Acoustic Communication of the Trumpeter Swan (*Cygnus buccinator*)

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Abstract

Six cygnet calls, eight adult calls, and one nonvocal sound of Trumpeter Swans are categorized and described. Calls vary greatly in complexity. Many form graded series, while others are discrete. Most of the cygnet calls are involved with soliciting aid from a parent, while adult calls have a wider variety of functions.

Introduction

The Trumpeter Swan (*Cygnus buccinator*) is so named because of a loud low pitched, trumpet-like call. Although this call is best known, these swans produce a variety of other vocalizations as well as nonvocal sounds. This study describes the acoustic structure of the sounds and provides contextual information along with functional interpretation.

The breeding range of the Trumpeter Swan is now greatly reduced. A number of states, including Wisconsin, are currently reintroducing these swans. Knowledge of the vocalizations, particularly the calls given by parents to the young, may be critical for the success of cross-fostering involving the Mute Swan (*Cygnus olor*) and for rearing using models and employing tape recordings.

Methods

This study was conducted at four sites in Wisconsin (Sparta, Monroe Co.; Saukville, Ozaukee Co.; Eagle and Mukwonago, Waukesha Co.) and two sites in Hennepin County, Minnesota from May-August 1988. The sites at Sparta, Saukville and Eagle were game farms. The swans at Hennepin County sites were semi-wild. In Mukwonago the trumpeter cygnets were cross-fostered by feral Mute Swans (*Cygnus olor*). This study is based on 39 individuals, but the sample size of individuals is small for any particular vocalization. Calls were recorded from swans varying in age from hatchling to adult. Since all the recordings were made in a single season, no individuals were studied continuously throughout their development. Breeding calls were not documented since the study started in late May. The recordings were made at a minimum of 0.3 m to a maximum of about 15 m from the birds with a Dan Gibson P650 parabolic microphone and a JVC PC-RM100 JW tape recorder.

Vocalizations were analyzed using a Kay Digital Sona-graph 7800 on a 150 Hz band-width setting. Some calls consisted of a variable number of similar elements. In these cases, measurements were made of each element and of inter-element intervals.

Behavioral information was recorded while taping in order to obtain contexts associated with the sounds. The behavior of the swans was noted every minute for 90 minutes. These observations included information on the spacing between birds, their activities and interactions, as well as locations of birds on lake maps.

Results

Calls of Cygnets

Each type of signal is first described, followed by contextual information and a functional interpretation. Cygnet calls are described first and sonagrams are presented in Fig. 1. For measurements of sonagrams see Table 1.

Scream.--Screams are one of the several calls given by a hatchling which still occur when the bird is 77 days old. The Scream is raspy, and seems to change in quality according to context. The call is of high amplitude, short duration, and one to two bands occur in the otherwise noisy structure. Samples were analyzed from three different nests.

The Scream was heard on a number of different occasions. This call was first recorded when cygnets were in the process of breaking out of the shell. Low amplitude Screams were also recorded as cygnets approached a foster mother and attempted to climb on her back. The call was also frequently noted when the female brought up submerged vegetation which stimulated the cygnets to compete for food. A high amplitude Scream was produced when a predator such as a human, dog or snapping turtle (*Chelydra serpentina*), approached closely. Such loud Screams were heard from cygnets as young as 9 h old while they were removed from a nest and during handling. On another occasion 77-day-old cygnets Screamed while being transported from a holding pen to a pond. Cygnets held their bodies erect and rigid when Screaming intensely.

The Scream expresses distress and elicits immediate attention from the parents. Screams may also warn siblings of impending danger. Cross-fostering Mute Swan females responded with a soft "buzz" if the Scream was of low amplitude. If the Scream was of higher amplitude, parents rushed to the cygnet.

Whaa.--Another vocalization given by hatchlings is the Whaa, a low pitched call of short duration. Analysis was based on five nests. The call has one to four bands with three bands being the most common. Older cygnets (11 weeks) gave longer Whaas than 47 day old cygnets. Some grading occurs between the Whaa and Scream. This call persists until the cygnets are 77 days old, possibly longer.

The Whaa was commonly heard while the female brooded the cygnets, and while the cygnets were led to water for the first time. It often occurred between Quiver calls. One cygnet gave Whaas while a sibling and mother fed some distance away, though the cygnet was near the father. While being carried from an enclosure to a pond, 77-day-old cygnets uttered Screams and Whaas. A semi-wild cygnet responded to its trumpeting parent with a Whaa just before food was dispensed. The Whaa of this semi-wild cygnet closely resembled the Whaas of the cross-fostered cygnets of the same age.

The Whaa may indicate mild alarm. Often it is given in response to some stimulus such as handling or introduction to water for the first time. The Whaa grades into the Scream when the situation changes. The Whaa increases in frequency range and apparently in amplitude as the situation becomes more stressful, and it increasingly acquires the characteristics of a Scream. The duration of the Whaa and the Scream are essentially the same.

Quiver.--This is a distinctive call consisting of a series of "cheeps" produced in rapid succession. Typically this call includes only one band, but hatchlings produce a slurred second band. There is considerable grading between the Quiver and the Scream in cygnets less than 24 h old. This call is commonly heard at hatching and persists through one year of age. Analysis was based on a minimum of five individuals.

The Quiver is frequently uttered while the female is brooding. It was also often heard while cygnets were swimming and feeding. This call may indicate "comfort" in the company of parents and siblings, and indirectly functions as a contact call that keeps the family close together. It is also known as a 'sleepy' call in reference to its probable role in encouraging the cygnets to synchronize their rest periods, and may also act in encouraging brooding (Scott 1972, Wilmore 1974). In this study, however, no direct correlation was found between the Quiver and resting or brooding. During resting periods, however, Quivers were of lower amplitude than during more active periods. Quivers are also given during the hatching process, and may function in bonding the cygnets and parents.

Cheep.--This call may occur as a single band, double band or even triple band, but is decomposed with a noisy structure when three bands occur. The double and triple banding occurred in Cheeps given by cygnets 9 h old; the single banded Cheep was heard from the 24 h old cygnets. The Cheep can occur as a single element or as a series of elements. The Cheep may be a variation of the Quiver, but it sounds distinctive to the human ear, and has a noisier acoustic structure. When given in a series, there are long inter-call intervals ($\bar{x}$ = 0.19 s), compared to the inter-call interval of the Quiver ($\bar{x}$ = 0.05 s). The duration is shorter than the Quiver but the frequency range is the same. Two different nests were used for analysis.

This vocalization occurs even before hatching (Scott 1972). In this study the Cheep was only given occasionally. One cygnet gave it while being held apart from other cygnets, and Cheeps interspersed between Quivers were given while cygnets were held after a male Mute Swan attacked them. Cheeps were also recorded from another group of cygnets when the cross-fostering parent led them to water. The Cheep is evidently a contact call that keeps the

family together. It may also indicate some degree of stress. Female parents responded by calling softly when the Cheep was given from an egg which is cooled or tapped (Scott 1972).

The Scream, Whaa, Quiver and Cheep are cygnet calls which first appeared just before or during hatching. The following cygnet calls were not evident until the cygnets were at least 9 h old.

Chirp.--The Chirp is a rapid series of soft, harsh calls of two to five elements almost resembling a low, hoarse bark, especially as the cygnet matures. This vocalization varies from 2-4 bands; the fourth band did not appear until the cygnets reached 77 days. Often the bands are distinct, although occasionally bands are somewhat decomposed. Grading occurs between the Chirp and the Cheep when the cygnets are young, and between the Chirp and the Whaa when the cygnets mature. These results were based on two different nests.

Chirping was common while cygnets were feeding intensely. The calls probably keep the family together, particularly during feeding episodes. Cygnets often chirped continuously as they clustered around the female when she brought submerged vegetation to the surface. Also, Chirping was uttered while one or more tame cygnets were physically held apart from other siblings for a short time. This call persists over a wide age span, from 9 h old to 77 days of age.

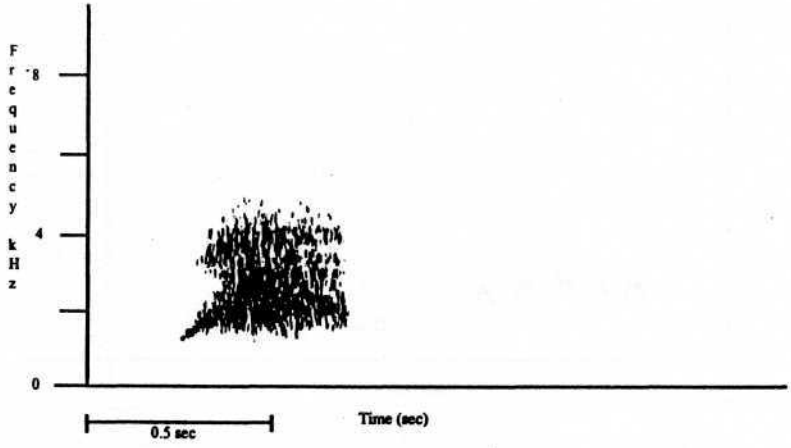
Raspy Chirr.--The preceding cygnet vocalizations were relatively common; Raspy Chirrs were very rare, but may have an important function. This call may be a variation of the common Chirp as the two calls are somewhat similar, but definite differences occur in the structure and the usage of the calls. The Raspy Chirr is a single decomposed band of three elements as opposed to

the multi-banded Chirp. It is 1 kHz higher pitched than the Chirp, and the inter-call interval is more than six times as long. The one recorded call had three elements.

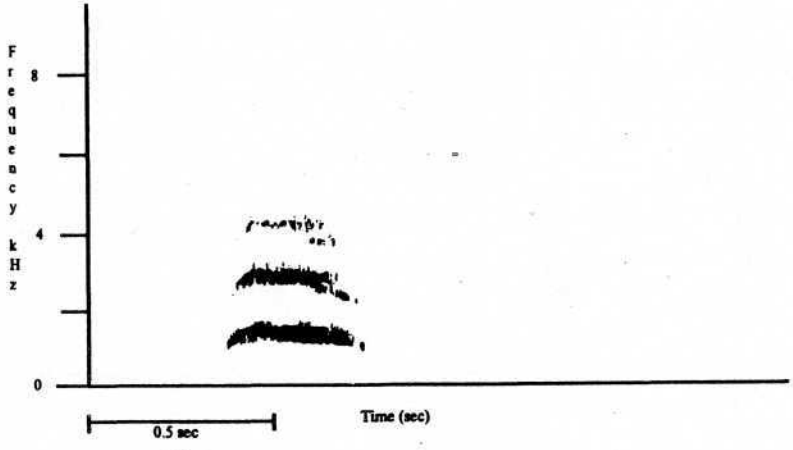
The Raspy Chirr was recorded only once, as two 3-day-old cygnets were fighting by rapidly jabbing each other with their beaks. The cross-fostering male did not intervene physically, but responded with several quick "snorts" followed by a long "snore". (These calls are given by Mute Swans.) After the male called, fighting among the cygnets immediately ceased. Our one observation of the Raspy Chirr suggests that this distinctive call expresses aggression among cygnets.

Table 1. Measurements of Calls of Trumpeter Swan Cygnets. Mean and standard deviation; number measured in parentheses.

Call	Duration of each element (s)	Frequency range of each element (kHz)	Inter-element interval (s)
Scream	0.37 ± 0.19 (17)	3.02 ± 0.87 (17)	---
Whaa	0.23 ± 0.16 (31)	0.49 ± 0.19 (31)	---
Quiver	0.05 ± 0.02 (58)	1.23 ± 0.60 (42)	0.05 ± 0.02 (49)
Cheep	0.12 ± 0.03 (17)	2.85 ± 1.73 (17)	0.21 ± 0.05 (6)
Chirp	0.14 ± 0.02 (22)	0.99 ± 0.62 (20)	0.11 ± 0.06 (15)
Raspy Chirr	0.11 ± 0.05 (3)	2.2 (3)	0.58 (2)

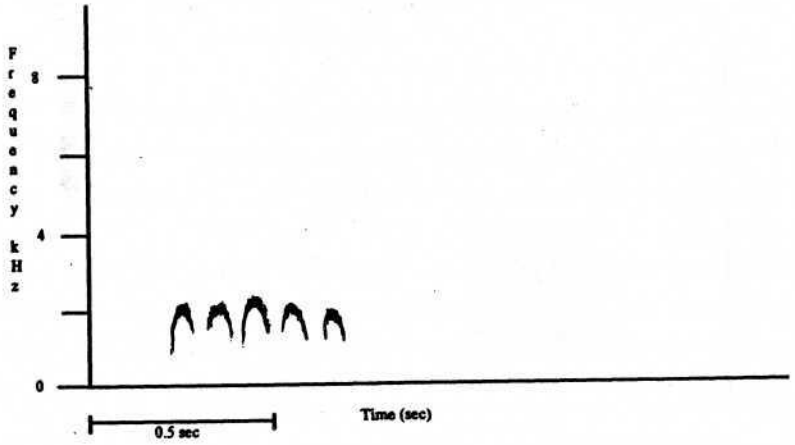


Cygnet: Scream

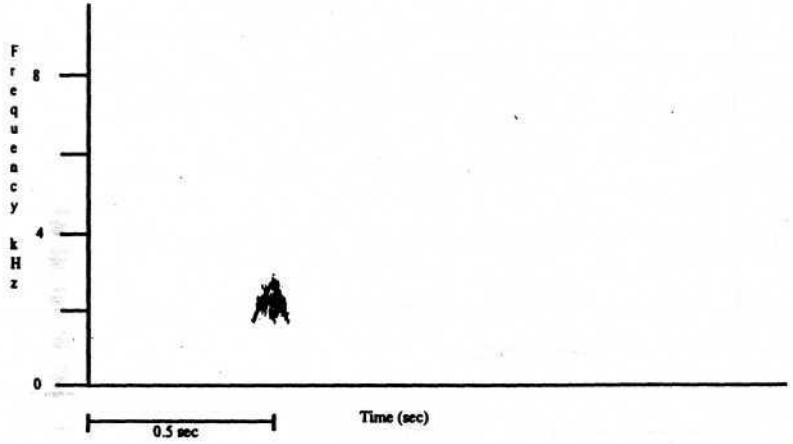


Cygnet: Whaa

Figure 1. Sonagrams of Cygnet calls.

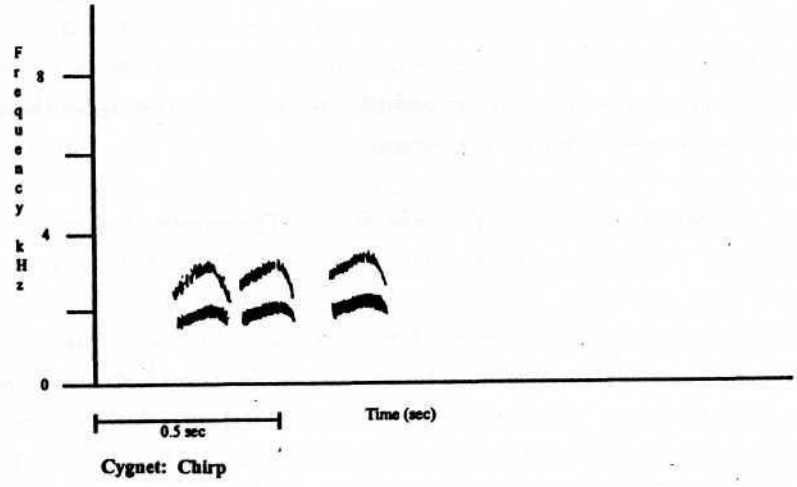


Cygnet: Quiver

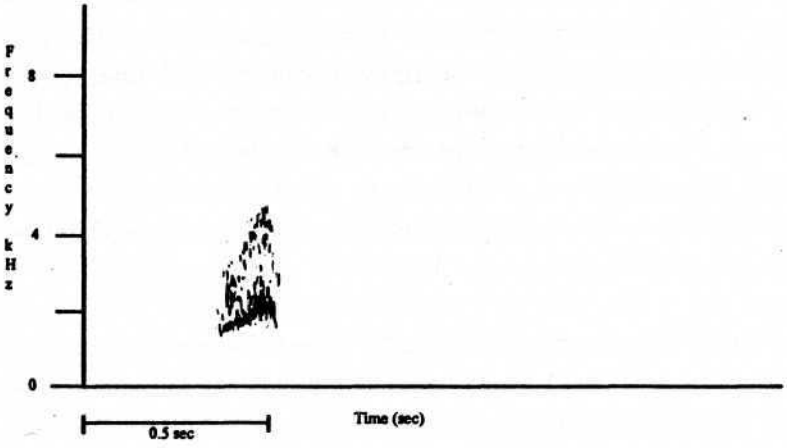


Cygnet: Cheep

Figure 1. (cont.)



Cygnet: Chirp



Cygnet: Raspy Chirr

Figure 1. (cont.)

Adult Calls

The following accounts deal with adult calls; these are dramatically different from cygnet calls. Measurements of calls are included in Table 2 and sonagrams in Fig. 2. A few of these adult vocalizations are produced by subadults (here defined as older than 77 days, but younger than three years).

Trumpet.--The call for which the Trumpeter Swan was named has a bugle-like quality or is sometimes likened to a rusty, French horn. The call can be heard by humans a mile or more away, depending on the terrain. Trumpets are often accompanied by head bobbing; sometimes the birds also shake their half-opened wings up and down. Calls of a minimum of ten individuals were analyzed. The acoustic structure of the Trumpet varies considerably, but it is multi-banded, and the main energy is usually in the lower frequency bands, but sometimes at mid-range. Individual variations occur. For example, some birds changed abruptly to an almost trill-like quality, and then reverted back again to the basic Trumpet within the same element. In addition, a few swans displayed an abrupt rise then a decrease in the second lowest frequency band at the introduction of their Trumpet. Subadults displayed more decomposition of bands than adults. Also, the lowest or second lowest frequency band shows a sudden rise in frequency in the subadults compared to the absence of frequency modulation of the bands of adults.

Trumpeter Swans are typically silent during the summer. However, if a bird is alarmed by the approach of humans, other animals, or airplanes, Trumpets occur. The duration of the elements in this vocalization does not seem to vary according to context. The Trumpet is an alarm call that warns family members of impending danger such as predators or other large animals. Apparently this loud vocalization often inhibits approach of the intruder.

Duet.--Two swans, usually a mated pair, may Trumpet together. Sometimes there is a great deal of overlap of the individuals' calls; other times there is only slight overlap. Occasionally a pair alternated Trumpeting before actually Duetting. Often the male initiated the Duet. As the Trumpet varies considerably, and the Duet consists of two birds Trumpeting, it was very difficult to separate the individual voices even with spectral analysis. The situation is complicated further by the fact that it is difficult to distinguish the sexes by appearance, and these birds were not marked. The lack of sexual differences in the calls parallels the lack of sexual dimorphism (Scott 1972). The Duet is a highly synchronized call, but some authors believe there is a slight difference in pitch between the sexes (Wilmore 1974, Kaiser 1987). Our spectral analysis shows that sometimes a member of a pair displayed a slight shift in the middle frequency bands though lower frequencies showed virtually no difference. At times, one of the pair displayed more of a trill or slight band decomposition compared to the other bird. However, an individual can also shift into a trill or decomposition of bands during a Trumpet, and then shift back again to the basic Trumpet, adding to the difficulty of identifying a Duet from a single Trumpet either by ear or spectral analysis. The Duet is often accompanied by the waving up and down of half-opened wings and head bobbing.

The Duet is commonly heard when there is a disturbance such as humans or other animals approaching a nest too closely. Duets may aid in synchronizing the pair's attack on intruders. Twice, members of two different pairs simultaneously Foot Clapped at humans following a Duet. The Duet also functions to cement pair bonding (Kaiser 1987, Larry Gillette pers. comm.).

Honk.--The Honk is similar to the Trumpet but is of moderate duration and given singly. If the Honk is given rapidly in a series, it acquires the characteristics of a Trumpet. The Honk has a wider frequency range but exhibits less variation than the Trumpet.

It is a multi-banded call with the greatest amplitude at around 1.6 kHz which is higher than that of the Trumpet (0.80 kHz). This vocalization also displays some of the decomposition of bands or trill-like qualities that appear in the Trumpet of some individuals. The Honk of the Trumpeter Swan sounds similar to the Honk of a Canada Goose (*Branta canadensis*).

The Honk is commonly given by subadults and occasionally adults. Adults honked when somewhat disturbed; they Trumpeted or Duetted when more alarmed. For example, when a human entered an enclosure containing both adults and subadults, the adults either Trumpeted or Duetted while the subadults only Honked. Also, the Honk is given by subadults in apparent response to harassment by adults. Subadults also Honked while being chased on land by a mated pair of adults. The Honk probably alerts others in the flock to danger, but does not express such intense alarm as the Trumpet.

Foot Clap.--The Foot Clap which lasts 4-5 s is produced by one or both members of a pair slapping their webbed feet against the surface of the water as they fly just above the water. The long vertical lines in the sonagram represent mechanical noise from alternate feet hitting the water. These lines occur at regular intervals which may vary by approximately 10 to 30 milliseconds depending on the individual performing the display. This sound is very loud, and is accompanied by an impressive visual display. An intruder may be easily intimidated by seeing a large white bird with rapidly flapping wings rushing over the surface of the water directly toward it. Sometimes Foot Clapping is also accompanied by Trumpeting. The heavy wingbeats of the swan add to the sounds of the Foot Clap.

The Foot Clap is directed at a potential predator or intruder. All Foot Claps recorded were directed toward humans who had approached the swans. In one case, a pair Foot Clapped

simultaneously. The next time, the female Foot Clapped alone, and then flew away. The male was flightless at this time. The displaying swan may take flight, but more often settles back down into the water. The Foot Clap is utilized when other strategies, such as loud Trumpeting and shaking outstretched wings, fail to inhibit the intruder.

Wail.--The Wail is a rare call heard only once during this study. It consists of four elements; the first one is much like a Honk. Successive ones are progressively more trill-like and higher in pitch.

This call was given by a female of a mated pair that was disturbed by humans and subadults in their enclosure. The male uttered a Nor call (see below), which was followed by loud Duetting. The female Foot Clapped, and took flight. She circled once, Wailing to her mate. The male gave no vocal response at this point; instead he dipped his head in the water while treading, and flapped his outstretched wings. After circling, the female flew away. When she was out of sight, the male once again tread water (a rapid up and down movement of the feet under water causing the body to rock from side to side.)

The function of the Wail is not clear. It probably informs the male of his mate's direction of flight. Wilmore (1974) noted that Trumpeters utter a long, Wailing note when joined by other swans during the breeding season, but it cannot be determined if this Wail is the same as the one we described. The Wail was recorded in July, outside of the breeding season.

Nor.--The Nor is a guttural call, apparently given during exhalation. It may be a single band but is often a 2-banded vocalization. One subadult uttered a 3-banded Nor. The second band, when it appears, is decomposed. The amplitude is, on the average, greatest at 0.62 kHz. The call consists of a single element in

adults. Sometimes the Nor shows irregular duration and some frequency modulation near the end of the call. During this study when the sex of the bird was known, only males gave this call. The Nor is of low amplitude, and designed for close range communication.

The Nor is given when the swans are alarmed and is accompanied by spread wings and the bill pointed to the ground. When on water, the swan dips his head into the water with his bill pointed down. One male ended the display by treading water. Johnsgard (1965) and Scott (1972) classified these visual elements as a threat display. Occasionally the Nor is immediately followed by Trumpeting. This sequence of events occurred when humans intruded too closely inside the swan's territory. When subadults uttered the Nor, it was not as loud as the adults' calls, and the associated visual display did not occur.

Hiss.--The Hiss was so low in amplitude that it was barely audible even at close range, and separating it from background noise was difficult. Only one recording of a Hiss was obtained. It starts as an irregular, noisy, 3-banded call that decomposes during the latter part of the vocalization.

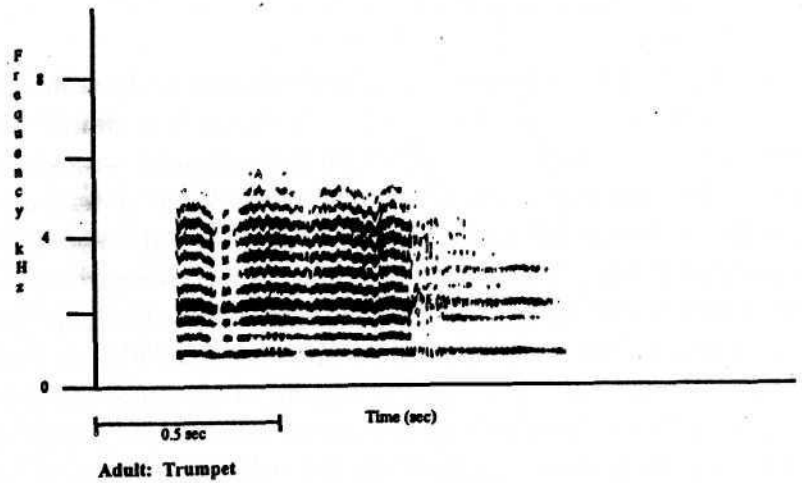
Eight observations involving two individuals were noted. On one occasion, an adult swan, while repeatedly Hissing, rushed a raccoon (*Procyon lotor*) at the swan's feeder. Another time an adult swan drove off, and continually Hissed at a raccoon that came within 1 m of a cygnet. During a third observation, an adult Hissed at a human who approached the swan's family at a feeding platform. Hansen et al. (1971) reported that a swan Hissed constantly at a float plane that drifted toward a nest site. Wilmore (1974) found that Trumpeter Swans Hiss if cornered during their flightless period. Trumpeter cygnets first begin to Hiss at 29 days (Scott 1972). The Hiss was not noted in the cygnets of this study.

Based on these observations, the Hiss is apparently a threat directed toward a potential predator at close range.

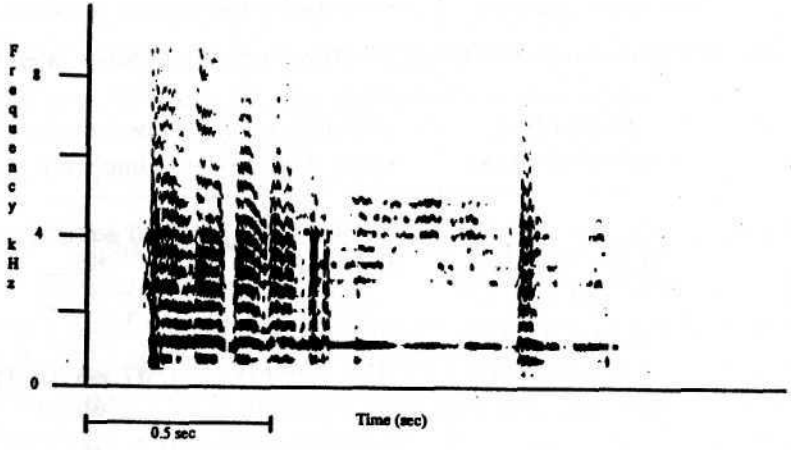
Trill.--Another vocalization used at close range is the Trill, which sounds like a soft, low Honk. Its structure is simple, often consisting of one to three bands. This call has the lowest pitch of those calls recorded. The Trill was given when a human approached a family of swans that was not very alarmed by the human's presence. When the swans noticed the human, they swam slowly away while a parent Trilled. If alarmed, the birds are likely to Trumpet or Duet rather than Trill. It was frequently the female that uttered the Trill. The cygnets responded by clustering tightly around the nearest parent. In one case, subadults were present, but there were no cygnets. Trills evidently function to alert the cygnets to a disturbance.

Table 2. Measurements of elements of Adult Trumpeter Swan Calls.

Call	Duration of each element (s)	Frequency range (kHz)	Inter-element Interval (s)
Trumpet	0.10 ± 0.10 (115)	3.65 ± 1.63 (114)	0.10 ± 0.07 (74)
Honk	0.11 ± 0.04 (9)	4.8 ± 1.1 (9)	---
Hiss	1.36 (1)	2.50 (1)	---
Trill	0.07 ± 0.02 (14)	0.60 ± 0.23 (14)	---
Wail	0.16 ± 0.05 (4)	3.83 ± 0.79 (4)	0.07 ± 0.01 (3)
Nor	0.43 ± 0.10 (9)	0.51 ± 0.18 (9) (1st band only - highest amplitude)	---
Non-Vocal Sounds			
Foot Clap	5.0 ± 2.8 (3)	6.47 ± 2.92 (3)	---

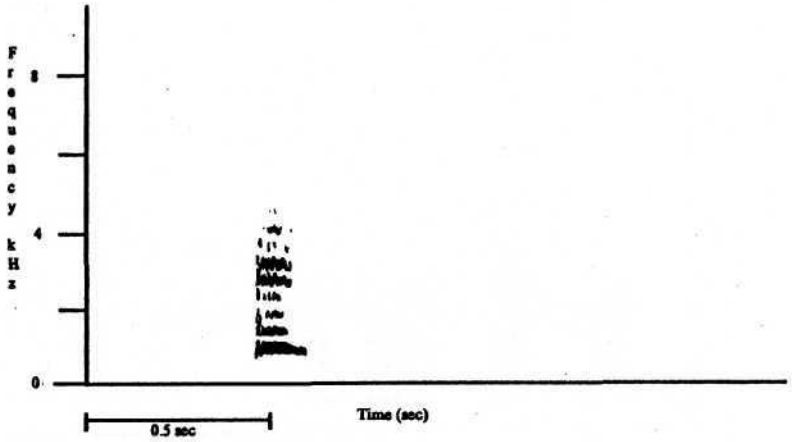


Adult: Trumpet

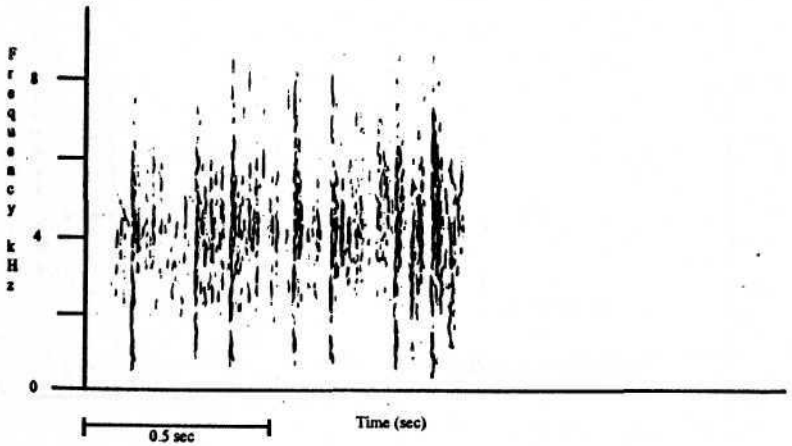


Adult: Duet

Figure 2. Sonagrams of Adult calls.

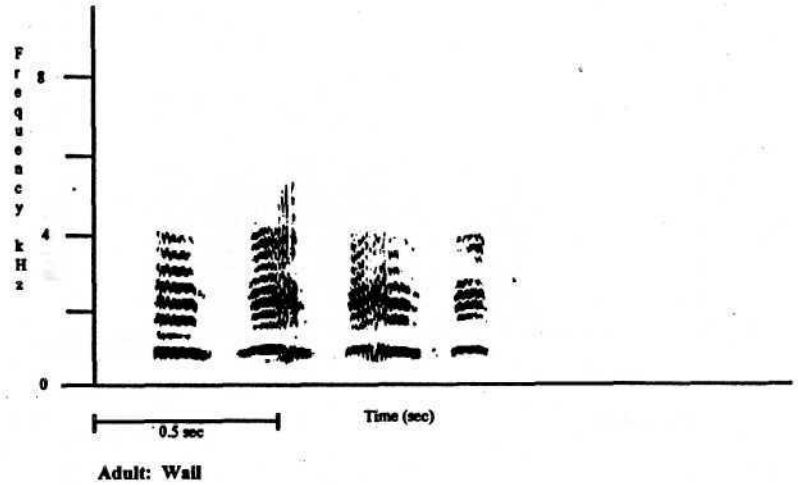


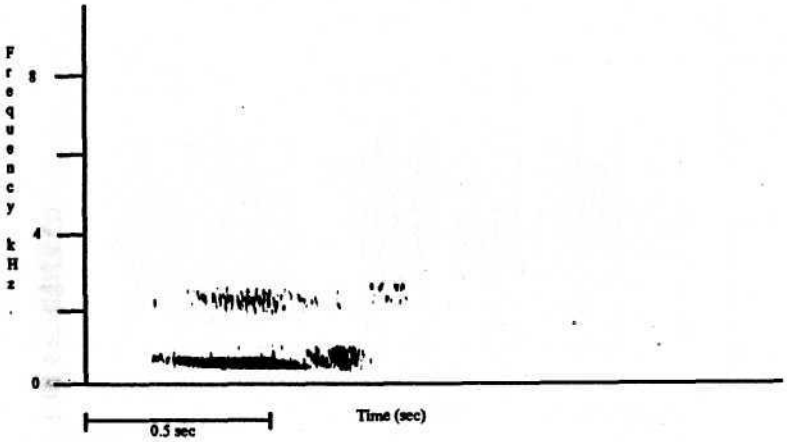
Adult: Honk



Adult: Foot Clap

Figure 2. (cont.)





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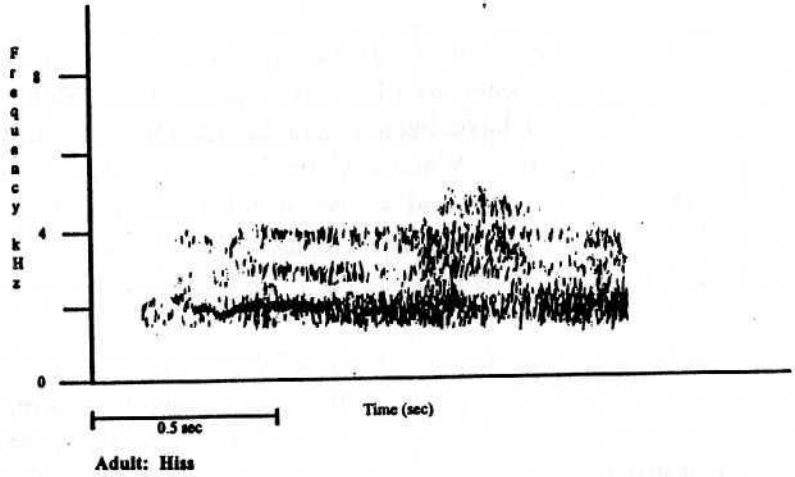
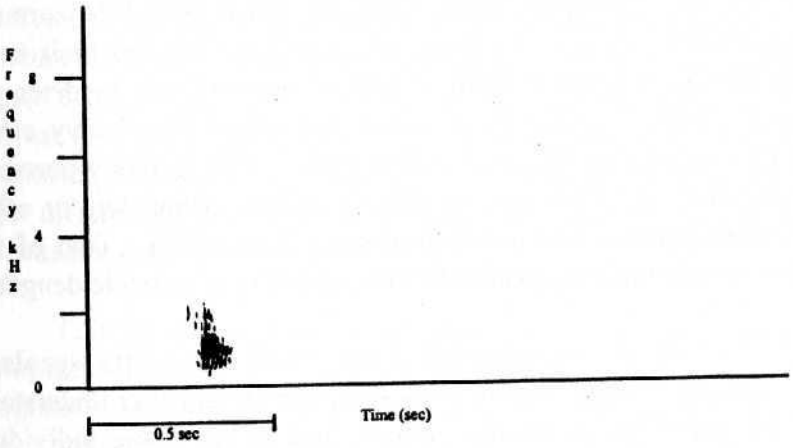


Adult: Hiss



Adult: Trill

Figure 2. (cont.)

Discussion

The acoustic signals of Trumpeter Swans have been categorized according to patterns of acoustic structure, context and probable function and have been found to include vocalizations with complex structures. Waterfowl produce their characteristic calls by variations in size and shape of the trachea and syrinx (Scott 1972). Trumpeter Swans have an especially long trachea with a high upward loop as it enters the breastbone.

Trumpeter Swan cygnets have a large call repertoire. Of the six cygnet vocalizations, four appeared to function in keeping the family united. The Trumpeter Swan family is an especially tightly knit group. When danger threatens, the cygnets stay tightly clustered between the parents (Hansen et al. 1971).

Of the eight adult signals, five were associated with territorial defense. Trumpeters were relatively silent during the summer months of this study. If, however, a predator invaded their territory, the Trumpeters employed one or more signals to deter the invader, providing the swans could not escape into heavy cover which was usually the case in this study. Trumpeters vigorously guard their territories against other invading Trumpeters or other creatures perceived as a threat (Hansen et al 1971). Two of the adult signals function to alert family members of possible danger.

Much more information is needed about acoustic signals in this species. Larger sample sizes are desirable to better understand all the functions of various signals, and to determine individual variations. Because this research was conducted during the summer, no flocking or breeding calls were documented. Also lacking is information on how cygnet vocalizations develop into subadult vocalizations, and how subadult vocalizations develop into adult acoustic signals, since no individuals were studied continuously

from hatchling to breeding adult. Most of the cygnet calls were those of cross-fostered cygnets, so it has not been determined if the cygnet vocalizations have been altered by the influence of another swan species. To what extent are these acoustic signals innate and to what extent learned? Other areas to investigate include signalling between parents and young at hatching, the role of the sexes in duetting, etc.

The chief contribution of our study was to describe and classify acoustic signals for a species lacking sonagraphic analyses. In addition, this research may illuminate a problem with the cross-fostering technique. Some Mute Swan cobs chosen for cross-fostering aggressively attacked Trumpeter cygnets shortly after hatching. It was apparent that Mute cobs recognized that the cygnets were not their young. Visual cues may have been involved, but dyeing the Trumpeter cygnets to look like Mute cygnets failed during this study. Color differences between Trumpeter and Mute Swan cygnets are only slight. The differences in Mute and Trumpeter cygnets calls, however, are definitely apparent. The structure of Mute cygnet calls is simple compared to Trumpeter cygnet calls, and calls of the two species sound distinctive. In contrast to Trumpeter cygnets, Mute cygnets have a very limited repertoire (Patton-Gross unpublished). There may have also been slight differences in the hatchling behavior of the two species, but this was not determined.

This study can also be used as an aid in artificial rearing of Trumpeter cygnets. First, researchers and swan tenders need to recognize particular vocalizations and to understand their meanings. Certain calls express various degrees of distress. Second, it is very important that the vocalizations develop normally. Calls could eventually affect breeding success or survival. Third, Kittelson (1988) suggested placing cygnets with unhatched eggs to provide stimuli to the vocalizing embryos. Where this is inconvenient or impractical, recordings of hatchling or young cygnet vo-

calizations could be employed. Fourth, Stanley Temple (pers. comm.) and Horwich (1988) have indicated the usefulness of Trumpeter brooding recordings for avicultural techniques. Horwich suggested playing Trumpeter Swan brooding calls two days prior to hatching. At hatching, a human in a costume would induce the cygnets to feed and follow by using the recordings. Temple suggested using similar techniques with older cygnets in a wild setting. Brooding calls used by a human surrogate would encourage the cygnets to stay close, decreasing risk of predation and loss of cygnets. Understanding and implementing the use of Trumpeter vocalizations should increase success in the reintroduction of Trumpeter Swans to their former breeding range.

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