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Acoustic luring best practices — Operational brief

Juvenile humpback whale, Kirchsee, Insel Poel

19 April 2026. Based on the 1985 rescue of Humphrey the humpback whale (Sacramento River, California) and the field diary of Bernie Krause, acoustician and Scientific Director of the Humphrey operation. The animal is alive at the date of this document.

Why acoustic luring, not acoustic repulsion

During the Humphrey rescue, three acoustic approaches were tried. Killer whale playback caused distress but no directed movement and was abandoned. Oikomi pipe-banging (a Japanese fishing technique using eight-foot metal tubes struck with hammers) moved the whale but only five to ten miles per day, with full retreats overnight; net progress over ten days was approximately fourteen miles. Seal bombs (underwater explosives detonating on contact with water) caused an immediate beaching in front of ten thousand spectators. By contrast, a single session of humpback feeding-sound playback moved Humphrey nearly fifty miles in seven hours, and the whale voluntarily followed the sound boat the entire distance. The feeding sounds were the only method that produced sustained, directed, voluntary movement without stress indicators.

The operational principle is that luring produces cooperation while repulsion produces evasion. A lured whale follows a lead vessel by choice. A repelled whale flees unpredictably and may strand, reverse course, or enter a trap bay. For Buckli/Hope/Timmy's situation, an animal in shallow water surrounded by multiple dead-end bays, acoustic luring could be the primary method and acoustic repulsion is the secondary containment method used only to block escape routes.

Recording preparation

The original recording used in the Humphrey rescue was a fifty-five-second cassette of humpback feeding sounds recorded by Scott Baker in Alaskan waters in 1984. The raw recording was unusable: it contained boat engine noise throughout because the recordist could not or did not stop the engine during recording. The segment was a single short loop repeated continuously.

Krause spent approximately forty hours in a recording studio processing this material. The steps were: (1) noise removal using a device originally developed for the FBI and FAA, stripping boat engine noise without destroying the integrity of the feeding sounds; (2) programming the cleaned segment into a digital Kurzweil sampling synthesizer; (3) varying duration, pitch, reverberation, amplitude envelope, and timbre across recombined segments to produce a

fifteen-to-twenty-minute tape that would not sound repetitive to the whale. This step was critical because humpback vocalizations, though often similar in structure, are almost never repeated identically. A looping fifty-five-second clip would be immediately recognisable as artificial.

For Buckli/Hope/Timmy: the recording source should be North Atlantic or Norwegian Sea humpback feeding vocalisations, not Pacific recordings, since population-specific vocal characteristics differ. The same processing protocol applies, clean, vary, extend. Multiple backup copies of the final recording must be carried aboard the sound boat.

Speaker and amplification system

The Humphrey operation used a United States Navy J-11 underwater transducer, a stainless steel cylinder weighing approximately 120 pounds (54 kg) with rubber diaphragms on both ends, deployed from the bow of a forty-foot cabin cruiser to a depth of ten feet (three metres). The J-11 is rated for a maximum of 200 watts; the team ran it conservatively at 168 watts. An 800-watt amplifier was available but Krause determined this would destroy the speaker and was based on incorrect data from the original experimenter.

The system required 120-volt AC power, which the initial lead boat (a fishing vessel) did not have. A different vessel with onboard power had to be sourced. For Buckli/Hope/Timmy: the sound boat must have reliable onboard AC power, a winch or davit system for deploying and recovering the underwater speaker in sea states up to two metres, and deck space for the amplifier and playback equipment. Redundant power sources (generator backup) and redundant playback devices are mandatory. Loss of the sound system mid-operation means loss of contact with the whale.

Playback protocol

The protocol used in the Humphrey rescue was developed by Joe Mobley, a graduate student at the University of Hawaii who conducted the original playback experiments with free-ranging humpbacks. The core principle is intermittent playback:

Sounds ON when the whale appears distracted, veers off course, or stops following the lead vessel. Sounds OFF when the whale is following in the vessel's wake and moving in the desired direction. This prevents habituation. The whale must not become accustomed to continuous playback, particularly in a situation where no actual feeding activity (fish presence) reinforces the acoustic signal. Habituation was specifically identified as a risk by Dianna Reiss, the dolphin researcher who co-directed the scientific component of the Humphrey rescue.

During the Humphrey rescue, Krause managed the tape manually: starting and stopping the recorder based on the whale's visible behaviour from aboard the lead boat. The whale covered forty miles from Antioch to Angel Island before the team lost visual contact in darkness. The following morning the whale was located near Point Richmond and guided the remaining distance to the Golden Gate. Total playback time across both days was substantially less than the seven hours of travel, the tape was silent for most of the journey while Humphrey followed voluntarily.

For Buckli/Hope/Timmy: the operator managing playback must have unobstructed visual contact with the whale at all times. The decision to play or pause is a real-time judgment call based on the animal's heading, speed, and surface behaviour. This cannot be automated or delegated to someone without direct line of sight.

Lead boat behaviour

When the Humphrey feeding sounds were first played, the whale rushed the lead boat from a quarter mile away in approximately fifteen seconds, nudged his nose against the underwater speaker at the bow, and positioned his body alongside the vessel. The boat listed severely. This initial approach is extremely dangerous and must be anticipated. The lead boat must have sufficient displacement and stability to absorb close contact from a thirteen-metre whale without capsizing.

Once the initial contact was established, the lead boat moved at dead slow, then increased gradually to six knots. The whale tucked behind the stern and followed. The vessel speed should be just fast enough to maintain forward progress but slow enough that the whale can keep pace without exhaustion. For Buckli/Hope/Timmy, two to four knots may be the upper limit, at least in the beginning.

The lead boat engine must be as quiet as possible. Humphrey's team observed that boat propeller cavitation noise and engine noise were significant components of the underwater soundscape. A diesel trawler at full throttle will mask the feeding sounds. The lead boat should run at minimal RPM consistent with steering authority.

Humphrey developed an "affinity" for the lead boat and basically followed it voluntarily, as the playback was only initiated once he veered off. This is the ideal goal of the acoustic lure approach.

Combined lure-and-repel corridor

The method that ultimately rescued Humphrey was a combination: feeding sounds broadcast from the lead boat ahead of the whale, and Oikomi pipe noise from a crescent of boats behind and to the flanks. This creates an acoustic corridor, attractive sound forward, aversive sound aft. The whale moves voluntarily toward the lure while the repulsion barrier prevents reversal or lateral escape into trap bays.

For Buckli/Hope/Timmy's Baltic transit, physical pipe-banging could be replaced by pre-recorded pipe noise played through smaller underwater speakers on the flanking vessels. This eliminates the safety risk of personnel hammering metal tubes over the gunwale in sea states above one metre, and allows precise volume control. The flanking speakers should be louder when the whale drifts toward a known trap bay and softer when the whale is on course.

Optional: Weighted curtain barriers

In the Humphrey rescue, the California Conservation Corps was prepared to drop a weighted curtain over the side of the Liberty Island Bridge after the whale passed beneath it, sealing the slough behind him and preventing return. The principle is a one-way gate: whale passes, barrier closes, retreat is blocked.

For Buckli/Hope/Timmy's operation, this technique could be deployed at each critical bay entrance the whale passes: Wismar Bay mouth, the passage between Fehmarn and Lolland, and the southern entrance to the Great Belt. The barrier can be a weighted net or acoustic curtain strung between anchored barges. Deployment must occur only after the whale has passed—if deployed prematurely, the whale may be driven against the barrier and strand. Timing is critical: the Humphrey team learned that the whale was acutely aware of underwater

obstacles even when submerged and invisible, and refused to pass over structures he perceived as blocked.

Weather conditions and wind swell

The Humphrey operation benefited from an extended Indian summer with calm conditions throughout the twenty-six-day rescue period. No swell, no significant wind, no adverse sea state. This is unlikely to be replicated in the Baltic in April. Although a free-swimming humpback whale is inherently capable of handling open-ocean swell, the escort fleet, acoustic equipment, and herding formation are not. Weather governs the operation's feasibility even when the whale itself is not at risk from wave action.

The Baltic Sea is commonly perceived as a sheltered body of water. This perception is dangerously wrong. When sustained wind blows across the open fetch of the Baltic, which can exceed several hundred kilometres depending on wind direction, the resulting wind swell builds significant wave height. At forecasted heights of 1.5 to 2.0 metres, the Baltic produces confused, steep seas that are hazardous to escort vessels. The wave period on the Baltic is typically shorter than ocean swell, meaning steeper wave faces and more violent motion for a given wave height. A 1.5-metre Baltic wind chop is substantially more punishing than a 1.5-metre Atlantic ground swell. Construction platforms and barges with heavy equipment have been damaged in this region by wave heights as low as one to 1.5 metres when operators underestimated the wind swell conditions.

The primary weather risk for a free-swimming herding operation is not the whale's safety but the breakdown of the escort formation. In swell above one metre, small boats cannot maintain the crescent formation needed to block escape routes into trap bays. Personnel cannot safely deploy or recover underwater speakers. Spray and wave impact threaten amplifiers, recorders, and electrical connections. The sound boat operator loses visual contact with the whale in trough-to-crest cycles. If the formation breaks, the whale is free to turn into any adjacent bay, Wismar Bay, Kiel Fjord, the Lübeck estuary, and re-strand. Every formation failure during swell conditions creates a stranding opportunity that may not be recoverable.

The Kirchsee, where the whale is currently located, sits in the wind shadow of Poel Island. The transition from this sheltered position to the open Bay of Mecklenburg exposes both the escort fleet and the herding operation to the full force of the Baltic fetch. The wind swell's character must be evaluated not only by wave height but by frequency and wave spacing. Wind swell on the Baltic can develop regular frequency patterns over long fetch distances. The current forecast shows conditions that will allow swell to build across the full open fetch. This is a long-fetch event: the wind has hundreds of kilometres of open water to generate wave energy before it reaches the Poel coast. Forecast heights of 1.5 to 2.0 metres understate the danger because they represent open-water averages. Near coastal features, refraction, shoaling, and reflection off breakwaters and harbour walls produce local wave heights significantly above the forecast value.

A secondary weather risk specific to free swimming is the effect of swell on the whale's navigation choices. Onshore wind swell pushes large volumes of water toward coastal sections and raises local water levels, temporarily increasing depth over sandbanks and into shallow bays. A bay entrance that is impassable at normal water levels may become accessible during a swell-driven surge. This means the whale could swim into a trap bay during high water that would not normally be available to him, then become stranded as water levels recede. The herding team must account for this: bay-blocking vessels and weighted curtain barriers must

remain in position even when water levels suggest the bay is too shallow to enter, because swell surges can change that within hours.

Operational implications for free-swimming herding: (1) all escort vessels must be rated for the expected sea state, small boats under twelve metres should not participate in open-water segments during swell conditions above one metre; (2) the acoustic equipment (speakers, amplifiers, recorders) must be secured against wave impact, spray, and roll; (3) the sound boat must be a heavy-displacement vessel (trawler, coast guard cutter, or research vessel) with sufficient stability to maintain a deployed underwater speaker in beam seas up to two metres; (4) the operation should be staged between sheltered waypoints, deploying weighted curtains behind each completed segment, with transit through exposed crossings timed to calm weather windows; (5) bay-blocking vessels must remain stationed at trap bay entrances regardless of apparent water depth, because swell-driven surges can temporarily open shallow passages; (6) if swell exceeds operational limits mid-transit, the fleet should hold position and maintain the acoustic lure to keep the whale stationary rather than attempt to continue herding through deteriorating conditions, losing formation coherence in heavy seas is worse than a temporary halt in progress.

Whale’s response to vessels

The breathing data collected for this animal shows that boat proximity produces the strongest stress signature in the dataset, with inter-breath intervals dropping to 47 percent of the alone-state mean. This is consistent with Humphrey’s behaviour: Humphrey avoided, evaded, and swam away from every vessel that approached him in a chase or herding posture. He swam underneath boats, reversed past them, or stopped dead and refused to move.

This changed entirely when the feeding sounds were introduced. Humphrey rushed toward the sound boat, made physical contact with the speaker, and voluntarily stayed within two body-lengths of the vessel for seven hours. The critical difference was that the sound boat was not chasing the whale. It was positioned downstream, stationary or moving slowly, broadcasting an attractive signal. The whale chose to approach. Every other vessel in the rescue had been approaching the whale; the sound boat was the first vessel the whale approached.

For Buckli/Hope/Timmy: given the documented respiratory stress response to vessel proximity, the number of boats near the whale at any given time must be minimised. The sound boat should initially position itself at a distance of 200 to 400 metres from the whale and begin playback. If the lure works, the whale will close the distance himself. The flanking repulsion vessels should remain at the maximum effective range of their speakers, which is substantially farther than the visual range of a person with a hammer on a pipe. Fewer, larger, quieter boats at greater distance will produce less stress than many small boats in close proximity.

Night operations

During the Humphrey rescue, the team lost visual contact with the whale at nightfall near Angel Island after seven hours of guided travel. They had no way to track him overnight. The following morning he was found several miles away, swimming erratically around the bay and avoiding contact with the rescue fleet. Night is when Humphrey repeatedly reversed his progress, swimming back upriver toward the Rio Vista bridge while the pipe crews slept.

For Buckli/Hope/Timmy: a satellite tag (minimally invasive suction-cup type, not the projectile tags that NMFS unsuccessfully attempted on Humphrey, which pierced the skin and were sloughed off) should be attached before or during the first movement. This provides continuous

position data overnight. If the whale reverses course during darkness, the team can respond at first light rather than spending hours searching. The weighted curtain barriers at completed segments further reduce overnight reversal risk.

Conclusion

Acoustic luring with humpback feeding sounds is the only method demonstrated to produce sustained, voluntary, directed movement of a trapped humpback whale over distances exceeding forty miles. It succeeded where killer whale playback, pipe-banging, and explosives failed or produced adverse outcomes. The method requires careful recording preparation, reliable underwater speaker deployment, intermittent playback managed by a trained operator with direct visual contact, and a lead boat with sufficient stability and quiet propulsion. Combined with flanking acoustic repulsion and weighted curtain barriers at cleared waypoints, this approach offers the best available framework for guiding a whale through a complex, multi-hazard transit from the Baltic to the North Sea. Weather conditions, particularly wind swell across the open Baltic fetch, must govern the timing of each transit segment. The operation should be staged to coincide with calm windows, and no movement from sheltered to exposed water should occur during an active swell event.

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The animal is alive at the date of this document.