

THE IN A HURRY SERIES

Whales

in a Hurry

The giants, their songs, and their comeback

Max Brocklesby

BOOKSINAHURRY.COM

Contents

The Whole Thing in One Page 4

Why You Should Care 5

The Core Ideas 7

How It Actually Works 20

What People Get Wrong 29

Use It 34

Terms 39

Go Deeper 42

Notes and Sources 43

Bibliography 51

The Whole Thing in One Page

The public whale is one animal assembled from several. It has the size of a blue whale, the white underside and leaps of a humpback, the square head of a sperm whale, the family life of an orca and a melancholy song playing beneath all of it. The real group is stranger. More than ninety living species of whales, dolphins and porpoises range from river animals scarcely longer than a person to the largest body life has produced. Some strain tonnes of krill through combs. Some hunt squid beyond sunlight. Some travel between hemispheres. Some remain within one coast, estuary or pack-ice edge.

They share one old problem. Their ancestors were land mammals that returned to water about fifty million years ago, and evolution could rebuild almost everything except their ancestry. Whales still breathe air, bear live young, make milk, keep warm and carry a heavy investment in each calf. The sea removed the need to support weight on legs, but it scattered food, mates and safe nurseries across immense distances. The whale body is a set of answers to that geography.

Size slows heat loss, extends fasting and makes long travel efficient, but only dense prey can pay for it. Baleen whales found one route: take mouthfuls or streams of small animals and keep the food while water escapes. Toothed whales found another: pursue individual prey, often using echoes to turn darkness into a measured space. A deep dive is not freedom from breathing. It is an oxygen budget managed through blood, muscle, slowed circulation and a tolerance for conditions that would injure a human diver.

Sound solves distance better than sight. Water carries it far, and whales have made acoustic worlds from clicks, whistles, pulses and low calls. Male humpbacks arrange sounds into changing songs that can spread between populations through social learning. Sperm whales exchange patterned click sequences called codas, and groups use distinctive repertoires. Their calls have structure and social meaning. That does not mean science has translated a whale language. Complexity is evidence of complexity, not

permission to supply a dictionary.

The same lives that crossed oceans were easy to exploit once people added steam, explosive harpoons, factory ships and global markets. Industrial fleets killed an estimated 2.9 million large whales during the twentieth century, and the count is a lower bound. Protection then produced one of conservation's clearest demonstrations: stop the main source of death and some populations can rise for decades. Several humpback populations have risen strongly, as have some southern right whales and bowheads in the western Arctic. Others remain a few hundred animals, or fewer. Antarctic blue whales are increasing from a remnant while staying far below their former abundance. North Atlantic right whales face extinction risk despite generations without legal commercial hunting.

There is no single whale comeback. There are populations recovering, stalling or declining under different combinations of entanglement, ship strikes, prey change and noise. Sound is habitat, routes are habitat, and an adult female lost today may mean calves never born for decades. The same long-lived design that carries whales across oceans also makes losses persist across generations.

That is the book.

Why You Should Care

A whale can occupy water you cannot see and lose water that remains physically open. A low call crosses kilometres beyond the reach of any eye. A ship then adds noise at the same frequencies, and nothing visible blocks the route. The whale still has an ocean. It may have less usable habitat.

That changes the way to look at these animals. Whales are often presented as spectacle: the blow, the breach, the tail disappearing. Their lives happen mostly elsewhere. A blue whale finds moving concentrations of krill across a basin. A sperm whale hunts in darkness, surfaces to breathe and returns to companions whose click patterns mark social belonging. A humpback mother may feed for months in one region, fast through migration and

nursing in another, and depend on a chain of places separated by thousands of kilometres. The animal is the visible part. The system is distance joined by memory, energy and sound. Once that system becomes visible, a coastline, shipping lane or patch of krill stops being background and becomes part of a life measured across years.

Whales also stretch the limits of the mammalian design. They show how far evolution can modify a body without starting again. Forelimbs become flippers, hind limbs nearly vanish, nostrils move upwards and a tail becomes the main engine. Yet the animal must surface, sleep, give birth and keep a calf warm while living in a medium that draws heat away and gives no firm place to rest. One tagged Cuvier's beaked whale remained submerged for 222 minutes. A blue whale can reach roughly thirty metres. Neither fact makes sense as a party trick. Each is the end of a chain of trade-offs.

Then there is the mind. Whale culture is no sentimental metaphor. Humpback songs change through copying. Sperm-whale communities maintain vocal traditions. Orca populations can share waters while eating different prey, in part because young animals learn the methods and preferences of their group. Social inheritance can shape where whales go, what they eat and whom they recognise. Genes build the capacity. Other whales supply part of the operating knowledge.

The history matters because industrial whaling exposed whale demography with a brutality no ethical experiment could reproduce. Fleets removed animals faster than many populations could replace them, often before anyone knew how many breeding groups existed. Collapse revealed the importance of adult survival, age at maturity, calving intervals and learned routes. Recovery revealed the other half. Humpbacks in some regions have multiplied across generations after hunting stopped. North Atlantic right whales have not escaped the arithmetic because ropes and ships still remove too many adults.

This is therefore a book about more than admiration. It is about how to reason when one familiar label hides many populations, when the relevant habitat cannot be seen, when a cause is removed but its damage persists,

and when success in one place creates a misleading global story. Conservation reports often ask whether a species is increasing. Whales force the better questions: which population, measured when, compared with what baseline, and with which sources of death still operating?

There are limits. Intelligence varies among species and is difficult to compare. A patterned call is not proof of grammar or translated meaning. Whale effects on nutrients and carbon are real in some settings but cannot be converted honestly into one planetary cash value. Even abundance is often reconstructed from incomplete surveys, catch records and models.

Those limits do not reduce the animals. They return them from mythology to biology, where the achievements are harder, the losses are clearer and the comeback becomes something worth understanding rather than merely celebrating.

The Core Ideas

A Land Mammal Rebuilt for Water

A whale is a mammal carrying the evidence of land into every dive. It breathes with lungs, maintains a high body temperature, bears live young and feeds them milk. Like other mammals, its trunk flexes mainly up and down, so the flukes beat vertically; most fish drive the tail from side to side. Even the tiny pelvic bones buried inside many whales are remnants of a body plan whose hind legs once carried weight.

The transition began in the early Eocene, a little over fifty million years ago, among hoofed mammals living around rivers and coastal waters in what is now Pakistan and India. The fossil record does not offer one cartoon line from wolf to whale. It offers a branching series of animals with different mixtures of land and water adaptations. Early forms had weight-bearing legs and whale-like ear structures. Later amphibious forms swam with powerful hind limbs and a flexible spine. Protocetids could cross seas while still retaining substantial limbs. By the time of basilosaurids, the hind limbs had become too small for walking and the animal was committed to the water.

This history places whales within the even-toed ungulate branch that includes deer, cattle, pigs and hippos. Hippopotamuses are their closest living relatives, which is often compressed into the false claim that whales came from hippos. The common ancestor was neither a modern hippo nor a modern whale. The two surviving designs went separate ways.

Returning to water demanded a reconstruction. The nostrils shifted backwards and eventually became one or two blowholes on top of the head. The forelimbs flattened into flippers whose bones still follow the mammalian pattern of upper arm, forearm, wrist and fingers. The hind limbs dwindled. Tail flukes evolved as the main propulsive surface. The neck shortened, the body streamlined and external ears disappeared. Hearing became coupled to tissues adapted for receiving sound underwater rather than air vibrating around a pinna.

Water solved some problems and created others. Buoyancy supported bodies that land legs could not. A large animal could travel without lifting its weight on every stride. Yet water removes heat far faster than air. Whales needed insulation, controlled blood flow and bodies with less surface area relative to volume. They also had to breathe while sleeping, nurse calves in moving water and keep air out of the digestive path when feeding at speed. Birth itself changed orientation. A cetacean calf often emerges tail-first. It must then reach the surface and coordinate its first breath in water. Milk can be expressed into the calf's mouth while both animals remain afloat, and its high energy content supports rapid growth.

One constraint never went away: the surface. However deep a whale hunts, the lungs must be refilled above water. However wide its migration, a calf must arrive alive and be guided through it. The whale body therefore joins two worlds rather than escaping one. Its food and social life are underwater, while every breath exposes it to waves, ice, boats and hunters.

That inherited compromise explains much of the later story. Whales became masters of the ocean without becoming fish. Their mammalian ancestry supplied warm blood, parental investment and flexible behaviour. It also left them air-dependent, slow to reproduce and unable to replace adults quickly.

The same design that made their lives possible would make industrial losses last for generations.

Size Is an Energy Bargain

The blue whale is the largest animal known to have lived, but the useful question is not how the sea allowed such size. It is what could pay for it.

Water supports mass, so a whale does not need pillar-like legs to keep a hundred-tonne body upright. Large bodies also lose heat slowly because volume grows faster than surface area. They carry larger energy stores, can fast through long migrations and move through water with lower transport costs per unit of mass. These advantages make size possible and often useful. They do not supply the calories.

A giant baleen whale lives on prey small enough to fit on a fingertip. That sounds inefficient until the prey are packed into a patch containing millions of bodies. Krill, copepods and schooling fish turn the ocean from a thin soup into a temporary solid meal. The whale does not win by selecting one item. It wins by processing water in bulk.

Rorquals, the group containing blue, fin and humpback whales, use an extreme version. Pleated grooves along the throat and belly expand as the whale accelerates into a prey patch with its mouth open. The mouth fills with water and prey, the body slows under enormous drag, and the whale then closes its jaws and pushes water out through baleen. One lunge can deliver a rich return. It also costs speed and time. The animal must find a patch dense enough to repay the acceleration, drag and handling. Tag records show that the spectacular mouthful is followed by a slower filtration phase. A larger whale can engulf more, but it cannot erase the time needed to close, strain and reset. Feeding is a sequence of costly bets on patches rather than one continuous harvest.

That trade explains both gigantism and its ceiling. A larger engulfing mouth can take a larger parcel of prey, and a larger body can travel between seasonal concentrations. Yet prey patches have finite depth, density and duration. The whale cannot feed continuously while migrating or breeding.

Bigger bodies need more total energy, take longer to grow and place greater demands on pregnancy and lactation. The best size depends on the geometry of food, not on a general evolutionary appetite for greatness.

Toothed whales reveal the contrast. Most pursue individual fish or squid, often at depth. Search and capture do not scale in the same way as swallowing a dense cloud. The sperm whale became enormous by exploiting deep prey and carrying exceptional diving capacity, yet it remains far below the largest blue whales. Among active hunters, manoeuvrability, prey handling and oxygen use impose different balances.

Extreme baleen gigantism also appears late. Whales had existed for tens of millions of years before several lineages evolved the largest bodies during the last few million years. A leading explanation links the change to cooling, intensified winds, upwelling and seasonal productivity that concentrated prey into rich but widely separated patches. New fossils continue to adjust the timing and regional detail, so no single climate switch should be treated as settled. The broader mechanism is stronger: patchier abundance can reward an animal able to take a huge meal, store it and travel far for the next one.

Size, then, is not decoration placed on a whale. It is a financial statement written in tissue. The benefits include heat retention, efficient travel, fasting capacity and a larger feeding apparatus. The liabilities include greater absolute demand, slow growth and dependence on concentrated food. A blue whale is possible because the ocean sometimes gathers tiny prey densely enough to finance a giant.

Baleen and Teeth Make Two Different Oceans

Living whales divide into two major branches, and the split is more useful than the familiar division between large and small. Baleen whales, the mysticetes, filter food. Toothed whales, the odontocetes, capture individual prey and include sperm whales, beaked whales, belugas, narwhals, dolphins and porpoises. A sperm whale is larger than several baleen whales. Feeding method, not scale, is the cleaner distinction.

Baleen is made from keratin, the material in hair and fingernails. Plates hang from the upper jaw in rows, with frayed inner edges forming a sieve. The apparatus cannot tell food from water. The rest of the body must bring the right mixture into the mouth and then separate it.

Different baleen whales solve that job differently. Rorquals engulf parcels through expandable throats. Right and bowhead whales swim with the mouth open, letting water flow through long, fine baleen suited to small prey. Grey whales often roll and use suction near the seabed, leaving pits and sediment plumes as they take in bottom-dwelling animals. Humpbacks can herd fish with bubbles, calls and coordinated movement before lunging. The word filter hides several machines. It also hides a transition. The earliest members of the baleen-whale line had teeth. Later fossils preserve toothed suction feeders and toothless forms that may predate modern baleen, revealing stages unlike any living whale. Modern filtration did not arrive as a complete replacement in one step. A feeding system was reworked while its owners still had to eat.

Toothed whales face another problem. A squid at a thousand metres is not a patch to strain. It is a moving target in darkness. Teeth may seize it, but finding and tracking it comes first. Odontocetes generate rapid clicks in nasal structures near the blowhole. The sound is shaped through fatty tissues in the forehead, travels outward, strikes an object and returns. Specialised fat pathways in the lower jaw conduct echoes towards the ear. Changes in delay, intensity and frequency provide information about range, direction and target properties.

This biosonar can be used at rates and intensities matched to the task. A whale searching broadly produces a different click pattern from one closing on prey. As capture nears, click intervals shorten into a buzz, updating the target rapidly. The process is active sensing: the animal illuminates its surroundings with sound and listens to the reflection.

Sperm whales combine suction, teeth and acoustic search. Beaked whales descend beyond sunlight and hunt scattered squid and fish. Orcas use vision, hearing and learned group tactics, and different populations may

specialise on fish, marine mammals or other prey while sharing the same waters. The ocean presented to each is shaped by what its body can detect and process.

The two branches also handle breathing and sound differently. Baleen whales have two external blowholes; toothed whales have one. Toothed whales evolved a nasal sound-producing complex associated with echolocation. Baleen whales use a specialised larynx and recycle air internally rather than exhaling a stream of bubbles with each call. Recent anatomical work has clarified parts of that mechanism, though it was based on a small number of stranded animals and cannot settle every species or vocal behaviour.

Neither system is superior in general. Bulk filtration works when prey can be concentrated. Individual pursuit works when prey rewards selection, tracking and capture. The distinction reaches beyond the mouth. It influences body size, dive pattern, social hunting, acoustic anatomy and where energy can be obtained. Baleen and teeth do not create two lists of species. They create two broad ways of making an ocean edible.

A Dive Is a Managed Oxygen Budget

A whale does not carry a magical exemption from breathing. It carries a budget.

Before descending, it exchanges air quickly at the surface. It then stores usable oxygen across the lungs, blood and muscles. Compared with humans, deep-diving whales can carry more blood relative to body size, higher concentrations of haemoglobin and muscle rich in myoglobin, the oxygen-binding protein that gives dark diving muscle its colour. The important store is distributed through the body rather than held in one oversized pair of lungs. This is why the familiar image of a whale taking a gigantic breath is incomplete. The visible blow is mainly warm, moist respiratory air condensing in colder surroundings, often mixed with spray around the blowhole. The whale is clearing and refilling a fast exchange system, not firing a column of seawater from its lungs.

Once submerged, the dive response changes spending. Heart rate falls. Blood flow is reduced to tissues that can tolerate delay and maintained for organs with immediate needs, especially the brain and heart. Muscles draw on local oxygen. Movement becomes economical where possible. A whale may glide during parts of descent and ascent as pressure changes buoyancy, avoiding strokes that would waste the reserve.

Pressure creates a separate challenge. Each ten metres adds roughly another atmosphere. Air spaces shrink, and gases under pressure can move into tissues. In deep divers, flexible chest structures and compressible lungs allow the alveoli, the gas-exchange surfaces, to collapse as depth increases. Air is displaced into stiffer upper passages where little exchange occurs. This can limit further nitrogen uptake, though real diving profiles, prior dives and rapid disturbance still matter. Whales manage pressure rather than becoming immune to it.

The aerobic dive limit is the duration that can be supported mainly by stored oxygen before reliance on anaerobic metabolism rises. It is not a stopwatch fixed for a species. Body size, activity, water temperature, prey depth, stress and the quality of the preceding recovery all alter the balance. Crossing the limit is possible, but the biochemical debt takes longer to clear.

Tagged Cuvier's beaked whales make the scale visible. They routinely perform deep foraging dives lasting around an hour, and one tagged individual remained submerged for 222 minutes. That record should not become the model of an ordinary dive. It was an extreme observation within a species built for exceptional depth. The remarkable fact is the full routine: descent, acoustic search, prey pursuit, ascent, surface recovery and repetition across days.

Feeding sets the economics. A baleen whale may take repeated lunges within a shallower dive, each one expensive because opening the mouth creates drag. A sperm or beaked whale spends oxygen reaching a deep hunting layer before the first prey attempt. Time at depth competes with travel and recovery. The best dive is not the longest. It is the one that returns enough food for the oxygen and time spent.

This matters when human activity changes behaviour. A disturbance that causes a whale to stop feeding, flee horizontally or surface early can alter the budget without leaving a wound. Repeated displacement may matter more than one dramatic response, especially where prey is seasonal. Conversely, a detected behavioural change does not automatically prove population-level harm. The chain must be measured from exposure through lost feeding or added cost to health, survival or reproduction.

A dive is therefore a controlled sequence of allocation. Oxygen is stored, protected, spent and restored. Depth is impressive. The harder achievement is returning with the budget intact often enough to make a living.

Sound Turns Water into Social Space

Light fades quickly underwater. Sound can travel far, especially at low frequencies, because water transmits pressure waves efficiently. A whale may hear another animal beyond the horizon of sight, locate prey in darkness or remain connected while separated by kilometres. Its acoustic environment is part of the space it can use.

Toothed whales exploit short, often high-frequency clicks for echolocation. High frequencies can reveal fine detail but are absorbed more quickly, which suits local search. Baleen whales tend to produce lower calls that can travel farther, although distance depends on frequency, depth, temperature structure, seabed, weather and noise. There is no single range for whale sound. The ocean is an uneven acoustic channel. Temperature and pressure can bend sound paths, while surface and seabed conditions absorb or scatter energy. A call may travel farther in one layer than another. Distance is therefore produced by the meeting of signal, water structure and receiver, not by loudness alone.

Humpback song is the famous case and a source of confusion. On breeding grounds, males produce long, patterned displays. Units combine into phrases, phrases repeat as themes, and themes form a song. Males within a population tend to converge on a current version, then modify it over a season. In the South Pacific, researchers have tracked song types

spreading eastwards between breeding populations across years. The transmission is too rapid and directional to be explained by genes. Whales heard and copied other whales.

Song is only part of whale sound. Humpbacks also use social calls. Blue and fin whales make powerful low-frequency calls. Bowheads maintain changing song repertoires in Arctic seas. Sperm whales exchange codas, short patterns of clicks associated with social interaction, while their regular echolocation clicks serve a different job. Orcas and other dolphins use group-specific call repertoires. Lumping all of this together as singing removes function and anatomy.

Producing sound underwater required its own reconstruction. Baleen whales use specialised structures in the larynx and can move air internally between lungs and a laryngeal air sac, avoiding the need to release it. Toothed whales generate clicks in a nasal complex and shape the beam through fatty tissues. Both systems preserve a precious diving resource: air can participate in sound production without being thrown away after each signal.

Hearing is equally specialised. External ear openings are inconspicuous. Sound reaches the hearing apparatus through tissue pathways adapted to water, with toothed whales using specialised fats around the lower jaw and ear region. The result is not a human ear submerged. It is a sensory system built into the head.

Human sound can interfere through masking, when noise overlaps a signal and reduces the distance or accuracy at which it can be detected. A ship does not need to deafen a whale to matter. It can make a call harder to hear, alter calling behaviour or raise the effort needed to maintain contact. Sonar, seismic surveys, construction and vessel traffic differ in frequency, intensity, duration and movement, while species differ in sensitivity and response. A single global claim about an ocean becoming some fixed number of times louder is therefore poor biology.

Thinking acoustically changes conservation. A route may remain open on a map while becoming costly to cross. A breeding area may contain the same

water while communication range contracts. Quieting ships, changing routes or timing noisy work can improve acoustic habitat without creating a reserve boundary. Sound turns water into social space, and noise can shrink that space without removing a litre of sea.

A Population Can Inherit a Culture

Culture is information or behaviour acquired socially and shared within a group. That definition does not require art galleries, moral rules or human grammar. It requires a pattern that cannot be explained adequately by genes and individual trial alone.

Whales provide some of the strongest non-human examples because many live long enough for generations to overlap, travel with companions and depend on knowledge that is difficult to discover from scratch. A calf can learn whom to follow, where to feed, how to handle prey and which calls mark its community. The ocean supplies the problem. Other whales can supply part of the answer. This makes a population historically specific. Two groups of the same species can inherit different solutions because each generation begins inside a local archive of companions, routes and routines. Biology supplies a range of possible behaviour; social history can make one possibility normal and another almost absent.

Humpback song shows rapid horizontal transmission. A new song version can move between populations as males encounter and copy one another. Sperm whales show a different structure. Females and young live in long-term social units, and units with similar coda repertoires form vocal clans that may share waters while maintaining distinct acoustic identities and behaviour. The clicks are not decorative accents. They help organise affiliation in a society where individuals spend much of their time out of sight.

Orcas make culture visible through food. In the northeastern Pacific, fish-eating and mammal-eating populations overlap geographically yet differ in prey, movement, group size, calls and hunting methods. Young whales acquire specialised techniques from their group. One population can ignore

food another regards as central. Ecological opportunity alone does not predict the menu because social inheritance narrows what is recognised, pursued and taught.

Migration can also carry learned components. Routes, stopovers and feeding grounds may persist across generations through maternal guidance and group memory. Genetics and environmental cues still matter. Culture works alongside them, not instead of them. A whale may have an inherited capacity to orient, respond to day length or recognise prey, while learning the practical geography of a particular journey.

This creates flexibility. A socially learned method can spread far faster than a genetic adaptation. A song version can cross breeding populations, and a feeding tactic can pass through a network of associated humpbacks. Groups can adjust call use or exploit a changing prey opportunity. Culture allows a population to store solutions outside any single brain.

It can also create inertia and loss. A traditional route may continue after its profitability changes. A small population may lose elders who carried knowledge of rare feeding grounds. When a local group disappears, recolonisation is not guaranteed merely because suitable water remains. Another population may lack the route, prey tradition or social connection needed to use it.

Researchers must still resist a flattering vocabulary. Similar behaviour does not prove copying. A common environment can produce the same answer independently. Demonstrating culture requires evidence about transmission, group differences, persistence and alternatives. Claims of cumulative culture, in which innovations build progressively across generations, are harder and depend on definitions.

The secure conclusion is already large. A whale population is more than bodies sharing genes and water. It can contain inherited acoustic conventions, prey preferences and geographical knowledge. Conservation that counts animals but ignores learned structure may preserve numbers while losing part of the population's operating memory.

Slow Lives Make Recovery Local and Fragile

Whales live on a timetable that protects adults and makes their loss expensive. Many species mature over years, produce one calf at a time and invest heavily in gestation, milk and care. Calving intervals vary with species, nutrition and condition, but rapid replacement is rare among the large whales. Population growth depends less on producing a flood of young than on keeping breeding females alive for many seasons.

That is why the word whale is too broad for conservation arithmetic. Species divide into populations that feed, breed, migrate and face danger in different places. Some mix freely; others remain genetically, acoustically or culturally distinct. A global species total can rise while one breeding population disappears. Management therefore works with stocks or population units, imperfect labels for the groups whose births and deaths need separate accounting.

Industrial whaling found those units before science described them. Whales surface predictably, gather where prey is dense and return to migration corridors or breeding grounds. Steam catchers and explosive harpoons turned those habits into targeting information. Factory ships removed the need to tow every carcass to shore. Fleets could follow abundance into remote seas, deplete one area and move to the next. The whales' solution to distance became the industry's search strategy.

When commercial hunting stopped across much of the world, direct mortality fell sharply and several populations demonstrated what long protection can do. Humpbacks recovered strongly in many regions. Some southern right-whale populations and the Bering-Chukchi-Beaufort bowhead population increased. Eastern North Pacific grey whales rebuilt from historical depletion, although recent prey-linked fluctuations show that recovery is not a permanent state.

The success is real, but its unit matters. The IWC's 2026 framework splits Southern Hemisphere humpbacks among assessment units classed as recovered, strongly increased but not recovered, and potentially small with

high scientific uncertainty. Antarctic blue whales have increased from a tiny remnant while remaining far below estimates of their former abundance. Some right-whale populations number only hundreds or tens.

The North Atlantic right whale makes the life-history problem stark. A 2026 IWC assessment gives 384 animals for the start of 2024. NOAA then documented 23 calves during the 2025/26 calving season, the highest total since 2009. One strong season is encouraging, not proof of recovery; entanglement and vessel collision continue to kill and injure whales. An adult female surviving several more years can contribute multiple calves. Her death removes herself, those possible births and the experience she might have passed on.

Modern threats rarely act in isolation. Fishing gear can cause immediate drowning or chronic drag and injury. Ships strike whales in busy routes. Noise can mask communication or change behaviour. Marine heatwaves and long-term climate change can move prey, alter feeding success and lengthen intervals between calves. Contaminants and disease add pressure in some populations. The strength of each pathway differs by place, species and season.

Recovery is therefore conditional rather than automatic. A legal protection removes one source of death. It does not guarantee prey, silence, safe passage or accurate population knowledge. Nor does a slow rise mean an intervention failed. Long-lived animals carry delays between better conditions, improved body condition, pregnancy, birth and recruitment into the breeding population.

The causal loop closes here. Whales returned to water but kept lungs, live birth, milk and prolonged care. They solved the ocean through routes, aggregation, sound and learning. Those traits made them catchable, and their slow replacement preserved the damage. Their comeback follows the same biology in reverse: protect adults, keep connected habitats usable and then allow enough whale generations for the arithmetic to change.

How It Actually Works

When Feet Left the Ground

About 52.5 million years ago, a four-legged mammal on the even-toed ungulate branch entered the cetacean fossil record beside rivers and shallow coastal waters in South Asia. *Pakicetus* could walk. Its skull, especially the construction around the ear, places it on the whale line even though the rest of the animal would not have looked at home beneath a modern blowhole.

The transition accelerated. *Ambulocetus* had large hind limbs and a body capable of moving between land and water. Later protocetids spread through warm seas, some retaining limbs that could support limited movement ashore while their tails and spines supplied more propulsion. Ankle bones helped settle their place among even-toed ungulates, while chemical signatures in teeth recorded increasing use of marine water. In basilosaurids, the body had crossed the threshold. Hind limbs were tiny and could no longer carry the animal. The nostrils had moved back along the skull. The ear was increasingly isolated for underwater hearing. Vertebrae and tail anatomy show propulsion shifting towards the rear of a body that no longer needed a shoreline. Birth could no longer depend on returning to land.

This was not a march towards a known destination. Amphibious forms were successful animals in their own settings, and branches ended without becoming modern whales. The sequence matters because separate structures changed at different rates. Swimming, hearing, feeding, breathing and reproduction had to remain workable at every stage. Evolution could not dismantle the land mammal and pause construction. Each intermediate animal had to live.

By roughly forty million years ago, fully aquatic whales ranged widely. Some were long, serpentine predators. Others occupied coastal and open-water roles that left no modern equivalent. The earliest history is therefore a radiation, followed by extinction and replacement, rather than a corridor

leading neatly to a blue whale.

Baleen and Teeth Separate

Modern cetacean history split into two surviving branches. Odontocetes kept teeth and developed the specialised nasal sound production used in echolocation. Mysticetes moved towards bulk filtration. Early members of the baleen line complicate the labels because some had teeth, while later toothless forms may have relied on suction before modern baleen evolved. Baleen whales did not begin as toothless giants. During the Oligocene, roughly thirty million years ago, oceans and prey systems changed while early members of both branches diversified. Skulls became more telescoped, with facial bones extending and overlapping in ways that moved breathing and sound structures. The mysticete lower jaw became long and bowed, creating room for a filter and, in rorquals, an expandable mouth. Odontocete skulls became increasingly asymmetric around the nasal sound apparatus.

The toothed branch diversified into river dolphins, porpoises, oceanic dolphins, belugas, narwhals, beaked whales and sperm whales. Its members found prey from muddy rivers to deep ocean basins. Sperm whales expanded the head into an enormous acoustic complex and made squid-rich depths profitable. Beaked whales became elusive specialists of deep foraging. Orcas remained flexible enough for local cultures to turn one species into sharply different predators.

Baleen whales diversified around ways of collecting small prey in volume. Right and bowhead whales became continuous skimmers. Grey whales developed strong suction and benthic feeding. Rorquals evolved pleated throats and engulfment. The line between branches determined more than the mouth. It reorganised sound, prey search, body size and the tempo of feeding. It also changed what leaves a fossil. Teeth preserve diet and age clues readily; baleen usually decays. Much of the transition to filtration has to be inferred from jaw shape, tooth wear, attachment surfaces and rare exceptional specimens. The living split is crisp. Its construction was not.

The Rise of the Giants

For most of whale history, no animal approached the largest living rorquals. Extreme baleen size arose during the last few million years. Cooling oceans, stronger seasonal cycles and changes in upwelling and ice probably helped concentrate prey into dense patches separated across larger distances. Fossils continue to alter the date and geography of that change, but the energetic logic holds. Patchy plenty rewards a body able to take a vast meal, store energy and travel to the next concentration.

Rorquals turned engulfment into a high-risk, high-return event. A blue whale accelerates, opens its mouth and allows the floor of the mouth and ventral grooves to expand around a mass of water and krill. Drag rises sharply and the whale slows. It then closes, filters and resets. Feeding tags have shown the body rolling, pitching and choosing among patches rather than moving like an automatic net.

The largest body in the history of life was built on temporary density. A blue whale cannot graze the average ocean. It must find the exceptional part. This also explains why buoyancy is an incomplete answer to gigantism. Water can hold up a large body, but it can hold up a starving one too. The decisive resource is a prey field dense enough that each mouthful earns more than the search, acceleration and filtration cost. Geological changes altered that resource map, and whale bodies followed. The bargain extends across seasons. Many large baleen whales feed intensively at high latitudes, build blubber and then migrate towards breeding grounds where food may be scarce. Pregnancy, nursing and travel are financed partly by energy gathered months earlier. A giant body therefore links a brief feeding opportunity to a long period of movement and fasting. Its size is useful because the ocean is productive at the wrong time and place.

Whales and People Before the Machine

People used stranded whales long before they could hunt large living ones. A carcass supplied meat, oil, bone and baleen in quantities that transformed a shoreline economy. Coastal communities later developed boats, lines, floats and collective methods suited to local species. In several Arctic societies, whaling became part of food systems, technology, status and social obligation. Skin and blubber supplied food, bone supplied tools or building material, and sharing rules distributed a catch whose scale exceeded one household. Knowledge of ice, currents, animal behaviour and safe approach passed through communities. These hunts were dangerous, limited by weather and carried out within cultures that cannot be reduced to a prelude to European industry. Their purposes, technologies and population effects varied, and they should not be merged into one timeless category called whaling.

Commercial whaling expanded in stages. Basque crews hunted right whales in the North Atlantic. Dutch and British fleets pursued bowheads around Spitsbergen and Greenland. American vessels crossed oceans for sperm-whale oil and baleen, sometimes remaining away for years. Crews lowered open boats, struck a whale by hand and attached themselves by line to an animal stronger than the boat. The ship's tryworks then boiled blubber into oil at sea, turning the deck into a smoky processing plant and allowing a voyage to continue until the hold was full.

Sailing whalers were formidable, but fast rorquals often escaped them. Blue and fin whales generally outswam open boats, and some carcasses sank before they could be processed. Their speed, size and carcass behaviour acted as partial refuges until technology removed them.

The Harpoon Cannon

In the 1860s, the Norwegian entrepreneur Svend Foyn combined a steam-powered catcher, a bow-mounted cannon and an explosive harpoon. The grenade head was designed to explode after penetration, increasing the wound. A powered vessel could chase rorquals, winches could control the line, and compressed air could help keep a carcass afloat for towing.

No single device created industrial whaling, but the package changed which whales were available and how quickly they could be taken. Larger, faster species became commercial targets. Shore stations processed carcasses into oil and other products. When local abundance fell, operations moved.

The next transformation removed the shore. Factory ships carried stern ramps, winches, flensing decks, boilers and processing equipment, allowing carcasses to be hauled aboard and reduced at sea. Teams worked through blubber, meat, bone and organs while catcher boats searched for the next animal. The ship converted an entire whale before weather and decay destroyed value. Catcher boats ranged around the mother ship, and fleets entered Antarctic waters where feeding whales gathered seasonally in extraordinary numbers. Radar, radio, aircraft and improved engines sharpened the search. A whale no longer needed to be near a port. It needed to be within the operating radius of an industry.

The sequence of catches followed profitability. For a time, regulators even combined species into the Blue Whale Unit, a quota currency that treated one blue whale as equivalent to set numbers of fin, humpback or sei whales. The accounting made unlike populations interchangeable on paper and encouraged fleets to take whichever mix returned most value. The largest and most valuable species were reduced, regulations shifted or quotas tightened, and fleets turned towards smaller whales. Blue whales gave way to fin whales, then sei whales and minke in many areas. The pattern can look like changing preference. It was often serial depletion.

The carcass became raw material measured in oil, meal and tonnes. The animal's migrations, feeding aggregations and surface breaths became

production data. A biological solution to ocean distance had been converted into a timetable for pursuit.

Emptying the Oceans

Reconstructing twentieth-century catches required more than adding official reports. A major synthesis estimated that nearly 2.9 million large whales were killed between 1900 and 1999. More than two million of those catches came from the Southern Hemisphere. The total is a lower bound because struck whales were lost, some records were incomplete and large illegal catches were concealed.

The Soviet Union supplied the most severe case of falsified reporting. Fleets killed protected species and submitted altered figures, sometimes recording one species as another. After the system ended, scientists and former participants helped recover true catch data. Population models changed because the original numbers had been fiction designed to satisfy quotas and hide violations.

The biological damage was uneven. Antarctic blue whales were driven down by catches measured in the hundreds of thousands, while species and populations less profitable or less accessible escaped the same intensity. Protection often arrived after fleets had already switched targets. Some populations were reduced to a small fraction of former abundance. Local knowledge and social structure may have disappeared with them. Removing large adults changed breeding prospects immediately, while the full population consequence unfolded across decades. A whale born after protection could mature in an ocean still missing most of its kind.

Whaling also distorted what scientists knew. Data came from dead animals selected by fleets, places fleets chose to work and records shaped by commerce. A catch map showed where hunters succeeded, not a complete map of where whales lived. Effort changed as ships became faster and search improved, so a stable catch could conceal falling abundance if each whale required more technology to find. Species identifications were uneven, and the boundaries used by fleets rarely matched breeding

populations. Abundance estimates often had to be reconstructed after collapse from fragments of the industry that caused it. The ledger is indispensable and contaminated by the purpose for which it was made.

From Quotas to a Moratorium

The International Whaling Commission was created in 1946 under a convention intended to conserve whale stocks while allowing an orderly whaling industry. Early management repeatedly lagged behind the fleets. Species were poorly distinguished, population units were uncertain, catch limits could exceed sustainable levels and political bargaining softened scientific advice. A quota could be negotiated for an ocean while the whales within it belonged to breeding populations with different histories. By the time a decline was statistically undeniable, ships might already have removed much of the breeding stock. Management asked science for precision that the catch itself was destroying.

As evidence of depletion accumulated and public attitudes changed, the Commission adopted a pause in commercial whaling in 1982, to take effect from the 1985/86 season. The moratorium remains in place. Calling it a universal ban creates errors. The legal system includes aboriginal subsistence whaling under agreed arrangements, scientific provisions, objections within the convention and hunting by states outside the Commission. Commercial catches did not vanish everywhere. Norway hunts under its objection to the moratorium. Iceland rejoined with a reservation and has taken whales commercially. Japan left the Commission in 2019 and began commercial catches that year. Nor did the Commission cease to manage. Its scientific work moved towards population assessments, catch-limit procedures, sanctuaries, welfare questions, bycatch, ship strikes and conservation plans. A body founded to regulate extraction became one of the main institutions recording what recovery and continuing danger looked like.

The decision still changed the dominant pressure across large parts of the world. It also shifted the burden of proof. Commercial whaling could no longer continue by default while scientists tried to demonstrate collapse

species by species. For many populations, annual hunting mortality fell towards zero. That did not restore lost adults or recreate erased breeding groups. It changed the direction of the arithmetic and began a test lasting whale generations.

The Uneven Comeback

Humpbacks produced the clearest recoveries. Their coastal migrations and distinctive tails made them comparatively visible to surveys and photo-identification. Catalogues built from fluke photographs turned encounters into life histories: a whale seen in one breeding ground could be matched years later on a feeding ground, with calves, scars and survival recorded along the way. Recovery became a set of known animals as well as a rising curve. In the IWC's 2026 framework, western Australian and western Indian Ocean humpbacks are described as recovered. Western South Atlantic humpbacks are strongly increased but not yet recovered, while a West South African breeding population is estimated at 484 animals, with an uncertainty interval from 138 to 860. One species contains comeback, incomplete recovery and severe uncertainty. Breaches returned to waters where commercial fleets had emptied the route.

That success can mislead when converted into a species-wide slogan. North Pacific humpbacks recovered strongly overall, then some feeding regions declined after the 2014-2016 marine heatwave disrupted prey and food webs. Southern right whales increased quickly off parts of Argentina and South Africa, while other right-whale populations remained scarce. The Bering-Chukchi-Beaufort population increased while a tightly managed subsistence hunt continued, yet bowheads around Svalbard and the Sea of Okhotsk still number only hundreds.

Blue whales divide the story again. The eastern North Pacific population has recovered towards its estimated pre-exploitation level. Antarctic blue whales are increasing, but the IWC's current summary relies on circumpolar estimates from the 1990s and 2000s and still places them far below reconstructed pre-exploitation abundance. Growth from near-annihilation is good news and evidence of continuing damage at the same time.

The North Atlantic right whale has been protected from commercial hunting for generations and still sits close to extinction. The IWC's 2026 product gives a best estimate of 384 animals alive at the start of 2024. NOAA documented 23 calves in the completed 2025/26 season, the highest count since 2009. One season cannot establish recovery, and births do not cancel adults killed or weakened by rope and ships. Entanglement can drown a whale quickly or impose months of drag, wounds and reduced feeding. Vessel strikes concentrate where routes overlap traffic.

Recovery therefore moved the conservation problem. In the whaling era, the main lever was direct killing. Today the work may involve weaker ropes, gear changes, seasonal closures, vessel-speed rules, rerouted traffic, quieter ships, acoustic monitoring and protection of feeding habitat. Each measure meets a different pathway and carries costs for fisheries, ports, shipping and coastal communities. General admiration supplies no design.

Climate change adds motion to every boundary. Prey can shift in latitude, depth and timing. Whales may follow into busier or less protected water. A traditional migration can arrive after a feeding pulse has moved. The effect is not one global decline but a rearrangement of risks, with slow reproduction delaying the visible result.

The comeback is best understood as a collection of natural experiments. Where direct killing stopped and food remained available, some populations grew for decades. Where entanglement, collision, lost habitat or tiny starting numbers kept mortality high, protection on paper was insufficient. The ocean did not recover whales. Specific populations recovered where enough adults survived long enough.

How we know

Whale evidence comes from tools that see different slices. Fossils preserve hard tissues and reveal anatomical sequence, but soft structures, behaviour and many lineages are missing. Catch logs record enormous effort and killing, while falsification, lost animals and shifting species names require correction.

Living populations are estimated through ship and aerial surveys, acoustic detections, genetics and mark-recapture models. Photographs identify individuals by tail patterns, callosities, scars or dorsal fins. Tags record depth, acceleration, sound and movement for a small, non-random sample. Earplugs and teeth can preserve growth layers and chemical histories. Biopsy samples reveal sex, relatedness, diet clues and population structure.

Every method has a detection problem. Deep divers spend little time visible. Calls identify only animals vocalising within range. Survey conditions alter what observers find. Population boundaries may be biological, cultural or managerial and do not always coincide. The strongest accounts combine methods and state the reference year. A whale number without a place, population, uncertainty range and date is usually less precise than it looks.

What People Get Wrong

"Whales are fish"

The mistake survives because shape is persuasive. A whale has fins, a streamlined body and no visible hair. It lives permanently in water. Early naturalists grouped animals by what they looked like and where they lived, and ordinary language kept the habit.

The internal design says otherwise. Whales breathe through lungs, produce milk, maintain body heat and descend from hoofed land mammals. Their forelimb bones retain the mammalian sequence, their spines drive tail flukes up and down, and their embryos begin with structures inherited from terrestrial ancestors. Fish reached efficient swimming through another history.

This is more than classification. Mammalian ancestry explains why whales must surface, why calves require prolonged investment, why blubber matters and why populations replace lost adults slowly. Calling a whale a fish removes the constraints that govern its life and recovery. Convergent evolution made the outline similar because water rewards a similar shape. It did not make the machinery the same. The comparison also guards against

a common scale error. A shark and a dolphin can look alike at a distance while differing in skeleton, reproduction, temperature control and sensory systems. Shape reveals the demands of water; ancestry reveals how each lineage met them.

"The biggest whales evolved first"

Gigantism looks primitive because whales are imagined as ancient monsters left over from a larger world. Museum halls reinforce the sequence by placing the blue whale as the final and most commanding image.

The fossil record runs the other way. Early whales were smaller amphibious mammals. Fully aquatic forms later diversified, and modern baleen whales existed for millions of years before several lineages evolved extreme size. The largest bodies appear mainly within the last few million years, alongside ocean changes that concentrated seasonal prey.

The correction changes the blue whale from a relic into a recent ecological solution. Buoyancy made size possible, but dense food patches made it profitable. If prey distribution changes, the bargain can weaken. A giant body is therefore evidence about ocean productivity, travel and fasting, not a timeless gift of living in water. The biggest whale arrived late because the feeding system capable of paying for it arrived late. Fossil size estimates remain imperfect because many skeletons are incomplete and body proportions must be reconstructed. That uncertainty can shift dates or rankings without restoring the old picture. Extreme size is still a late development within a much older whale history.

"All whales sing"

Recordings, films and tourism have made song the default soundtrack for every whale. The word whale then expands one striking behaviour across more than ninety living cetacean species.

Cetaceans use sound extensively, but humpback-style song is a specialised display rather than a group-wide soundtrack. Male humpbacks arrange units, phrases and themes into long sequences that change over time.

Bowheads also produce elaborate, changing songs. Blue and fin whales make patterned low calls. Sperm whales exchange social codas and use echolocation clicks. Orcas and dolphins have calls and whistles. These are different signals produced by different anatomical systems for different jobs.

The distinction matters because conservation depends on frequency, function and context. Noise that masks a low mating call may not affect a high-frequency click in the same way. A monitoring system tuned to song can miss silent animals or species using other signals. "Whale song" is a useful cultural phrase and a poor acoustic category. It also distorts who is producing the display. The classic humpback song is associated mainly with males on breeding grounds and migration routes, while mothers, calves and feeding groups rely on other calls. Hearing a humpback does not mean hearing a song, and silence does not mean social absence.

"Whale song is a language"

The claim is attractive because whale sounds are patterned, learned and socially variable. Analyses of sperm-whale codas have found combinatorial timing features, and a 2026 study identified vowel-like acoustic categories and phonological patterning in recordings from fifteen female and immature eastern Caribbean whales. Headlines then jump from structure to translation.

Science has not made that jump. Those studies establish complex structure in a particular communication system and population-level dataset; they do not supply a dictionary, demonstrate semantics across the repertoire or show human-like syntax. Humpback song has hierarchical organisation and cultural transmission, yet its detailed meanings remain uncertain.

The right conclusion is stronger than sceptical dismissal and narrower than language. Whales learn vocal traditions, combine sound features and use calls in social lives hidden from human senses. Treating every pattern as a sentence encourages researchers and the public to hear the meaning they hoped to find. Structure is a discovery. Meaning is a separate question. Establishing meaning requires linking a signal reliably to context, receiver

response and alternatives, then testing whether the relationship generalises. Human listeners are prone to finding sadness, names or conversation in unfamiliar sounds. Those impressions may motivate research, but they cannot complete it.

"They all make the same migration"

The standard whale map shows a neat annual shuttle: feed in cold polar water, breed in warm tropical water, repeat. It fits many humpbacks, right whales and orcas well enough to become the template.

Whale movement is more varied. Some populations travel between high-latitude feeding grounds and lower-latitude breeding areas. Others remain within regional seas, rivers, estuaries or ice margins. Individuals may skip a migration, use different routes or feed during the supposed fasting season. Sex, age, reproductive state, prey and ocean conditions can divide one population's movements.

The simple map remains useful as a first case, not a law. Its danger appears in management. Protecting two endpoints does little if ship traffic, fishing gear or energy development blocks the corridor. Assuming every animal leaves can also hide year-round residents. Migration is a population strategy assembled from ecology and learning, not an instruction printed once for the whole species. Eastern North Pacific grey whales include animals that make famous long coastal journeys and others that feed seasonally much farther south. Orca communities may range widely or use compact home areas. The exceptions are part of the biology, not failures to follow the diagram.

"More whales mean fewer fish"

The arithmetic seems obvious. Whales eat fish or krill. People catch fish. Adding a predator must subtract the same amount from human catches.

Food webs do not work as a shared bucket with fixed contents. Whales eat different prey in different places and seasons, while fisheries target selected stocks through their own gear and markets. Predation can alter competition among prey species. Whale faeces return nutrients near the surface,

stimulating production in some systems. Carcasses feed deep communities. These effects are documented, but their strength and direction depend on the ecosystem.

The correction does not prove that whales always increase fisheries or that competition never occurs. It rejects a universal subtraction. Removing whales on the promise of more fish has repeatedly ignored habitat, plankton, climate, other predators and fishing pressure. The useful question is which whale population eats what, where and with what measured consequence. A slogan cannot replace that accounting. The whale pump, in which whales feed at depth and release nutrients nearer the surface, has been measured in particular systems. Whale falls support deep-sea consumers for years. Neither result establishes one global net effect on every commercial fish stock. Scale, nutrient limitation and species interactions decide whether a pathway matters.

"The whaling ban saved the whales"

The commercial moratorium is remembered as a clean ending: the world banned whaling, whales came back and conservation worked. It contains enough truth to be dangerous.

In 1982 the International Whaling Commission voted to set commercial catch limits to zero from the 1985/86 season. It sharply reduced killing across many populations and enabled major recoveries. It was never a universal end to all whale hunting, and recovery did not follow everywhere. Some states continued commercial catches through legal positions outside the moratorium's ordinary operation. Aboriginal subsistence hunts continued under separate management.

More importantly, the main causes of death changed. North Atlantic right whales remain at severe risk from entanglement and ships. Tiny populations face genetic, demographic and cultural losses. Noise and moving prey can reduce usable habitat. The moratorium proves that removing a dominant pressure can work. It does not prove that one rule completed the job, or that "the whales" share one result. A population beginning with hundreds cannot

recover on the timetable of an election or funding round. A rise from a devastated baseline can look rapid while leaving abundance far below its former level. Success needs a reference population, date and threat budget, not a celebratory photograph.

Use It

Name the Population

When a report says whales are recovering, ask which whales. The useful unit may be a species, an ocean basin, a breeding population, a feeding aggregation or a culturally distinct community. Those boundaries overlap imperfectly.

A global humpback trend can hide a decline in one feeding region. A species classified as secure can contain a breeding population near extinction. Two groups of orcas in the same water can eat different prey, use different calls and rarely interbreed. The label on the field guide is therefore the beginning of the question rather than the answer.

Carry the same discipline into conservation statistics. Demand the place, date, uncertainty range and comparison baseline. Check whether the estimate counts individuals directly, models unseen animals or combines several stocks. A rise from 500 to 1,000 is a doubling and may still represent a devastated population. A stable total can hide lost reproductive females. Naming the population prevents good news in one place from paying the moral debt of another. It also tells you what action is possible. A ship-speed rule, fishery closure or breeding-ground protection must be matched to the animals that use that place, rather than to a species range drawn across half an ocean.

Follow the Energy

Size, migration and feeding behaviour become clearer when translated into an energy budget. Ask where food is dense enough, when it appears, what it costs to reach and how much can be stored.

A blue whale cannot live on the average concentration of krill across an ocean. It needs patches rich enough to repay a lunge and a body large enough to travel between them. A beaked whale spends oxygen and time reaching deep prey before hunting begins. A mother may finance migration and milk with blubber accumulated months earlier. Every impressive behaviour has an income and a cost.

This lens also disciplines climate claims. Temperature can matter directly, but much of a warming ocean's effect passes through ice, currents, plankton, fish and the timing or location of prey. The decisive question is whether feeding success, body condition and reproduction change. Follow the chain from physical conditions to prey to whale behaviour to demography. Stop where evidence stops. This is especially useful when a whale changes distribution. Movement can indicate successful tracking of food, displacement from good habitat or a failed search. Location alone does not tell you whether the energy account improved.

Treat Sound as Habitat

A map of whale habitat drawn only from depth, temperature and food is incomplete. Add the acoustic layer: which signals must travel, which noises overlap them, when the noise occurs and whether the animal can avoid it.

Masking is easiest to understand as reduced usable range. A call that once reached a companion may disappear into vessel noise sooner. The water remains, but the social connection has contracted. Echolocation can be disrupted in another frequency band and at another scale. A sonar exposure, construction project and continuous shipping lane are not interchangeable sources.

This changes the intervention. Protecting habitat may mean slowing or rerouting ships, quieting machinery, scheduling loud work outside a sensitive season or measuring background sound before and after action. The relevant success metric is not silence. It is whether whales can detect, communicate, feed and travel well enough for the population consequence to improve. Monitoring must also account for whales that stop calling or

leave. Fewer detections after noise begins can mean fewer animals, quieter animals or a failed instrument, and each explanation requires different evidence.

Look for the Life-History Lag

Whale recovery contains delays that make both optimism and pessimism unreliable. A reduction in adult deaths can take years to appear as more calves, and those calves take further years to enter the breeding population. Poor feeding in one season can affect pregnancy, calf survival or the interval before the next birth.

Read trends with that lag in mind. One strong calving season is encouraging and cannot establish recovery. One bad year may reflect a temporary prey shock rather than a lasting decline. A decade of repeated adult mortality is harder to dismiss because long-lived populations depend heavily on survival across many years.

The same logic explains why prevention matters. Saving an adult female preserves her current life, possible future calves and knowledge carried through the group. Replacing her numerically with one newborn is not equivalent. In slow-lived systems, age and reproductive value matter alongside headcount. Population models make this explicit by asking how survival and reproduction vary by age or sex. A management measure that saves a small number of high-value adults can alter the long future more than a larger change in a less limiting stage.

Separate Protection from Risk Removed

A law, sanctuary or moratorium changes rules. Recovery changes when a source of death or lost reproduction changes in the water. Keep those steps separate.

The commercial whaling moratorium reduced a dominant pressure across many populations and earned its place as a conservation success. North Atlantic right whales show the limit of legal protection when fishing lines and ships still kill adults. A speed rule matters only where vessels slow, in the

places and seasons where whales overlap traffic. A gear standard matters only if it reduces severe entanglement without shifting risk elsewhere.

This is not an argument against protection on paper. Rules create authority, expectations and enforcement. It is an argument for completing the causal chain. State the threat, the mechanism of the measure, compliance, measured exposure and the biological outcome. A protected whale can still die. A regulation that changes behaviour and survival is more than a declaration. Compare the observed result with the plausible result without the measure, since a population can decline more slowly and still have benefited. Then ask whether the remaining decline exposes a missing intervention rather than proof that the first one did nothing.

The limits

Whales invite overclaim because direct observation is difficult and public interest is generous. Researchers often work with small tag samples, incomplete carcasses, sparse surveys or sounds whose senders cannot be seen. A result from one population may not travel to another. Behavioural responses do not automatically become population declines, and the absence of a visible response does not prove harmlessness.

Mental claims need particular restraint. Social learning, recognition, cooperation and vocal complexity support evidence of sophisticated cognition. Brain size alone does not place species on one ladder, and these findings do not permit confident stories about grief, names, morality or human-like conversation. Some interpretations will strengthen as experiments improve. Others may remain inaccessible because the decisive behaviour occurs kilometres away or a thousand metres down.

Ecological effects also resist conversion into a slogan. Whales move nutrients, consume prey, support scavengers and store carbon in living tissue. The size and sign of those effects vary with species, food web, nutrient limitation, location and timescale. Restoring whales is justified by biodiversity, welfare, ecological function and historical repair without pretending each animal is a fixed carbon-credit machine.

The one thing to keep

Keep the population in its whole habitat.

A whale is easy to reduce to the moment it surfaces. The blow appears, the back rolls and the animal disappears. Conservation can make the same error by counting bodies while treating everything between sightings as empty water.

The missing habitat includes a prey patch that forms for three weeks, a route learned from a mother, a deep hunting layer, a low-frequency channel, a quiet interval between ships and the survival of adults old enough to remember where to go. None is visible in the photograph. Each can decide whether the animal returns next year with a calf.

This is why the comeback cannot be one curve. Humpbacks multiplying in one ocean do not restore an eastern North Pacific right-whale population measured in tens. An Antarctic blue-whale increase does not erase how far the population remains below its former scale. Twenty-three right-whale calves in a season are welcome, while ropes and hulls still determine whether their mothers survive.

The permanent change is a change of unit. Do not see a whale as a giant object moving through vacant sea. See a slow-lived population carrying anatomy, energy, routes, relationships and learned sound through a human-used ocean. Then success becomes harder to announce and easier to design: keep adults alive, keep food reachable, keep routes passable, keep acoustic space usable and measure the result across whale generations.

A breach is an event. A comeback is a system working long enough for more whales to inherit it.

Terms

A working glossary for the anatomy, behaviour and conservation language used in this book. Several labels are management conveniences rather than perfect natural boundaries, so the definition includes the limit where it matters.

Cetacean. Any member of Cetacea, the mammal group containing whales, dolphins and porpoises. Everyday speech uses whale more narrowly, but biological discussions often need the whole branch.

Mysticete. A baleen whale. Living mysticetes lack functional teeth as adults and filter prey using keratin plates. They include rorquals, right whales, bowheads and grey whales.

Odontocete. A toothed whale. The branch includes sperm and beaked whales, belugas, narwhals, dolphins and porpoises. Odontocetes have one blowhole and use specialised acoustic systems.

Rorqual. A baleen whale with pleated throat grooves that expand during engulfment. Blue, fin, sei, Bryde's, minke and humpback whales belong to this highly mobile feeding group.

Baleen. Rows of keratin plates hanging from a mysticete's upper jaw. Frayed inner edges retain prey while water leaves. Plate length and fineness match different feeding strategies.

Ventral grooves. Long folds running along the throat and belly of rorquals. They allow the mouth floor to expand around a large volume of prey-filled water during a lunge.

Lunge feeding. Accelerating into a dense prey patch with the mouth open, engulfing water and prey, then filtering. The return can be large, but acceleration and drag are costly.

Skim feeding. Swimming with the mouth open while water flows continuously through baleen. Right and bowhead whales use this method to collect small prey from suitable concentrations.

Blowhole. The nostril opening on top of a whale's head, connected to the respiratory tract rather than the mouth. Mysticetes have two external openings; odontocetes have one.

Fluke. One half of the horizontal tail surface, or both halves collectively as tail flukes. Up-and-down movement supplies the main thrust, reflecting the whale's mammalian spinal motion.

Blubber. A thick, vascular layer of fat beneath the skin. It insulates, stores energy, shapes the body and can support fasting, migration, pregnancy and milk production.

Myoglobin. An oxygen-binding protein in muscle. High myoglobin concentrations help diving mammals store oxygen where working tissue can use it, contributing to the dark colour of diving muscle.

Dive response. Coordinated physiological changes during submergence, including a slower heart rate and redistributed blood flow. It protects oxygen for sensitive organs while other tissues use local stores.

Aerobic dive limit. The approximate duration that stored oxygen can support before anaerobic metabolism rises substantially. It varies with activity and conditions, so it is not one fixed species stopwatch.

Echolocation. Active sensing through emitted sounds and returning echoes. Toothed whales use click timing and acoustic detail to locate, track and inspect prey or surroundings in poor visibility.

Melon. A fatty structure in the forehead of most toothed whales that helps shape and direct outgoing echolocation clicks. Its form differs among species and acoustic tasks.

Song. A long, patterned vocal display with repeated organisation. Male humpback songs are the best-known example. The term should not be applied to every whale call or click.

Coda. A short, stereotyped sequence of clicks used socially by sperm whales. Coda repertoires vary among social units and vocal clans, helping

researchers study identity and cultural transmission.

Dialect. A group-specific pattern in calls or repertoires. The label describes consistent acoustic differences without proving that whale signals work like the regional varieties of human language.

Culture. Behaviour or information acquired socially and shared within a group. In whales it can include songs, calls, prey preferences, hunting methods and parts of migratory knowledge.

Matriline. A social line organised through mothers and their descendants. Several toothed-whale societies contain stable maternal relationships through which association, knowledge and vocal traditions can persist.

Migration. Regular movement between areas used for feeding, breeding or other seasonal needs. Routes differ among populations and individuals, and some whales remain resident or migrate only partly.

Krill. Small crustaceans that form dense swarms and support many baleen whales. Their local concentration, depth and season matter more to a feeding whale than ocean-wide average abundance.

Whale pump. The movement of nutrients towards surface waters when whales feed deeper and release waste nearer the top. Measured effects are setting-specific rather than one universal productivity bonus.

Photo-identification. Matching individual whales from stable visible features such as fluke patterns, callosities, dorsal fins or scars. Repeated photographs can reveal survival, movement, calving and association histories.

Stock. A management unit intended to represent whales sharing demography and exposure to human activity. Stock boundaries are practical approximations and may not match genetic or cultural population structure.

Entanglement. Contact with fishing line or gear that traps, cuts or drags on a whale. Consequences range from scars to impaired feeding, chronic injury, drowning and death.

Ship strike. A collision between a vessel and a whale. Risk depends on traffic, speed, whale distribution, detection and behaviour, with many fatal events never recovered or observed.

Acoustic masking. Interference that makes a signal harder to detect or interpret because other sound overlaps it. Masking can reduce communication or sensing range without causing physical hearing damage.

Moratorium. The International Whaling Commission's pause on commercial whaling catch limits, adopted in 1982 and operating from the 1985/86 season. It is not a universal ban on every whale hunt.

Go Deeper

Four routes into a subject that crosses palaeontology, physiology, behaviour, history and conservation. None tries to make one species stand in for the whole group. Begin with Pyenson for the complete arc, then choose culture, institutional history or identification according to which part of the whale problem now feels least finished.

The broad narrative. **Nicholas D. Pyenson, *Spying on Whales: The Past, Present, and Future of Earth's Most Awesome Creatures* (Viking, 2018).** Pyenson is a Smithsonian palaeontologist, and the book moves between fossils, living whales, museum collections and fieldwork without turning into a species catalogue. Read it for the long arc from land mammals to modern giants and for a clear account of how whale scientists extract evidence from bones, carcasses and changing oceans. It is personal in places, but the research remains the engine.

Culture and mind. **Hal Whitehead and Luke Rendell, *The Cultural Lives of Whales and Dolphins* (University of Chicago Press, 2015).** This is the strongest next step after the chapters on song, codas and social inheritance. The authors define culture carefully, compare evidence across cetaceans and ask how learned traditions affect ecology, evolution and conservation. It is accessible to a committed general reader, though denser than a popular natural history. Its restraint is part of its value: impressive behaviour is

separated from claims the evidence cannot yet carry.

Whaling, science and power. D. Graham Burnett, *The Sounding of the Whale: Science and Cetaceans in the Twentieth Century* (University of Chicago Press, 2012). A large, demanding history of how governments, industry and scientists tried to make whales countable and governable while fleets were destroying the populations under study. Read it for the institutions behind the moratorium, the politics inside apparently technical categories and the reason a whale estimate is never only a number. This is the longest recommendation and should be approached as a serious history rather than an introductory survey.

Seeing the living diversity. Mark Carwardine, *Field Guide to Whales, Dolphins and Porpoises* (Bloomsbury Wildlife, 2022). Use this beside photographs, sightings or documentaries. The illustrations, range information and identification features make the breadth of Cetacea tangible, from river dolphins and beaked whales to rorquals. A field guide cannot explain the full mechanism or history, but it corrects the composite media whale by forcing attention onto distinct bodies, blows, fins, movements and distributions. It is the easiest book here to open for ten minutes and keep returning to.

Notes and Sources

Scope, names and current data

Whale as a working term. Cetacea includes whales, dolphins and porpoises, while ordinary English uses whale for a less exact subset. The manuscript concentrates on animals commonly called whales and uses dolphins, porpoises and orcas where they clarify the odontocete branch, culture or terminology. Living species totals change as genetic work revises taxonomy, so the text uses "more than ninety" rather than a fixed count. Berta, Sumich and Kovacs provide the general systematics; Carwardine supplies the field-guide treatment.

Population before species. The International Whaling Commission

distinguishes species, populations, stocks and assessment areas because a global label can hide sharply different histories. Current figures in the manuscript were verified on 4 September 2026. Publication or page-update date is not treated as the observation year. The North Atlantic right-whale estimate, for example, is a 2024 abundance estimate presented in a 2026 IWC status product.

The Whole Thing in One Page and Why You Should Care

Scale and body size. NOAA Fisheries gives Antarctic blue-whale lengths up to about 110 feet and weights above 330,000 pounds, while other populations are generally smaller. The manuscript uses "roughly thirty metres" and "well over 100 tonnes" to avoid attaching the whole species to an exceptional record. Goldbogen and colleagues explain the energetic limits on body size.

The 222-minute dive. Quick and colleagues reported the 222-minute Cuvier's beaked-whale dive within a long-term tagging study. It was an extreme observation, not a normal duration. The narrative therefore sets it beside routine dives and avoids converting a record into a species average.

Twentieth-century catches. Rocha, Clapham and Ivashchenko reconstructed nearly 2.9 million large whales killed from 1900 to 1999, including more than two million in the Southern Hemisphere. Their estimate is a minimum because it cannot fully recover struck-and-lost animals or every unreported catch.

The Core Ideas

Origins and timing. Uhen's review places the earliest cetaceans in the fossil record at about 52.5 million years ago. Thewissen and colleagues provide the key land-capable skeletons, artiodactyl ankle evidence and South Asian transition. The sequence is branching and incomplete, so the text avoids presenting *Pakicetus*, *Ambulocetus*, protocetids and basilosaurids as one direct line of ancestors.

Whales and hippos. Molecular and fossil evidence places cetaceans within Cetartiodactyla, with hippopotamuses as the closest living sister lineage. This does not mean whales descended from living hippos. The common ancestor preceded the distinctive modern forms of both groups.

Birth, milk and the mammalian inheritance. Berta, Sumich and Kovacs support the integrated account of live birth, lactation, thermoregulation, limb homology and respiratory separation. Tail-first birth is common rather than universal. Cetacean milk is energy-dense and can be expressed into the calf's mouth; the prose avoids implying one identical nursing posture or mechanism across every species.

Gigantism. Slater, Goldbogen and Pyenson linked the comparatively recent rise of extreme baleen-whale size to Plio-Pleistocene changes in ocean productivity and prey patchiness. The causal interpretation remains active because new fossils can move dates and reveal regional exceptions. Goldbogen and colleagues' 2019 comparative work supplies the broader constraint: filter feeders can gain increasing energetic returns from size, while toothed predators face different prey-capture limits.

Lunge feeding and prey demand. Goldbogen and colleagues review engulfment mechanics, including acceleration, drag, expandable ventral tissues and filtration. Savoca and colleagues used tags and prey measurements to estimate consumption directly and found that baleen whales can eat substantially more than estimates based mainly on metabolic extrapolation. The text does not turn those results into one fixed daily ration for all whales.

The origin of baleen. Peredo and colleagues' toothless fossil *Maiabalaena* supports a staged transition in which tooth loss and baleen did not appear as one simultaneous switch. Other early mysticetes preserve teeth, suction-capable jaws and toothless conditions without direct modern equivalents. Whether teeth and baleen overlapped in particular lineages remains debated, but a staged reworking of feeding is better supported than an abrupt arrival of the living condition.

Diving physiology. Kooyman and Ponganis provide the classic integrated account of oxygen stores, cardiovascular adjustment and pressure. Schorr and colleagues established long-term Cuvier's beaked-whale dive records; Quick and colleagues extended the behavioural aerobic-dive analysis. Lung collapse can reduce gas exchange at depth, but it is not complete protection from decompression problems under every profile or disturbance.

Baleen-whale sound production. Elemans and colleagues examined larynges from stranded minke, humpback and sei whales, conducted experiments and built models supporting a specialised laryngeal mechanism with internal air recycling. The small sample, including limited representation of adult singing males, prevents universal anatomical detail from being treated as settled across all mysticetes.

Humpback song. Payne and McVay established the hierarchical description of units, phrases, themes and songs. Garland and colleagues tracked song types moving through South Pacific breeding populations, providing strong evidence for rapid cultural transmission at ocean-basin scale. Song function includes reproductive display, but precise messages or receiver interpretations remain less secure than pattern and transmission.

Bowhead song. Stafford and colleagues documented 184 song types over three winters from the small Spitsbergen bowhead population. The result supports changing, diverse repertoires in that population, not a universal numerical claim for all bowheads.

Sperm-whale codas. Rendell and Whitehead documented vocal clans whose coda repertoires correspond to broad social and behavioural groupings. Sharma and colleagues found contextual and combinatorial structure in Dominica sperm-whale vocalisations. Beguš and colleagues analysed 3,948 codas recorded from fifteen female and immature eastern Caribbean sperm whales between 2014 and 2018, identifying vowel-like acoustic categories and several forms of phonological patterning. Both newer studies concern structure in a bounded dataset. Neither supplies translated semantics or a general account of sperm-whale communication across oceans.

Orca specialisation. Ford and colleagues documented sharply different diets in sympatric fish-eating and mammal-eating killer-whale populations in the northeastern Pacific. Whitehead and Rendell place this within the wider evidence for cetacean culture. The example supports social inheritance without claiming that environment or genes are irrelevant.

Feeding culture. Allen and colleagues used a twenty-seven-year dataset and network-based diffusion analysis to show that social transmission contributed to the spread of lobtail feeding among humpbacks in the Gulf of Maine. The finding supports one population-level example of learned feeding, not a universal rate or repertoire for humpbacks.

Life-history arithmetic. Age at maturity, gestation, calving interval and survival vary widely across cetaceans. The manuscript avoids one universal schedule and retains the general result supported by marine-mammal demography: large whales invest heavily in single calves, and population growth is highly sensitive to adult survival, especially that of reproductive females.

Narrative sequence

Fossil landmarks. Thewissen and colleagues support the Eocene South Asian setting, amphibious locomotion and artiodactyl relationship. Uhen supplies the broader chronology and warns against a ladder-like account. The claim that each intermediate form had to remain workable is an evolutionary inference, not a statement that every anatomical transition is represented by a known fossil.

The mysticete-odontocete split. Berta, Sumich and Kovacs and Peredo and colleagues support the contrasting histories of teeth, baleen, skull telescoping and sound production. The Oligocene date is rounded because estimates depend on fossil placement and molecular calibration.

Pre-industrial whaling. Tønnessen and Johnsen provide the long commercial history, while Burnett follows the later relationship among whaling, science and government. The treatment distinguishes Indigenous subsistence systems from mobile industrial fleets. It does not claim that

every pre-industrial hunt was sustainable or identical in cultural meaning.

Svend Foyn and mechanisation. Tønnessen and Johnsen and the New Bedford Whaling Museum document the combination of steam catcher, cannon, explosive harpoon, powered line handling and methods for keeping rorqual carcasses afloat. Credit is stated as a package pioneered and commercialised by Foyn rather than as the creation of every component by one inventor.

Factory ships and serial depletion. Tønnessen and Johnsen describe stern-slipway factory ships, Antarctic expansion and the movement from larger to smaller target species. Burnett explains quota systems and the Blue Whale Unit, which converted different species into a common accounting measure. The manuscript interprets the changing catch mix as often reflecting depletion, while leaving room for prices, rules and operating costs.

Illegal Soviet whaling. Ivashchenko and Clapham reconstruct systematic falsification and hidden catches from corrected records and testimony. The case changes population estimates and illustrates why official catch statistics cannot be accepted without institutional context.

The IWC moratorium. The International Whaling Commission's official account records adoption in 1982 and operation from the 1985/86 season. The legal detail matters: it set zero commercial catch limits under the Schedule but did not abolish aboriginal subsistence whaling, treaty objections, scientific provisions or hunting by non-members. The text calls it a pause or moratorium rather than a universal ban.

Humpback recovery and measurement frame. Zerbini and colleagues modelled western South Atlantic humpbacks at about 93 per cent of estimated pre-exploitation abundance in 2019. That was a population-specific reconstruction with uncertainty in the historical baseline. The body now follows the IWC's 2026 status framework, which describes the population as strongly increased but not yet recovered and reports 11,672 animals with a wide interval. The classification and the older

percentage are not treated as contradictory measurements of one identical quantity. Current IWC graphics also separate the 2026 publication update from southern humpback growth inputs covering 1995 to 2015, and report a distinct West South African population estimate of 484 with an interval of 138 to 860.

Blue whales and data vintage. IWC population summaries show sharply different trajectories. Eastern North Pacific blue whales are near the estimated pre-exploitation level. Southern Hemisphere and Antarctic blue-whale estimates show increase from an exceptionally depleted base, while remaining far below reconstructed pre-whaling abundance. The current IWC summary notes that the Antarctic assessment still depends on circumpolar estimates from the 1990s and 2000s. Publication date, observation period and assessment frame are therefore kept separate, and the body avoids one global blue-whale total.

Bowheads, right whales and grey whales. IWC status materials support the recovery of the Bering-Chukchi-Beaufort bowhead population and the continued scarcity of Okhotsk and Svalbard-area bowheads. They also show strong regional variation among southern right whales and the separation between eastern and western North Pacific grey-whale histories.

North Atlantic right whales. The IWC's 2026 status product gives a best estimate of 384 animals alive at the start of 2024, with a 95 per cent interval of 375 to 394. NOAA Fisheries documented 23 calves during the completed 2025/26 season, the highest count since 2009, while retaining concern about the small number of reproductive females, entanglement and vessel strikes. The assessment publication year, population reference year and calving observation period are stated separately. A strong calving season is treated as encouraging evidence, not a reversal established by one year.

Entanglement and collision. Knowlton and colleagues use scarring and sighting histories to show repeated entanglement in North Atlantic right whales. Laist and colleagues synthesise ship-strike records and the influence of vessel type, speed and whale distribution. Both evidence bases undercount events because many carcasses are never found or examined.

Noise and masking. Southall and colleagues provide exposure criteria for residual hearing effects, while the wider acoustic literature distinguishes injury, behavioural response and masking. The text keeps those pathways separate. Population consequences require an additional chain through feeding, communication, condition, survival or reproduction.

Climate-linked prey change. IWC population assessments and NOAA status work document cases where marine heatwaves and prey redistribution coincide with changes in whale abundance, distribution or reproduction. The manuscript does not attribute every movement or poor calving year to long-term climate change without population-specific evidence.

How we know. Berta, Sumich and Kovacs provide the overview of surveys, tagging, age estimation, anatomy and population genetics. Burnett supplies the historical warning that measurement systems were shaped by whaling institutions. IWC status products combine current publication with estimates and trend windows from different observation periods. The notes therefore state reference years and uncertainty for retained current numbers rather than treating every 2026 graphic as a 2026 census.

What People Get Wrong and Use It

Fish resemblance. The similarity of fish and whale outlines is a standard example of convergence. The correction matters because thermoregulation, lungs, milk, live birth and slow demography follow ancestry rather than body outline alone.

Migration diversity. Berta, Sumich and Kovacs and IWC species accounts support broad variation among complete migrants, partial migrants, regional residents and individuals using different seasonal strategies. The familiar high-latitude feeding and low-latitude breeding shuttle is common among large baleen whales but not universal.

Whales and fisheries. Roman and colleagues review whales as consumers, prey, nutrient vectors and carcasses. Roman and McCarthy measured the whale-pump pathway in the Gulf of Maine. These sources

support mechanisms, not a universal claim that more whales always raise fishery yield. The manuscript explicitly retains possible competition and setting-specific outcomes.

Carbon. Pearson and colleagues review storage in whale biomass, sinking carcasses and indirect productivity pathways, along with large uncertainties and risks of double counting. The book rejects fixed per-whale carbon values and does not present whale recovery as a substitute for reducing greenhouse-gas emissions.

Protection and counterfactuals. Population response should be compared with a credible no-action trajectory rather than with immediate growth alone. A measure can reduce decline without producing recovery if another mortality source remains. This is an inference from population dynamics and is stated as a lens rather than a population-specific measured result.

Go Deeper verification

The four recommendations were checked against publisher or library records on 4 September 2026. Pyenson was published by Viking in 2018; Whitehead and Rendell by University of Chicago Press in 2015; Burnett by University of Chicago Press in 2012; and Carwardine's current field guide by Bloomsbury Wildlife in 2022. Each was used materially in modelling, terminology, evidence control or reader guidance.

Bibliography

Books and major reference works

Berta, Annalisa, James L. Sumich and Kit M. Kovacs. *Marine Mammals: Evolutionary Biology*. 3rd ed. Academic Press, 2015.

Burnett, D. Graham. *The Sounding of the Whale: Science and Cetaceans in the Twentieth Century*. University of Chicago Press, 2012.

Carwardine, Mark. *Field Guide to Whales, Dolphins and Porpoises*. Bloomsbury Wildlife, 2022.

Pyenson, Nicholas D. *Spying on Whales: The Past, Present, and Future of Earth's Most Awesome Creatures*. Viking, 2018.

Tønnessen, J. N., and A. O. Johnsen. *The History of Modern Whaling*. Translated by R. I. Christophersen. University of California Press, 1982.

Whitehead, Hal, and Luke Rendell. *The Cultural Lives of Whales and Dolphins*. University of Chicago Press, 2015.

Research and scientific synthesis

Allen, Jenny, Mason Weinrich, Will Hoppitt and Luke Rendell.

"Network-Based Diffusion Analysis Reveals Cultural Transmission of Lobtailing in Humpback Whales." *Science* 340 (2013): 485-488. DOI 10.1126/science.1231976.

Beguš, Gašper, Maksymilian Dąbkowski, Ronald L. Sprouse, David F. Gruber and Shane Gero. "The Phonology of Sperm Whale Coda Vowels." *Proceedings of the Royal Society B* 293 (2026): 20252994. DOI 10.1098/rspb.2025.2994.

Elemans, Coen P. H., et al. "Evolutionary Novelty Underlies Sound Production in Baleen Whales." *Nature* 627 (2024): 123-129. DOI 10.1038/s41586-024-07080-1.

Ford, John K. B., et al. "Dietary Specialization in Two Sympatric Populations of Killer Whales in Coastal British Columbia and Adjacent Waters." *Canadian Journal of Zoology* 76 (1998): 1456-1471. DOI 10.1139/z98-089.

Garland, Ellen C., et al. "Dynamic Horizontal Cultural Transmission of Humpback Whale Song at the Ocean Basin Scale." *Current Biology* 21 (2011): 687-691. DOI 10.1016/j.cub.2011.03.019.

Goldbogen, Jeremy A., et al. "How Baleen Whales Feed: The Biomechanics of Engulfment and Filtration." *Annual Review of Marine Science* 9 (2017): 367-386. DOI 10.1146/annurev-marine-122414-033905.

Goldbogen, Jeremy A., et al. "Why Whales Are Big but Not Bigger." *Science* 366 (2019): 1367-1372. DOI 10.1126/science.aax9044.

Ivashchenko, Yulia V., and Phillip J. Clapham. "Too Much Is Never Enough: The Cautionary Tale of Soviet Illegal Whaling." *Marine Fisheries Review* 76, nos. 1-2 (2014): 1-21. DOI 10.7755/MFR.76.1_2.1.

Knowlton, Amy R., et al. "Monitoring North Atlantic Right Whale Entanglement Rates: A 30 yr Retrospective." *Marine Ecology Progress Series* 466 (2012): 293-302. DOI 10.3354/meps09923.

Kooyman, Gerald L., and Paul J. Ponganis. "The Physiological Basis of Diving to Depth: Birds and Mammals." *Annual Review of Physiology* 60 (1998): 19-32. DOI 10.1146/annurev.physiol.60.1.19.

Laist, David W., et al. "Collisions between Ships and Whales." *Marine Mammal Science* 17 (2001): 35-75. DOI 10.1111/j.1748-7692.2001.tb00980.x.

Payne, Roger S., and Scott McVay. "Songs of Humpback Whales." *Science* 173 (1971): 585-597. DOI 10.1126/science.173.3997.585.

Pearson, Heidi C., et al. "Whales in the Carbon Cycle: Can Recovery Remove Carbon Dioxide?" *Trends in Ecology & Evolution* 38 (2023): 238-249. DOI 10.1016/j.tree.2022.10.012.

Peredo, Carlos Mauricio, et al. "Tooth Loss Precedes the Origin of Baleen in Whales." *Current Biology* 28 (2018): 3992-4000.e2. DOI 10.1016/j.cub.2018.10.047.

Quick, Nicola J., et al. "Extreme Diving in Mammals: First Estimates of Behavioural Aerobic Dive Limits in Cuvier's Beaked Whales." *Journal of Experimental Biology* 223 (2020): jeb222109. DOI 10.1242/jeb.222109.

Rendell, Luke, and Hal Whitehead. "Vocal Clans in Sperm Whales." *Proceedings of the Royal Society B* 270 (2003): 225-231. DOI 10.1098/rspb.2002.2239.

Rocha, Robert C., Phillip J. Clapham and Yulia V. Ivashchenko. "Emptying the Oceans: A Summary of Industrial Whaling Catches in the 20th Century." *Marine Fisheries Review* 76, no. 4 (2015): 37-48. DOI 10.7755/MFR.76.4.3.

Roman, Joe, et al. "Whales as Marine Ecosystem Engineers." *Frontiers in Ecology and the Environment* 12 (2014): 377-385. DOI 10.1890/130220.

Roman, Joe, and James J. McCarthy. "The Whale Pump: Marine Mammals Enhance Primary Productivity in a Coastal Basin." *PLOS ONE* 5 (2010): e13255. DOI 10.1371/journal.pone.0013255.

Savoca, Matthew S., et al. "Baleen Whale Prey Consumption Based on High-Resolution Foraging Measurements." *Nature* 599 (2021): 85-90. DOI 10.1038/s41586-021-03991-5.

Schorr, Gregory S., et al. "First Long-Term Behavioral Records from Cuvier's Beaked Whales." *PLOS ONE* 9 (2014): e92633. DOI 10.1371/journal.pone.0092633.

Stafford, Kathleen M., et al. "Extreme Diversity in the Songs of Spitsbergen's Bowhead Whales." *Biology Letters* 14 (2018): 20180056. DOI 10.1098/rsbl.2018.0056.

Sharma, Pratyusha, et al. "Contextual and Combinatorial Structure in Sperm Whale Vocalisations." *Nature Communications* 15 (2024): 3617. DOI 10.1038/s41467-024-47221-8.

Slater, Graham J., Jeremy A. Goldbogen and Nicholas D. Pyenson. "Independent Evolution of Baleen Whale Gigantism Linked to Plio-Pleistocene Ocean Dynamics." *Proceedings of the Royal Society B* 284 (2017): 20170546. DOI 10.1098/rspb.2017.0546.

Southall, Brandon L., et al. "Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects." *Aquatic Mammals* 45 (2019): 125-232. DOI 10.1578/AM.45.2.2019.125.

Thewissen, J. G. M., et al. "Skeletons of Terrestrial Cetaceans and the Relationship of Whales to Artiodactyls." *Nature* 413 (2001): 277-281. DOI 10.1038/35095005.

Thewissen, J. G. M., et al. "Whales Originated from Aquatic Artiodactyls in the Eocene Epoch of India." *Nature* 450 (2007): 1190-1194. DOI

10.1038/nature06343.

Uhen, Mark D. "The Origin(s) of Whales." *Annual Review of Earth and Planetary Sciences* 38 (2010): 189-219. DOI

10.1146/annurev-earth-040809-152453.

Zerbini, Alexandre N., et al. "Assessing the Recovery of an Antarctic Predator from Historical Exploitation." *Royal Society Open Science* 6 (2019): 190368. DOI 10.1098/rsos.190368.

Institutions and current status sources

International Whaling Commission. "Commercial Whaling", "Population Status Summaries" and "Status of Whales: Table of Graphics". Current products and legal summaries accessed 4 September 2026.

New Bedford Whaling Museum. "Whales and Hunting" and "Modern Whaling" research resources. Accessed 4 September 2026.

NOAA Fisheries. "Blue Whale", "Cuvier's Beaked Whale", "North Atlantic Right Whale", "North Atlantic Right Whale Calving Season 2026" and "By the Numbers: 2026 North Atlantic Right Whale Calving Season". Accessed 4 September 2026.