[e]Ammonia values on arrival measured with a photometer (model 7000, Palintest, Gatehead, England).

middle of the tank would most likely constitute a loss in energy that would outweigh the potential gain by filtering the water.

The ratfish tanks, deprived of any filtration, functioned as sealed containers, much like a large "plastic bag." It seems the very low packing density may have played a key role in preventing the water quality from deteriorating too much. The values of ammonia and pH at the end of the journey seem to corroborate this finding, with pH reaching 7.66 in a nonbuffered tank.

The addition of ammonia-detoxifying agents and buffering chemicals caused a decrease in ammonia and increase in pH in tanks 2 and 4. These chemicals were not used in any other tanks because the ammonia concentration did not reach 0.25 mg/L. Given the apparent good external condition of the animals at the time of measurement, it was believed that the introduction of chemicals in these tanks was not necessary and could potentially have a negative effect.

Temperature might have also played an important role in the success of the transport, because efforts were made to maintain it close to the temperature on departure (between 7° and 8°C). This was fairly easy during the first 17 hours of the trip (Table 2) because the ambient temperatures in Vancouver, Seattle, and Amsterdam were not higher than 10.0°C. The cargo hold temperatures on all flights were also set for 10.0°C, and ice was added to the tanks transporting the ratfish. This was the main reason why only 10% water was exchanged using the supply from Rotterdam (i.e., at 14.5°C). Although a greater exchange would be desirable for maintaining low ammonia and high pH, it was thought that the benefit in adjusting these two would be outweighed by the negative impact of a temperature increase.

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