Why Whales Leap

The action, which is called breaching, seems to be purposeful. It is associated with the social aspects of whale life and probably serves in communication

by Hal Whitehead

A whale's leap from the water is almost certainly the most powerful single action performed by any animal. It is called breaching, a term that whalers of the 18th and 19th centuries gave this dramatic activity and that present-day investigators of the phenomenon have retained. Considering the great bulk and weight the whale must lift in breaching, one wonders why the animal does it.

A breach provides the only opportunity most human observers have to see an entire whale, and it has inspired a wide variety of impressions. Thus J. N. Reynolds, recounting for readers of *The Knickerbocker* in 1839 the adventures of whalers in the Pacific, wrote: "Occasionally, a huge, shapeless body would flounce out of its proper element, and fall back with a heavy splash; the effort forming about as ludicrous a caricature of agility, as would the attempt of some over-fed alderman to execute the Highland fling." To Herman Melville the breach was sublime. "Rising with his utmost velocity from the furthest depths," Melville wrote in *Moby Dick,* "the Sperm Whale thus booms his entire bulk into the pure element of air, and piling up a mountain of dazzling foam, shows his place to the distance of seven miles and more. In those moments, the torn, enraged waves he shakes off, seem his mane."

The whalers of earlier centuries, searching for their quarry in slow sailing vessels, had many opportunities to observe the whales they were trying to catch. For years the anecdotes told by such men formed the basis of what was known of breaching and other kinds of whale behavior. Among the explanations of breaching they proposed, somewhat anthropomorphically, were feeding, stretching, amusement, being chased by swordfish and an "act of defiance," which was presumably directed at the whalers.

In the past few years scientific observations of whales in the open ocean have begun to yield useful quantitative data on many aspects of their behavior, including the breach. Roger Payne of the U.S. World Wildlife Fund and his associates have contributed many insights through their long study of southern right whales (*Eubalaena australis*) off the Valdés Peninsula in Argentina. Other important studies include work with gray whales (*Eschrichtius robustus*) off Baja California by Kenneth S. Norris of the University of California at Santa Cruz and a number of other investigators and observations of humpback whales (*Megaptera novaeangliae*) off Hawaii by James D. Darling of the University of California at Santa Cruz, Peter Tyack of the Woods Hole Oceanographic Institution and others. My own work has also been mainly with humpbacks that are in the western North Atlantic off Newfoundland during the summer and on Silver Bank in the West Indies during the winter.

Such long-term observations are crucial to an understanding of breaching because the phenomenon is generally rare. Most whales are seldom seen to breach. Hence it usually takes many years to witness even a moderate number of breaches. In this respect the research on Silver Bank was particularly important. Humpback whales from the western North Atlantic congregate there during the winter months for mating and calving. They reach a density approximating one whale per square kilometer. Many of them breach: during our transects of some 200 kilometers across the bank for the purpose of estimating the size of the population we saw breaching in about 20 percent of the pods (usually containing from one whale to four whales) we sighted.

A leap by a humpback entails the lifting of as much biomass as would be accounted for by 485 people weighing an average of 68 kilograms (150 pounds) each. The largest humpbacks reach lengths approximating 15 meters (49 feet) and weigh 33 metric tons (72,765 pounds).

The breaches of the humpback and of other whales known to breach range from a full leap clear of the water to a leisurely surge in which only half of the body emerges. In more than a fourth of the breaches by humpbacks at least 70 percent of the animal comes out of the water, but it is rare for the entire whale to be seen above the surface. Humpbacks breach at all angles up to 70 degrees with respect to the surface of the sea.

Payne has observed the breaching process while watching southern right whales from cliffs or small airplanes. The whale swims horizontally until it has developed enough speed. Then it tilts its head upward and raises its flukes, or tail. These actions convert the horizontal momentum into vertical momentum and the whale emerges from the water. Because of the horizontal approach, a whale can breach in water that is only a few meters deep.

Whales perform other actions that superficially resemble breaching. One of them is lunging. In this maneuver the whale thrusts no more than 40 percent of its body through the surface. A lunge can be executed horizontally, vertically or at any angle between those extremes. The whale can be oriented so that its dorsal surface or ventral surface is uppermost or so that it is lying on its side. Whales often are seen closing their jaws while lunging, sometimes ingesting a mouthful of plankton or small fish. Lunging is therefore usually considered to be associated with feeding. Humpbacks, however, can be seen to lunge as they try to outmaneuver one another in large groups, for example when from two to 10 males compete for access to a female among them. Lunging, then, happens when a whale breaks the surface as an unin-

tentional result of an underwater maneuver. A breach, on the other hand, seems to be purposeful.

Another activity in which certain aquatic animals intentionally jump above the surface is porpoising. The animal makes a series of horizontal leaps while traveling fast. Robert W. Blake of the University of British Columbia has calculated that by making such leaps a small whale or a dolphin minimizes frictional drag. He has also shown that large whales would not benefit in this way by porpoising, and indeed I have never seen humpbacks do it.

Breaches fall naturally into two types, which I call belly flops and true breaches. In the belly flop the whale remains dorsal side up throughout the breach and lands on its belly. In a true breach the animal emerges from the water on its side, twists with flailing flippers and lands on its back. Humpbacks make true breaches about 80 percent of the time; about 20 percent of the time they belly flop.

A belly-flopping whale is more likely to be seen to blow, or exhale, than a whale making a true breach. Payne has suggested that belly flopping might be as painful for whales as it is for people. It does, however, leave the blowhole clear of the water for a longer time than the true breach does. It thus might be the choice when the whale wants to breathe during a breach.

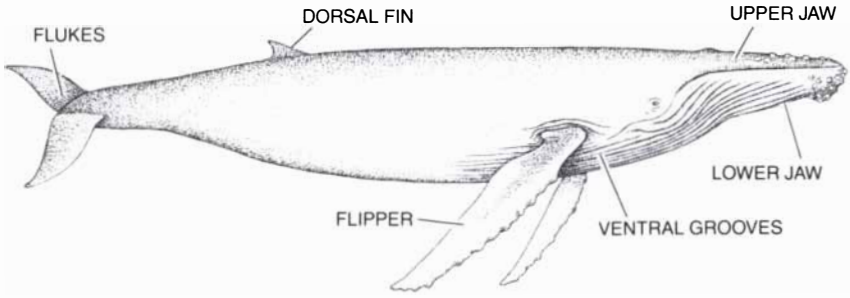
Breaches are often executed in sequence. A particular whale may breach every 40 seconds or so for a few minutes. Among pods of humpback whales in the western North Atlantic the mean sequence length was 9.4 breaches. (The mean includes occasions when a sequence consisted of only a single breach.) Usually all the breaches appeared to be made by a single animal. One sequence we observed on Silver Bank consisted of 130 breaches in 75 minutes, probably all by the same animal.

Within a sequence the tendency is for belly flop to follow belly flop, true breach to follow true breach. Among both humpbacks and right whales a breaching animal tends to lift successively less of its body out of the water as a sequence progresses. As one might expect in the circumstances, the whale seems to be getting tired.

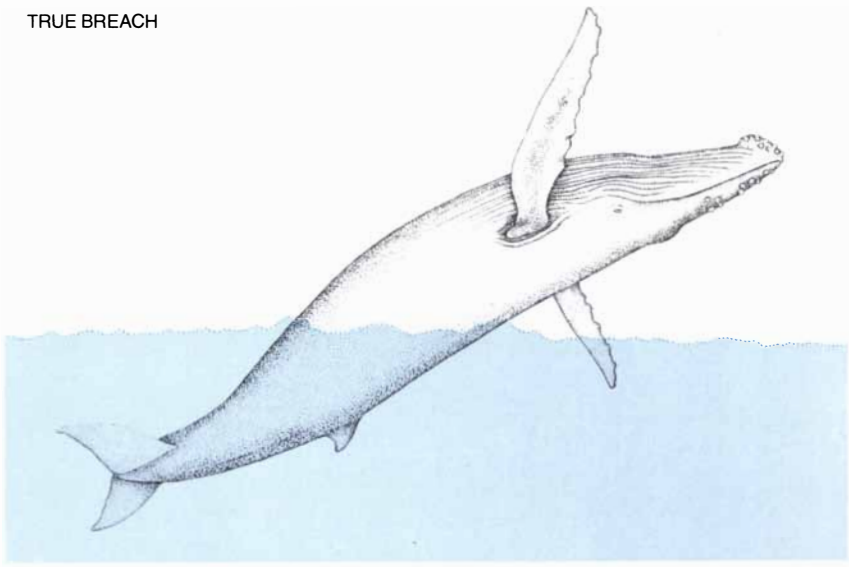
How much energy is a whale consuming as it makes a breach, and how much power is it developing as it leaves the surface? Using measurements from photographs of breaching whales, I have simulated the breaching process on a small computer. In a full breach, in which most of the animal leaves the surface of the water at an angle of about 35 degrees, a 12-meter adult humpback breaks the surface at about 15 knots (17 miles per hour). Because that is almost the maximum speed the animal can attain, a full breach represents the extreme use of a humpback's propulsive power.

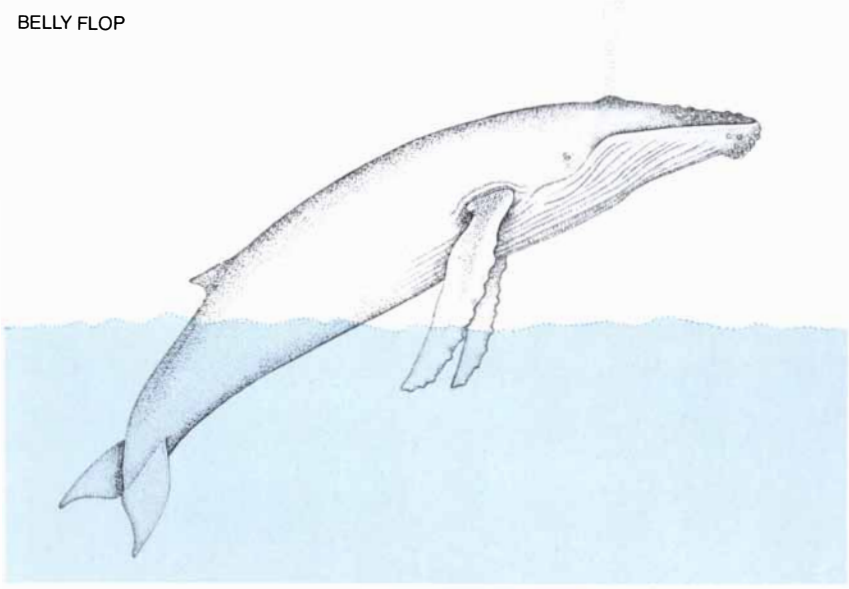
The energy necessary to make such a

BREACHING WHALE was photographed in the Pacific Ocean near Hawaii. The whale, a humpback (*Megaptera novaeangliae*), was executing a true breach, in which the animal emerges from the water on its side, twists in the air and lands on its back. The other type of breach, done much less frequently, is a belly flop. Most of the breaches observed (approximately 80 percent) are true breaches.



HUMPBACK WHALE was the subject of most of the author's observations of breaching. The humpbacks he and his colleagues studied spend the summer off Newfoundland and the winter on Silver Bank in the West Indies. Social interactions among the humpbacks are probably more important in the winter, the season when the whales mate and give birth.





TRUE BREACH AND BELLY FLOP begin as the whale emerges from the water at any angle up to 70 degrees with respect to the surface. The animal lands on its back or belly respectively, as is depicted here. Often in a belly flop the whale blows, or exhales, suggesting that the belly flop (done infrequently) might be the choice when the animal wants to breathe. The belly flop keeps the blowhole clear of the water for a longer time than the true breach.

breach is roughly 2,500 kilocalories. The whale's resting metabolic rate is some 300,000 kilocalories per day. Hence the energy consumed in a breach is a little less than a hundredth of the animal's minimum daily caloric requirement. The energy translates into about 2.6 kilograms (5.7 pounds) of the capelin fish (*Mallotus villosus*), a major item in the humpback's diet. (Humpbacks often catch capelin in 100-kilogram gulps.) One breach is therefore not a particularly significant event in the daily energy budget of a whale. A sequence of 20 breaches or more, however, consumes a good deal of energy. It is not surprising that successive breaches are weaker.

It is less easy to say why a whale breaches. Studying the behavior of large whales has been likened to astronomy. The observer glimpses his subjects, often at long range; he cannot do experiments, and he must continually try to infer from data that are usually inadequate. Under conditions of this kind one way to investigate the function of an activity is to examine its context.

I have spent several hundred hours in small sailboats following groups of humpbacks through their daily routines. This work, together with the observations by Payne and others, is yielding a fairly clear picture of the circumstances in which whales breach. It is not giving rise to a set of firm rules about breaching; such certainty is usually not possible in studies of the behavior of advanced animals. The best one can do is to put forward statistically significant tendencies. What they suggest is that breaching is mainly associated with social interaction among whales, perhaps in communication and (among young whales) play.

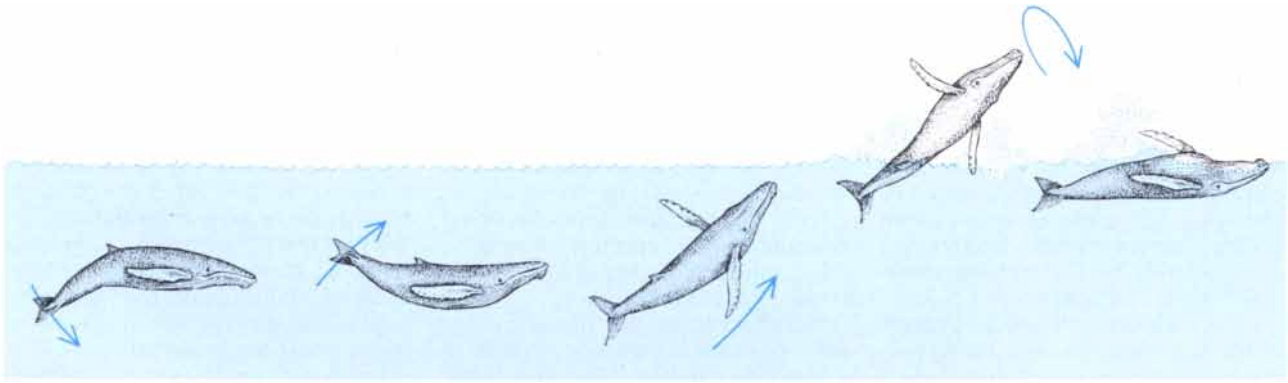
Whales often breach when a pod containing two or more humpbacks splits into two groups or when two pods (sometimes consisting of single whales) merge. A breach also often takes place within 15 minutes of a lobtail: a thrash of the whale's flukes onto the surface of the water. It may similarly be associated with flippering (a flipper lifted above the water and slapped down) and other demonstrations. Christopher W. Clark of Rockefeller University and Payne have observed similar patterns among southern right whales.

It is notable and apparently contradictory that humpbacks breach less in summer, even though groups split and merge more often then than they do in winter. Mating and calving take place in winter, however, and such social interactions are probably more important than the summer ones. Hence

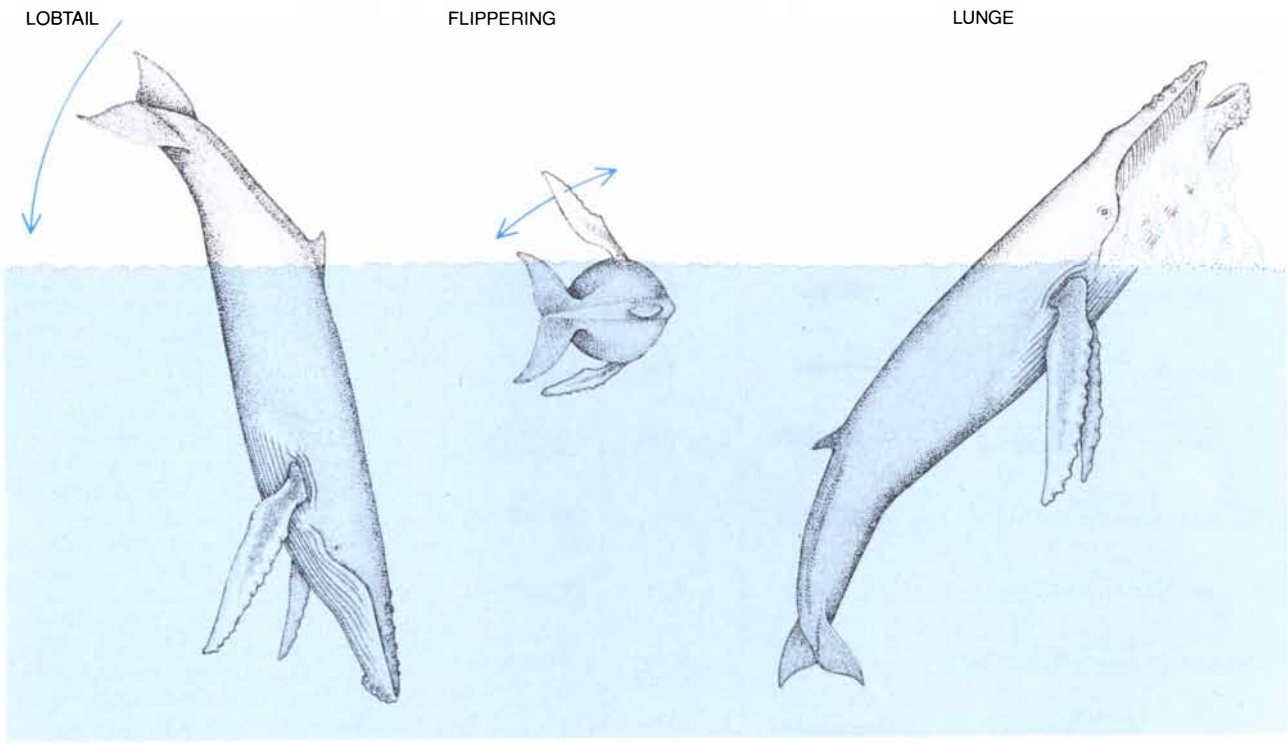
breaching rates are correlated not only with the number of social interactions taking place but also with their importance in the life of the whales.

An additional correlation between breaching and social activity is seen when one looks at the rates of breaching among different whale species. In examining this question I drew up a table that includes the ratio of mean mass to length cubed as an indication of rotundity. The more rotund species would seem to be less likely to breach because of unfavorable hydrodynamics. It is surprising, then, that observations show that they do it more frequently.

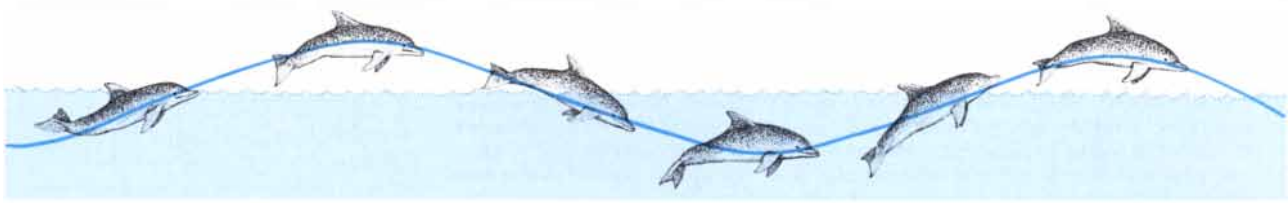
Right whales, gray whales and humpbacks—the three best-studied rotund species—congregate in winter on traditional breeding grounds. They sel-



EXECUTION OF BREACH begins when the whale, swimming more or less parallel to the surface, builds up speed. It raises its flukes and tilts its head upward, changing the horizontal momentum to vertical momentum. This whale is beginning a true breach.



ACTIVITIES RELATED TO BREACHING include lobtailing, in which the whale slaps its flukes on the surface, and flippering, in which a flipper is slapped on the surface. They seem to be purposeful. Lunging, which brings only part of the body out of the water, is evidently an unintentional result of an underwater maneuver. A breach often is done within 15 minutes of lobtailing or flippering.



PORPOISING consists of a series of horizontal leaps made when the animal is moving at high speed. For a small whale or a dolphin the action minimizes frictional drag from the water. Porpoising would not be efficient for large whales, and they seem not to do it.

dom feed there, subsisting instead on the energy stored in their thick layers of blubber. Social interactions are frequent and sometimes vigorous on those breeding grounds, and it is there that most breaching is seen.

In contrast the blue whale (*Balaenoptera musculus*), the finback (*B. physalus*) and the sei (*B. borealis*)—all slim—do not seem to frequent particular breeding grounds but remain dispersed during the winter months. This strategy probably reduces their net expenditure of energy, so that they do not need thick blubber layers. They may employ loud low-frequency sound or perhaps a monogamous social system to obtain access to mates. In any event they probably have rather few close-range social interactions.

Little is known of the social systems of the bowhead (*Balaena mysticetus*), Bryde's whale (*Balaenoptera edeni*) or the minke (*B. acutorostrata*), but the general impression among close observers is that among these baleen whales the more social species have the higher breaching rates. The sperm whale (*Physeter catodon*), a toothed whale that breaches frequently, has a particularly complex social system.

What other clues emerge from investigations of the context of breaching? One unexpected finding, obtained in several independent studies, is that whales breach oftener as the wind speed rises. It is not an abrupt increase during gales, when a whale might be trying to get a breath of air unaccompanied by spray, but rather a gradual increase over quite moderate wind speeds. Payne has speculated that whales might be using the breach as a means of communicating by sound (from the slap of reentry) when noise from wind and waves obscures their normal vocalizations.

Payne made another discovery that led him to think breaches might have a signaling function. He found that among southern right whales breaching begets breaching. In other words, the likelihood that an individual whale would breach increased when whales nearby were breaching. Intrigued by this finding, I carried out a rudimentary form of the procedure known as spectral analysis on some of our transects on Silver Bank. The results suggest that breaching humpbacks form clusters about 10 kilometers in diameter. A whale was more likely to be breaching if it was within 10 kilometers of other breaching whales. At the height of the season such a cluster might have 100 humpbacks, of which from 10 to 15 might be breaching. Under good conditions they might be expected to hear the sound of a breach over a distance of a few kilometers. Thus the findings lend tentative support to Payne's hypothesis that breaching has a signaling function. If other whales see or hear a breach, information has been conveyed. The message would at least be that a whale has breached.

Is a breach an efficient way of conveying any other message? It makes a spectacular sight and a loud noise for observers on the surface, but most of the other whales are below the surface at the time of a breach. Even in the clearest water the limit of underwater vision is about 50 meters. Under favorable conditions, however, sound can travel quite far in seawater. The question therefore becomes whether a whale can generate louder sounds, in at least a few frequency ranges, by breaching than it can by vocalizing. Little information is available on the strength of the underwater sound produced by a breach, and no information is available on whether whales try to maximize their output of sound during a breach.

A breach might also be a display intended as an act of aggression, as a challenge, as a show of strength or as a maneuver in courtship. Aggression seems to be a fairly unlikely motive. A whale is a smooth and well-cushioned animal, and so it is difficult to see how a breach could do significant harm unless the victim was much smaller than the breacher. I know of a case where a humpback landed on a boat during a series of breaches off Newfoundland, but the incident seems to have been an accident rather than a display of aggression by the whale. During many months at sea in small boats, I have never felt that any of the thousands of breaches we observed was aggressively directed toward us. Moreover, the whale can probably display aggression more effectively by administering a blow with its flukes.

A whale making a full breach is exhibiting its maximum power to any whale within sight or earshot. Hence the breach might be useful as a courtship display, a challenge or a show of strength. A female might choose a

SPECIES	RATIO OF MASS TO LENGTH CUBED	BREACHING RATE
HUMPBACK *(MEGAPTERA NOVAEANGLIAE)*	10.6	VERY FREQUENT
RIGHT *(EUBALAENA AUSTRALIS)*	16.2	OFTEN BREACHES
GRAY *(ESCHRICHTIUS ROBUSTUS)*	14.3	OFTEN BREACHES
SPERM (MALE/FEMALE) *(PHYSETER CATODON)*	10.7/19.1	OFTEN BREACHES
BOWHEAD *(BALAENA MYSTICETUS)*	26.7	OCCASIONAL
BRYDE'S *(BALAENOPTERA EDENI)*	6.1	OCCASIONAL
MINKE *(BALAENOPTERA ACUTOROSTRATA)*	12.3	UNUSUAL
FINBACK *(BALAENOPTERA PHYSALUS)*	4	RARE
BLUE *(BALAENOPTERA MUSCULUS)*	6.3	ALMOST NEVER
SEI *(BALAENOPTERA BOREALIS)*	3.6	ALMOST NEVER

BREACHING AND ROTUNDITY seem to be positively linked: the rounder the whale is, the more likely it is to breach. Rotundity is indicated by the ratio of the whale's mean mass to the cube of its length. In general the slimmer whales do the least breaching, although the hydrodynamics of breaching would seem to favor them. Apparently the correlation arises from the fact that the rotund species frequently engage in the kind of social activity often accompanied by breaching, particularly when they congregate in the winter on traditional breeding grounds. They do not eat much in winter, subsisting mainly on their reserves of blubber. The slimmer whales are much less social and probably feed consistently all year.

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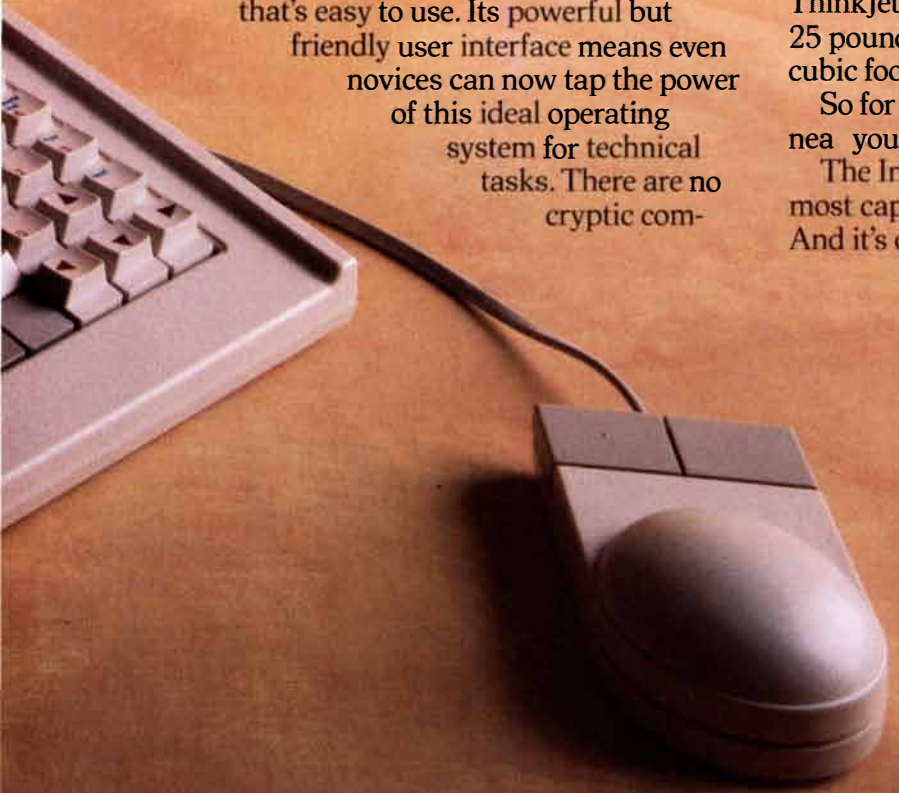

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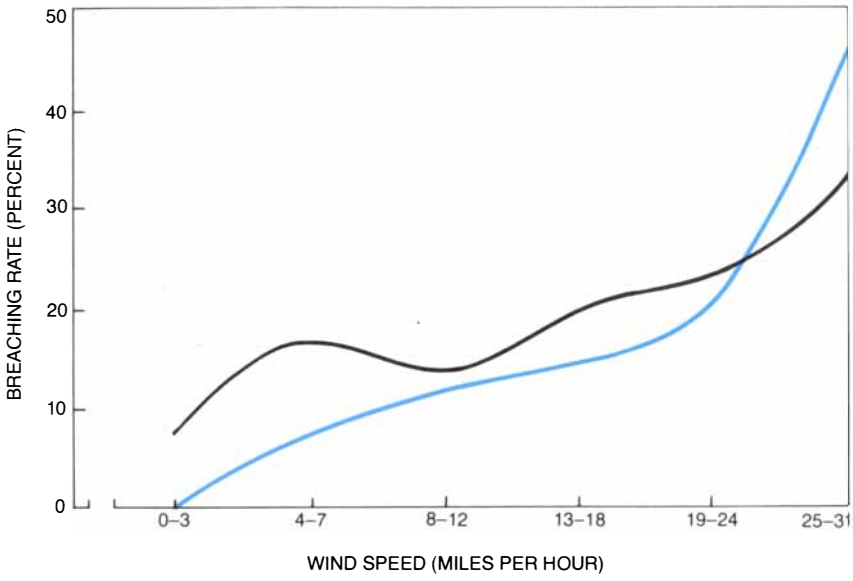

BREACHING AND WIND SPEED also show a positive correlation. The correlation is charted for data derived by the author for humpbacks in 1978 (*black*) and 1980 (*color*). Roger Payne of the U.S. World Wildlife Fund believes breaching increases as the wind rises because it aids communication when the noise of the wave obscures normal vocalizations.

mating partner at least partially on the basis of the strength of his breach or his ability to keep up a strong output of power or sound during a sequence of breaches. Such a male would be demonstrating strength and stamina and so perhaps (indirectly) genetic fitness.

Similar correlations might make a breach useful as a challenge or a show of strength directed at other males competing for access to a particular female. Breaches by right whales and humpbacks are often seen when males are engaged in such a competition.

One must also consider the somewhat blurry concept of play. People watching an animal perform an action with no immediately obvious function tend to call it play. As a result the concept has become a catchall category for otherwise inexplicable behavior, in which breaching has often been included. Recently play has had serious attention from a number of biologists and students of animal behavior, and it is now generally regarded as a valid (but hard to define) behavioral category. If breaching is an important activity for whales, and if the way in which it is done influences its effectiveness, there are good selective reasons why calves and possibly adults might "play" at it.

Breaching has most of the characteristics of other activities that animal behaviorists call play: it is common in social contexts, it is often done by young animals and in many instances it has no obvious function. Some investigators have speculated that a purpose of play in other young animals is to aid the development of musculature; breaching might serve this role in young whales.

The most spectacular breaches are made by the youngest whales. Right-whale, gray-whale and humpback calves begin breaching when they are only a few weeks old. The breaches are often vigorous and may run on in long sequences. On Silver Bank calves breached oftener than adults. Indeed, it would be rather exceptional for adult animals to engage regularly in such a vigorous activity as a form of play. Hence it seems unlikely that play is the main function of breaching among adult whales.

The findings I have reported and the hypotheses I have discussed do not indicate any single clear function for breaching. The evidence suggests the activity has several functions. Although there are strong correlations with sociality and breaches have characteristics that would make them effective as signals of physical prowess, no evidence conclusively supports either hypothesis.

My subjective evaluation is that breaching often serves to accentuate other visual or acoustic communication. It is a kind of physical exclamation point. Just as people raise their voice, gesticulate with their hands or jump up and down to emphasize a communication, so the whale breaches. And, like eavesdroppers, human observers usually miss the message, noting only its salient features.